EVALUATION OF THE MACROFUNGAL COMMUNITY AT LOS AMIGOS BIOLOGICAL STATION, MADRE DE DIOS, PERU

by

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INTRODUCTION

Fungi constitute the second most diverse group of eukaryotic organisms on earth, after the insects, in the number of species thought to exist. They are united by their mode of nutrition, growing through the substrate secreting degradable enzymes and absorbing nutrients through their cell walls. Because they obtain their nutrients by absorption, they can successfully exploit a variety of organic matter. They play myriad roles within the world's ecosystems among which the most important may be the cycling of nutrients derived from the breakdown of plant and animal matter, allowing the re-use of scarce biotic and abiotic resources (Rossman *et al*., 1998).

Scant attention has been accorded to the role of fungi in ecosystem functioning and in the maintenance of biodiversity itself. Broadly based integrated interdisciplinary studies are required to place fungi in an ecosystem context. Not only biomass involved may be considerable, especially when below-ground and litter inhabiting fungi are considered, but it is their functions, which are crucial to ecosystem maintenance. In addition 75 to 80% of vascular plants have mutualistic mycorrhizal fungi. Fungi play important roles as parasites in the natural bio-control of some organisms such as insects and plant parasites. They act as mutualists of wood-boring insects and they are a source of nutrients for a great variety of organisms (Hawksworth, 1991). Fungi are primary responsible for a large portion of the recycling of mineral nutrients through the decomposition of organic matter and for the transfer of these nutrients into plants via mycorrhizal fungi or by depositing them on the soil for their absorption. Fungi along with other soil organisms serve as sources and sinks of labile nutrients that are necessary for plant growth, participating in carbon entrapment. Thus, fungal and microbial biomass can

control significant fractions of labile pools in humid and wet tropical forests and regulate the availability of nutrients that may limit plant growth (Lodge, 1992).

Moist tropical forests often occupy ancient weathered oxisols and latisols where leaching produced by the heavy rainfall may have removed minerals and nutrients from it. It has been estimated that 94% of Amazonian soils are nutrient limited (Hedger, 1985). The availability of phosphorous to higher plants is generally limited since phosphorous combines with aluminum and iron oxides in the highly weathered soils to form insoluble complexes. Elements such as nitrogen and potassium are leached from ecosystems when the soil has little cation and anion ex-change capacity, and their availability may thus be quiet low in tropical forests with high rainfall. The degree to which fungi regulate the availability of limiting nutrients depends on the size and fluctuation of the labile pool and on the quantity and fluctuation of fungal biomass. Studies conducted at El Verde in Puerto Rico (subtropical wet forest), proved that fungi have the ability to immobilize phosphorus and other nutrients, preventing them from being leached due to high rainfall. Nutrients, once obtained by saprotrophic fungi are not released immediately or indiscriminately to other organisms but remain within the mycelium acting as storage units. Nutrients are often spatially relocated within the ecosystem, affecting the ecosystem's functions (Lodge, 1992; Boddy *et al.*, 1995).

Dead wood is the primary nutrient source of tropical macrofungi and constitutes an important component of forests ecosystems. Dead wood can reduce erosion, increase soil organic matter, store carbon, and serve as a reserve of nutrients and water. Wood forms the major component of aboveground biomass of terrestrial ecosystems, representing over 70% in forest ecosystems, and fungi are the major agents of wood

decomposition (Boddy *et al.*, 1995). Decomposition rates of tropical wood are extremely high and the factors that influence this rate are mainly climate, saprotrophic organisms, and secondary compounds present in the wood. Nevertheless, the ecological relationships between wood-inhabiting fungi and substrate qualities remain to be systematically studied in the tropics (Lindblad, 2001).

This project comprises macromycetes. Macromycetes or macrofungi is an artificial group, which include those fungi forming reproductive structures (sporocarps, basidiomes, sporophores, carpophores, fruitbodies, etc.) that are visible with the naked eye or larger than about 1 mm. They comprise an important component of the lowland rainforest ecosystem. Fruiting bodies, produced by these macromycetes, serve as important nutrient sources and refuge for other components of the ecosystem such as insects and other arthropods. Associations between insects that use fungi as a resource and the fungi exploited are variable in nature, including from obligate mycetophagous species to opportunistics. On the other hand, macrofungi groups such as the family Clavicipitaceae (Ascomycota) use insects (and some arthropods) as their nutrient source and play a role in the regulation of the host population. Members of the Clavicipitaceae are also considered a significant “hot spot” for invertebrate pathogens and are known to be much more diverse in the tropical areas than in temperate regions, especially in undisturbed forests (Hodge, 2003; Chaverri *et al.* 2006). A few tropical species from these entomopathogenic fungi have moved from the forest to agricultural ecosystems, which should be considered in order to limit potential pests that can affect important crop pollinators. Currently, many species belonging to this family (anamorphs and telemorphs) are being using as biocontrol agents of agricultural pests. Most of the fungal species

assessed for biocontrol have come from agricultural ecosystems, so natural forests, as the one studied, presents a potential pool of new biocontrol agents.

Fungi help to preserve plant biodiversity at tropical rainforests, by causing a high rate of plant mortality. In a study conducted at Panama's rainforest, Gilbert (2005) found that fungal attack caused 47% and 39% annual mortality of seed in the soil seed bank of *Miconia argentea* (Melastomataceae) and *Cecropia insignis* (Cecropiaceae), two pioneer tree species. Fungal pathogens attack tropical trees seedlings, preserving the biodiversity of the community because only the strongest individuals from each plant species in that generation will survive the infection; therefore, there will not be only one dominant species that can displace the rest. Consequently, fungi play an important role in the balance of death and survival, which will generate the future tree species composition of a community. The majority of these pathogens are not macromycetes; however, some of them are, such as neotropical polypores like *Ganoderma, Amauroderma,* and *Phellinus* species (Ryvarden, 1992). They attack living trees, making them more susceptible to damage from wind and rain. Others will infect living trees but really only colonize and decay extensively when the tree is dead or dying from other factors. For instance, a survey done at the Barro Colorado (Panama) found that the percentage of live trees with polypore fruiting bodies range from zero to 33%, while 56% of all dead trees had polypores (Gilbert, 2005). Members of the Xylariaceae are also believed to be plant pathogens of tropical plants (although in less proportion than polypores); these species invade the host when it is still alive and wait for a change in conditions which favors the fungus causing canker or root rot diseases. *Kretzschmaria clavus*, a widespread tropical

fungus, is an example and should not be underestimated as a potential pathogen of commercial crops (Whalley, 1992).

Because of their widespread distribution and association with all organic and many inorganic substrates, the actual number of fungal species in existence is difficult to assess (Rossman *et al.*, 1998). Several estimates of fungal diversity have been made, based on several types of data. Hawksworth proposed the most common estimate for the number of fungus species. He proposed an estimate of 1.5 million fungal species on earth; largely by extrapolating the ratio of host plants to fungi (1:6) found for the well studied mycobiota of the British Isles (Hawksworth, 1991). He also concluded that based on these estimates, the currently accepted number of described fungal species represents as little as 5% of the potential global mycobiota. Smith and Waller (1992) considered 1.5 million too low and suggested that there are probably 1 million undescribed fungi living on tropical plants alone. Subsequents estimates have ranged from 500 thousand to 9.9 million, but it is prudent to retain 1.5 as the working hypothesis for the number of Fungi on Earth while additional data are obtained (Hawksworth, 2001). Cifuentes *et al.* (1997) proposed a ratio of 3.5:1 of macromycetes species to vascular plants for subtropical regions. Caution is needed when making extrapolations since the smaller area surveyed the more species of fungi outnumber those of flowering plants. The latter because saprobes (habit of most of the tropical macromycetes) have wider distribution than plants and are often non-specific. The ratio of 6:1 of fungi vs. vascular plants proposed by Hawksworth may be higher or lower in tropical regions but tropical fungi are not known sufficiently to even speculate about their richness (Rossman *et al.*, 1998). More recently, Muller *et al.* (2007) proposed a number of macrofungi species, ranging between 53,000

to 110,000. They also proposed that the total number of macrofungi in Tropical America should be approximately 14,000 species based on a 5:1 ratio of plant to macrofungi.

Overall, fungal diversity overall is greater at lower latitudes, such as tropical areas (Lodge *et al.,* 1995). Most of the fungal species remaining to be described are probably found in the neotropics because of the vastness of the tropical area, the number of unexplored habitats there, and the existence of a latitudinal biodiversity gradient with the tropics richest in taxa. The unexplored tropical rain forests represent the richest ecosystem in Earth in terms of variety of micro-habitats, individual genomes, and morphological diversity (Moncalvo, 1997). Neotropical regions are expected to be the richest sources of new species. For instance, Batista and his co-workers described approximately 3500 species between 1954 and 1972 (Da Silva *et. al.*, 1995). These new fungi came mainly from easily accessible parts of the Amazon, and several species new to science were discovered from single perennial leaves. Therefore, areas of difficult access are probably holding many new species waiting to be discovered. Some macromycetes groups are particularly diverse in the neotropics such as Xylariales (an Ascomycota order of mostly decaying fungi) and Agaricales (a Basidiomycota order of mostly saprobes fungi). Singer (1989) published 276 new species of agarics of which 241 were from Central and South America (Hawksworth, 1991). The studies of Dennis (1970) also demonstrated that Xylariaceae is well represented in tropical South America, reporting more than 100 species for this family, a number that later Læssøe (1999) proposed to be even greater (up to 500 species). In contrast, ectomycorrhizal genera are exceptionally poorly represented in the neotropics whereas in other tropical areas, such as the Congo flora, are very diverse (Dennis, 1970).

The number of fungal species is deeply related to the number of different possible substrata located within a site. The type of vegetation in an area affects the species' richness and the abundance of macrofungi since plants constitute the habitat and energy source for most fungi, and all fungi show some degree for host or substratum specificity (Lodge *et al.,* 1995). In the case of the tropics, low host specificity is expected comparing with the temperate regions, because natural selection can act against specificity that limits colonization of widely spaced hosts (Janos, 1980). In most tropical wet forests tree dominance is low and diversity is high, which also means that macrofungi will have more types of substrata to exploit. In addition, forests with greater stature and structural complexity can create more microhabitats and microclimates for fungi. For the fungi treated in this study, diversity of habitats rather than geographic location is believed to have the strongest influence on fungal species richness (Dennis, 1986).

Whatever future research establishes as to the true number of species, it is indisputable that there is a tremendous number of undescribed fungi in tropical regions. If only 5% of the world's species (70,000) have now been described, 1.43 million must remain unrecognized. In conclusion, the state of knowledge of the tropical mycobiota is still in the pioneer phase of exploration. This phase represents only the first portion of the alpha-taxonomy, which embrace the knowledge of the species present and their variability (Hawksworth, 1992).

Although macrofungi have perhaps the longest history of diversity studies of any mycota, they nevertheless are understudied throughout most of the world. More data are available from Europe than from any other region; yet, even for Europe the knowledge of macrofungal diversity is incomplete. Taxonomic obstacles and the absence of long-term

studies prevent us from conclusively answering even basic questions about the number of species at a specific location or whether diversity is greater in one type of forest than in another (Mueller *et al*., 2004). The percentage of well-known fungi is low for several reasons related to the nature of fungi themselves. Fungi are composed of a threadlike vegetative structure called mycelium, which usually exists immersed in soil or plant parts and only become visible when reproductive structures are produced (Rossman *et al.*, 1998).

The methods used to inventory fungi are inherently labor–intensive and many years of collecting are required to encounter the numerous larger species that only rarely produce fruiting structures. Lodge (1997) found that several species of Entolomataceae fruited every second or third year in a wet subtropical forest in Puerto Rico, whereas a few other species were found only during 1 year of a 13 year survey; Straatsma *et al* (2001) found that the species richness estimators did not stabilize during a 21 year survey. In addition, to the fruiting seasonality problem, some fungi may decay before they can be adequately documented, resulting in a significant loss of data. Lacy (1984) observed the duration of different species' sporocarps in nature, finding that fruiting bodies from *Marasmius* lasted in average 4 days, *Lepiota* 6 days, *Coprinus* 3 days and *Pluteus* 4 days. The short period of time in which sporocarps are available for being collected decreases the chances of them being documented. Therefore, understanding the causal and correlative factors that are related to fungal diversity may be especially helpful in suggesting which threatened areas are likely to support a high diversity or a unique group of fungal species, and are consequently of greater value in conservation efforts (Lodge *et al.*, 1995).

Understanding how fungal populations and communities are spatially and temporally distributed in tropical forests is fundamental to estimate their diversity. Such information is also useful in determining how fungal populations affect the abundance and distribution of other organisms and ecosystems processes at the landscape level (Lodge *et al.*, 1995). Fungi and ecosystem functions are greatly influenced either directly or indirectly by weather conditions. The temperature and humidity conditions of the air and soil and the patterns observed by these parameters are among the principal factors that regulate fungal growth and reproduction (Ohenoja, 1993). Several recent studies have demonstrated that the vegetation composition of the area plays a very important role in the fungi community (Ferrer, 2001; Muller *et al.*, 2004; Lodge, 1997). Variations in biotic and abiotic factors affect directly the macromycetes community composition, diversity, abundance, distribution, and growth rate. Thus, a particular species may fruit at different seasons across wide geographic distances or along strong elevational gradients.

The rate of rainfall is one of the most important factors, even more than temperature, in determining the fungal community composition. There is a range of humidity concentration that benefits sporocarp production for each species. Delaney *et al.* (1998) found that the wetter life zones had slower turnover rates of dead wood than their drier ones, with the fastest turn over in the “moist transition zone,” and the slowest in the moist life zone. The last can be explained also because high moisture content and associate restriction of aeration also limit the activity of mycelial fungi in felled or fallen timber. The moisture content of dead wood especially in wet forests can be too high for

many wood-rotting fungal species to survive. In such areas, there will be a selective pressure for species with high tolerance for moisture contents in wood (Lindblad, 2001).

Fungal succession has been defined as “mycelial succession” (Hyde *et al.*, 2002), but for the purposes of this study we considered fungal succession as the succession of sporocarps within the study area. Succession of macrofungi must be considered when inventorying, measuring, and comparing communities, and when plots are analyzed. First, there are successions of sporocarp production on particular substrata, although all species may be present in the substrata from the beginning. Succession involving changes in community composition often are related to changes in the quality of substrata. Hedger (1985) found, for example, that some species of *Lepiota* only grow well on leaf litter that previously has been decomposed by other fungi, such as certain *Marasmius* species. Second, successional changes occur in the vegetation at a site, which may have a direct impact on fungi through the establishment of new host taxa and changes in the amount and quality of available organic matter (Lodge *et al.*, 2004). During decomposition the nature and abundance of substrata change with time from readily decomposable compounds to a proportionally greater recalcitrant fraction. A Substrate is initially colonized by pioneer saprophytic fungi or sugar fungi (Zygomycota), which use simple soluble nutrients. They are followed by the more specialized polymer degraders which utilize cellulose, hemicelluloses, or chitin. In later successional stages, the fungal flora composed of species able to break down recalcitrant compounds, which are accompanied by secondary opportunistic invaders (mainly Basidiomycota). Generally, the early stages of succession are characterized by a high biochemical and fungal diversity, whereas later phases comprise fewer functional groups. The successional changes within the fungal

community are associated with an increase of drought, accumulation of recalcitrant substrates, and lower C/N ratio (Ruess *et. al*, 2005).

No comprehensive effort to document the macrofungi of Peru has been attempted, even for individual groups of fungi. There are a few works that have been done in the country as the one by Dr. Magdalena Pavlich (1976). Pavlich reported and documented 102 species of macromycetes (93 Basidiomycota and 9 Ascomycota) with special emphasis in cloud forest species. Some undergraduate theses have been conducted in the Amazon among them the one conducted by Hernan Castaneda & Roby Buendia in 1986, the one conducted by Gazis (2004) and the latest survey done by Maribel Espinoza Azan in 2005 (Pavlich, *pers. comm.*). Some foreign scientists have included sections of Peruvian Amazonian regions in their surveys. Singer in 1958 made a field trip to Peru and included some specimens in his book "Agaricales in modern Taxonomy" (Strack *et al*., 1997). Dennis in 1970 published his intensively work "Fungus Flora of Venezuela and Adjacent Countries" in which he included collections made at the northeastern part of the Peruvian Amazon basin. More recently Thomas Læssøe**,** Luis Diego Gomez, and Gregory Muller have been conducting exploratory surveys and making collecting trips in where areas from the Peruvian Amazon have been incorporated.

Hawksworth (1992) compiled information from different reliable sources as Index Fungorum, Mycological Society of America, and the British Mycological Society, showing the number of investigations done in different countries as well as some information about their resources (available databases, museum collections, published articles, books, etc). According to this investigation, mycologists that have done surveys in Peru have described a total of 52 new species from 1981 to 1990, which is a

demonstration of the low number of surveys made in the country or might be a sign of the loss of information that remains unpublished. What is of concern from this publication is that Peru appears as having no levels of information resources (as checklists, collections, bibliography) for macromycetes.

Conservation implications

Fungi conservation has received scant attention in most countries. This is regrettable in view of their role in ecosystem function and so in the maintenance of biodiversity but further because of the unexploited genetic resource they represent. Moore *et al.* (2001) suggested the following steps for fungal conservation: (i) conservation of habitats, (ii) *In-situ* conservation of non-mycological reserves/ ecological niches, and (iii) *Ex-situ* conservation especially for saprotrophic species growing in culture. The *in situ* conservation is hampered by the lack of information such as the species present in particular sites, the length of time and labor-intensiveness of producing lists, knowledge of the rarity of individual species, and in most cases the lack of understanding of precise ecological requirements of species. Even in the relatively intensively studied British Isles, is not possible to have confidence that the database can make judgments on rarity. *In-situ* conservation of fungi is therefore best effected by ensuring the preservation of the widest range of least disturbed habitat types, and macromycetes can be of value in determining such sites. The safeguarding of centers of plant diversity would be a major step in securing the associated fungi. These management decisions are of especial importance in tropical regions because most of the undescribed fungi are located within these areas, which are going under a massive reduction. The

deforestation rate for the neotropics is calculated at least in 13 million acres of forest annually[1], leading to an enormous loss of habitats, and with them an unknown number of species.

Some European countries experienced and reported a decline in population and in geographical range of macromycetes, leading them to take some remarkable strategies to battle this situation. Austria, Denmark, Germany, Finland, and Norway have published a list of macromycetes species considered to be in danger of near-future extinction as a result of a complex of environmental changes (Arnolds, 2001). The Red Data List[2] reflects their concern about the possible extinction of some known and yet unknown species. Species included in Red List are usually associated with ecosystems that are themselves endangered (Ing, 1996). The Amazon, being a threatened ecosystem, should be object of consideration and macromycetes should be included in its endangered species list. Even though Red Lists are in essence a statement of concern based on existing knowledge (if the knowledge is inadequate so will be the list) and we still have a long way to get to know the neotropical mycoflora consciously, we need to take actions soon since the loss of habitat has a much faster rate that our achievements in this regard. Developing inventories and increasing the exploratory surveys in tropical areas will assist scientists in determining which species are considered as rare or endemic to a region. Hence a Red List can start being built in order to prevent the extinction of some valuable species.

The primary motivation for conducting a biotic inventory is to manage biodiversity. In order to achieve this objective it is necessary to know (1) what the

[1] Data obtained from Rainforest Alliance organization.
[2] Rarity, Endangerment, and Distribution Data lists.

biodiversity of a site is; (2) where it is located in that site; (3) how to obtain the organisms in order to study or exploit them; and (4) the ecological roles and biotic interactions of the organisms. These are prerequisites for fulfilling the obligations of the Convention on Biological Diversity (Hawksworth *et al.* 1997). My study deals with the first two points of the requirements which will serve as the foundation for the following two steps.

The present research is part of a much larger project called "Andes to Amazon Biodiversity Program" (AABP), whose principal mission is to support and help to conserve natural areas located in the Amazon basin in order to preserve a priceless resource: biodiversity.

Project Objectives

The main goal was to expand the baseline database about fungal diversity and ecology in the Amazon region of southeastern Peru, establishing an inventory of the macrofungi species. This project has taxon-driven implications for conservation research and planning in the region. The following were the project's goals: (1) A preliminary checklist of the species found in the area; (2) An overview of the macrofungi community composition in three main habitats (high terrace primary forest, high terrace secondary forest, and floodland primary forest); and (3) An overview of the macrofungi community composition changes along three different seasons.

Questions and Hypotheses

The following were the questions that drove the project:

- How diverse is the macrofungal community?
- How the community diversity and composition vary between habitats?
- How the diversity, abundance, and population structure vary with seasonal patterns?

The area was estimated to present a high diversity in macromycetes species since it is located in one of the richest places in microhabitats on Earth, offering a great diversity of suitable substrata. Primary forests were expected to hold the highest number of species, and secondary forest the lowest. The community structure was anticipated to change according to the quantity of rainfall, being the months with more rainfall the ones with more number of species.

Materials and Methods

Study area

This study was carried out in the Los Amigos conservation concession of The Amazon Conservation Association (ACCA), which is located within the lower Los Amigos watershed in the department of Madre de Dios, Peru (Figure 1, A - D). The Department of Madre de Dios, dominated by the Madre de Dios River basin, is an important geopolitical region in the pristine SW Amazon. This Department lies at the southwestern edge of the Amazon basin near the Andean foothills in southern Peru, and is covered primarily by lowland tropical/subtropical moist forest. Threats to the forest occur in the form of hunting, gold mining (Figure 2), timber extraction, impending road construction, and slash-and- burn agriculture; however, Los Amigos is still in a relatively pristine state. Collections were made at Los Amigos Biological Station[3], which is part of Los Amigos Conservation Concession. The station is located at approximately 12°34'07"S 70°05'57" W (Figure 1, C) at an elevation of 268 m. The closest settlement to CICRA is the community of Boca Amigos, approximately 3 km downriver and the closest city is Puerto Maldonado, the capital of Madre de Dios, approximately 90 km downriver from CICRA.

[3] CICRA ('Centro de Investigación y Capacitación del río Los Amigos' – Training and Research Center of the Los Amigos river).

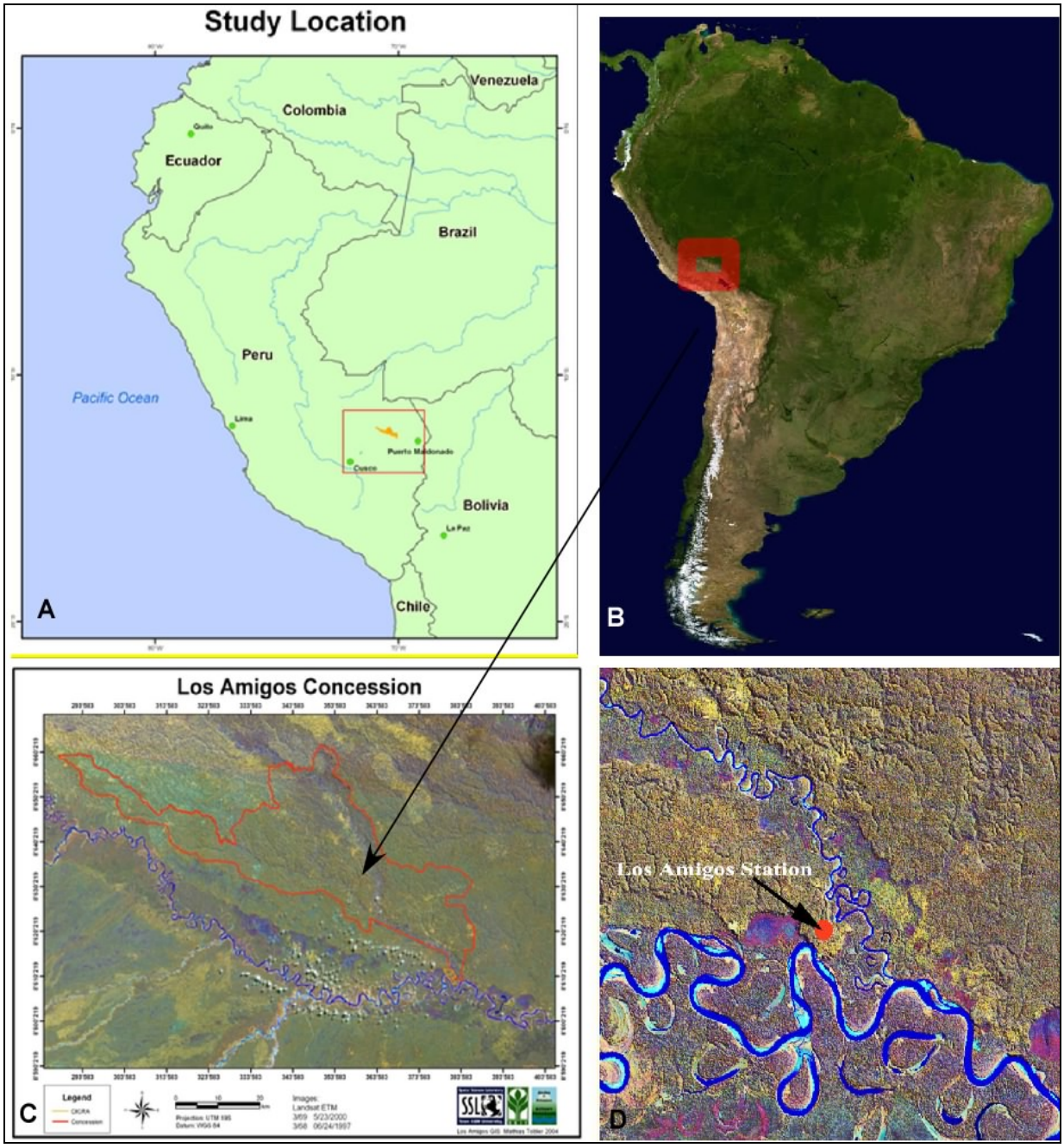

Figure 1 (A – D). *Location of the study site.* The study site is located in the Peruvian southeastern region within the Amazon basin in one of the few remain pristine areas of the Amazon.

Figure 2. Gold mining in the Madre de Dios River. Gold mining is one of the major threats to ecosystems in this region of the Peruvian Amazon. Mercury is used to extract gold from the river's soil and over time accumulates in the watershed.

Climate and Seasonality

Mean annual rainfall at the station in 2000-2006 was between 2,700 and 3,000 mm. Rainfall is markedly seasonal, with more than 80% of the precipitation falling between October and April, during the wet season. June, July, and August are the driest months, each averaging less than 80 mm of rain. May and September average slightly more than 100 mm (Figure 3), appearing as the transition months between seasons. The dry season in Madre de Dios is also the season with the lowest air temperatures, the highest river water temperatures, the lowest solar radiation levels, the thickest leaf litter on the forest floor, the highest river water pH, the shortest days, the highest stream conductivities, and

(because it is also a time of lower rainfall in the Andes) the lowest river levels. Temperature shows a much milder seasonal signal (Figure 4). The dry season is slightly cooler than the wet season, but monthly means never depart from the range of 21-26 °C (Pitman, 2006).

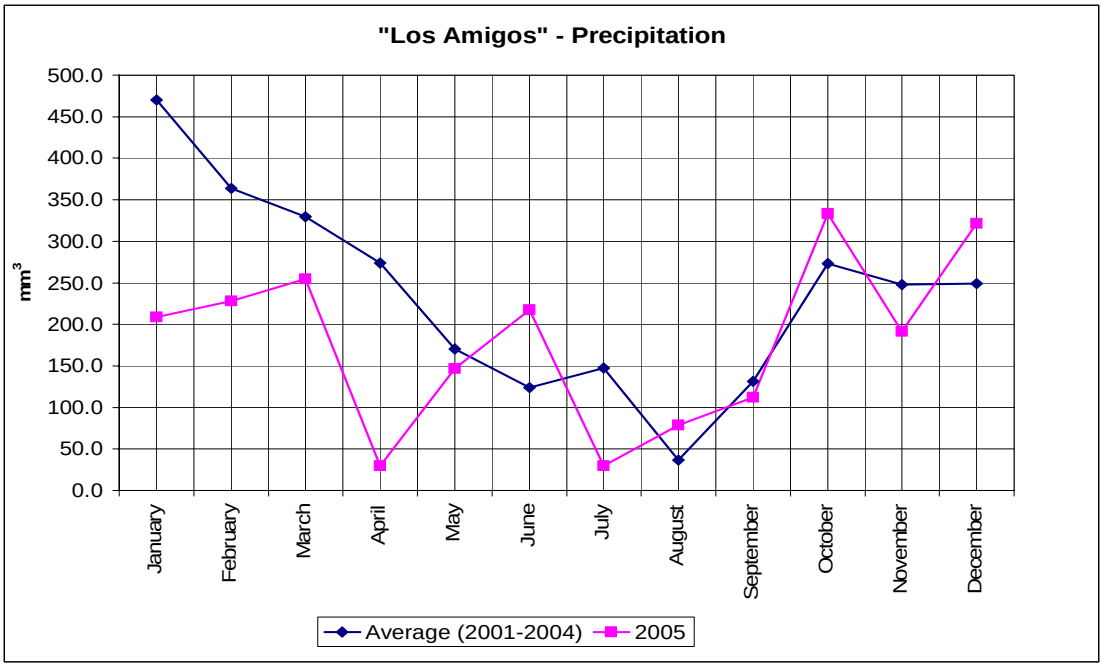

Figure 3. *Graph showing the fluctuation in precipitation at "Los Amigos" for 2001 – 20004 and for 2005 separately.* The average precipitation during 2005 was significantly less than the average between 2001 and 2004.

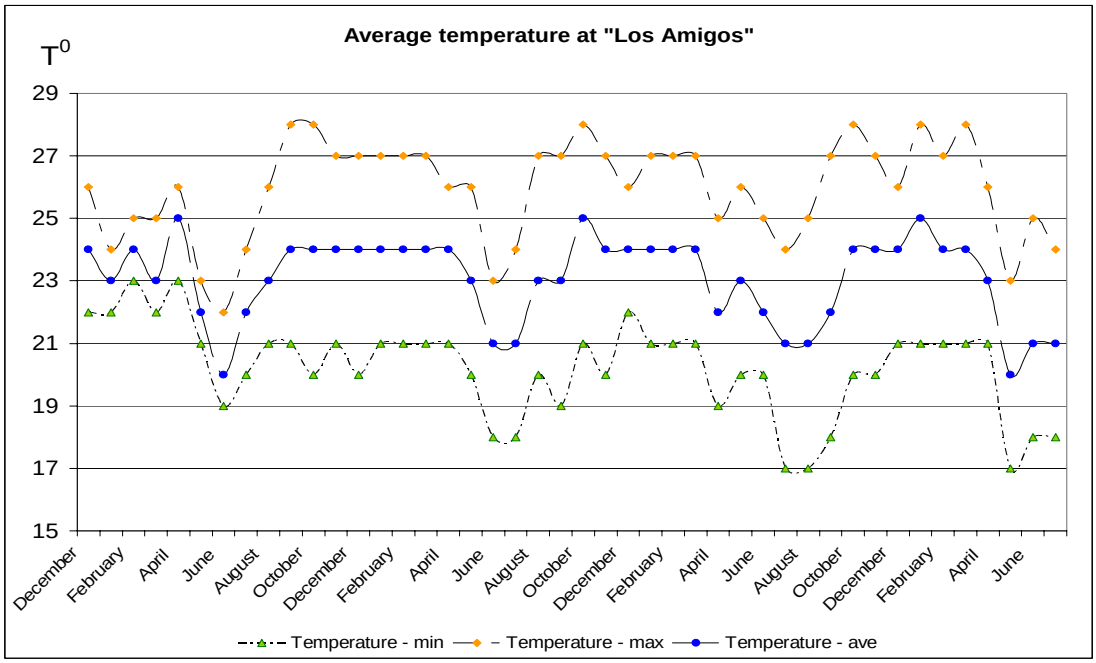

Figure 4. *Graph showing the temperature fluctuation from Dec 2000 to Jul 2004 at "Los Amigos".* Minimum, maximum, and average are shown in different colors. The temperature range goes from 17 ºC to 28 º C.

Soils

A mosaic or a mix of clay, sand, and silt as well as gravel composes soils in the Madre de Dios region. Soil texture varies considerably, even within a single forest type; however, the vast majority of upland soils in the region fall into just two classes: ultisols and inceptisols, which dominate much of western Amazonia (Pitman, 2007). *Terra firme* soils are sandier, more acidic, and poorer in nutrients than floodplain soils. At floodplain, young soils (i.e., new levees created by river dynamics) tend to be less acidic than older soils and to concentrate nutrients at much greater depths than older soils (Figure 5). A study of upland soils in a forested site on the road between Puerto Maldonado and Laberinto (Osher *et al.*, 1998) found that upland soils were very acidic, with pH of 3.6-4.7. In addition, with depth acidity decreases and clay content increases. Kaolinite was

the most abundant clay mineral, while in sandy soils quartz was dominant (Pitman, 2007).

Figure 5. *Vegetation at floodland as seen from Madre de Dios River.* Such low terraces are subject to inundation only during occasional extreme flood events

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Figure 6. *High terrace as seen from trail "Segundo Mirador."* Los Amigos area has a clearly distinguishable up terrace forest.

Vegetation

The flora of the Los Amigos is currently still under investigation by the botany team lead by the Botanical Research Institute of Texas (BRIT) team. However, first studies have already attempted to broadly characterize the vegetation types that occur in the region. According to Mendoza (2001), the types of vegetation in the Los Amigos concession area can be classified as follows. 'Aguajales' are found in swampy and boggy depressions and comprise primarily of communities of Aguaje palms (*Mauritia flexuosa*). Large trees with abundant emergent trees (Figure 6) characterize terraced forests or high terrace forests. Floodplains are areas periodically inundated by rain or by the surge of the

river. Successional forests are associated with the high river dynamics and thus located on areas periodically inundated or near shores of rivers. Pioneer vegetation composed of shrubby vegetation grows on the shallow and mostly sandy riverbanks (Figure 12 & 13). Secondary forests occur due to both natural and anthropogenic disturbance (Figure 7). The most conspicuous forms are large patches of dense bamboo, locally called ‘Pacales’. These areas are characterized by the presence of *Guadua spp.*, which grows especially in large gaps caused by fallen trees (Figure 8 & 9). Foster (2001) also provides his overview of the flora for the uplands in the Los Amigos Watershed. He concludes that the flora of the flat terraces is especially characterized by a high density of *Bertholletia excelsa* (‘Castaña’) and other emergent trees of the family Lecythidaceae which are mixed with hundreds of other tree species. Stranglers are rare, and the density of lianas is relatively low. Herbs, epiphytes, and trunk climbing plants are few. This vegetation formation has remained in general undisturbed (Figure 10 & 11), and except for the activities of selective logging and ‘Castaña‘collection, the area does not show signs of extensive clearing. On the other hand, the flora of the dissected hills occupies the largest area in the region and is least known. Large parts in the area are covered with an understorey of spiny bamboo, mostly under a sparse tree canopy but occasionally as open solid stands. Other large areas are covered with dense vine tangles. Yet others seem to have closed canopy forest.

Figure 7. *High terrace secondary forest habitat.* Vegetation at secondary forests is less dense and is mainly composed by fast growers and pioneer plant species. This young secondary forest is littered with the huge, star-shaped leaves of *Cecropia sciadophylla*, the dominant pioneer tree species in western Amazonia. The canopy is not as closed as in primary forest, letting the light pass through.

Figure 8. *High terrace secondary forest habitat.* "Paca" (*Guadua sp*.) is a very common and abundant species at Los Amigos secondary forest. It grows very quickly; filling the gaps produced by natural disturbance such as the ones produced by a fallen tree.

Figure 9. *Mantle at high terrace secondary forest habitat.* The secondary forest's mantle is composed mainly by leaf litter and twigs which take longer to decompose since there is a high light incidence that evaporates the water and delay the decaying process. *Cecropia* is one of the species that contributes with a great percent of the leaf litter.

Figure 10. *High terrace primary forest habitat.* The mantle in a primary forest is characteristically humid with a thin layer of non-decayed leaf litter located on top of a partially decomposed leaf litter and humus layer.

Figure 11. *High terrace primary forest habitat.* Vegetation at primary forest is typically very dense, with old growth trees and closed canopy. The vegetation underneath the canopy is composed by highly diverse tree saplings.

Figure 12. *Floodland primary forest.* The floodland habitat at Los Amigos is a mature primary forest presenting old growth trees and a relative high canopy.

Figure 13. *Floodland primary forest.* The floodland primary forest mantle presented a thin layer of intact leaf litter on top of a humus layer. The canopy is not as closed as in high terrace primary forest.

Leaf litter

One important environmental factor to take into account is the "forest litter seasonality." Leaf litter produced by the plant subsystem act as storage of nutrients becoming suitable substrates for saprobic fungi. A feature of all moist tropical forests is the presences of masses of litter mostly leave and small branches, trapped in the canopies of treelets and understorey trees. Fungi known as "litter trapping fungi" contribute to hold the litter using their mycelium system (Hedger *et al.,* 1993). Furthermore, foliicolous fungi are abundant in the tropics; therefore, the amount of leaf litter influences their abundance and distribution.

Litter data is only available for two types of habitats: high terrace and floodland forest, therefore, distinctions between secondary and primary forest cannot be conducted. In both habitats, the accumulation of litter in the forest's floor presents a seasonal cycle

apparently related to the amount of precipitation. The driest months (June, July, and August) present the highest amounts of litter (Figure 14).

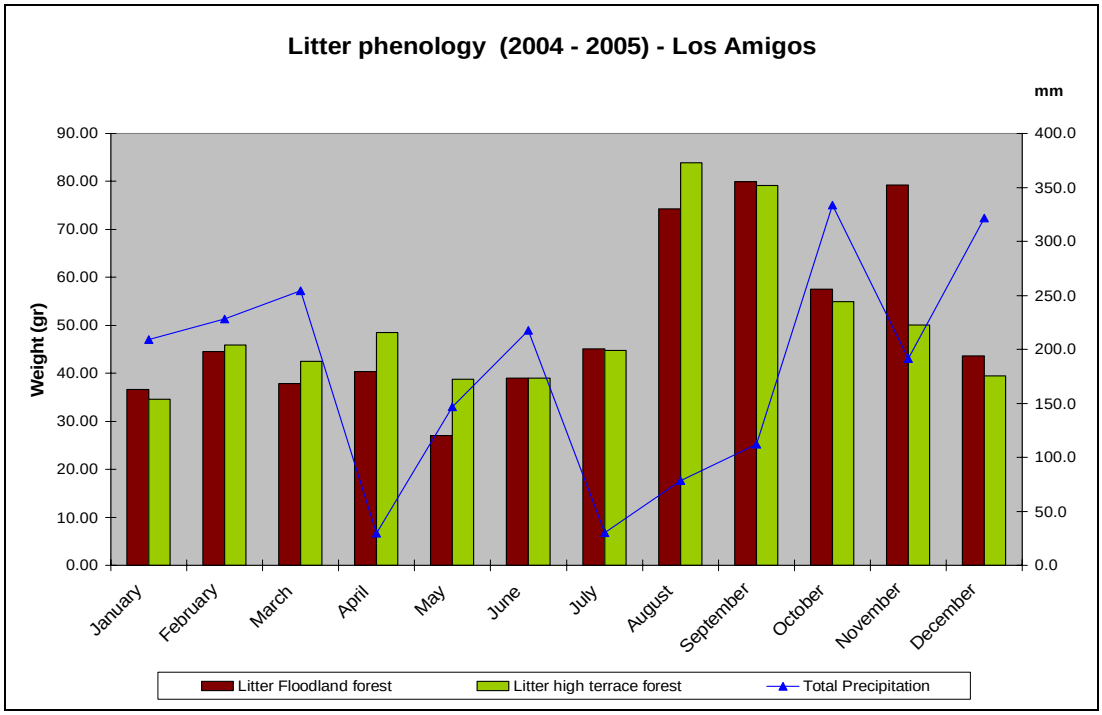


Figure 14. *Litter phenology (2004 – 2005) at Los Amigos biological station*[4].

Species

This project focused on macromycetes, which are fungi that form reproductive structures (sporocarps, basidiomes, sporophores, carpophores, fruitbodies, etc.) that are visible with the naked eye or larger than about 1 mm. Two main methodologies were used to assess the goals of the project: intensively and continuously fungus collection among each habitat surrounding the station and long term sampling plots for the comparison of fungal diversity among three main habitats (high terrace primary forest, high terrace secondary forest, and floodland or floodplain primary forest). The Ascomycota and Basidiomycota are important components of the community, but because they belong to different taxonomical phyla, these groups were analyzed

[4] Data given by Fernando Cornejo and John Janovec, 2007. Los Amigos Phenology Project ,BRIT.

separately to determine whether they show similar patterns of community structure within each habitat. In addition to those two groups, some collections were made belonging to a third group, deuteromycetes. Deuteromycetes[5] are not usually considered within the macromycetes since they are mostly composed by micromycetes; however, there are some macro–representatives included in this survey. A general description of the collection protocols for each objective is made below.

Methodology

Inventory construction

To create the checklist and to analyze the beta diversity (species richness of the region), all the different habitats were sampled, using the trail systems as transects. The trail system used consisted of more than 150 km (Figure 15, Appendix IV) passing through the major types of habitats present in the area as: mature floodplain forest, upland terrace and hill forest, bamboo-dominated forest, and wetlands. Trails are marked with flags every 25 m, helping in the geo-referencing of the specimens collected. Every trail was visited at least 3 times during the 6 months period (June to Dec 2005), some of them were visited more times (4– 10) depending on their length, location, and richness.

All the specimens received a collection number, which included the date of collection, habitat type, GPS location, number of plot or trail, and some extensive notes that can be important to identify the specimen. Once the sample was detected and the data annotated in the field notebook, it was collected and transported in a special envelope to the station laboratory. At the station samples were documented according to a special protocol for each family of macro-fungi. These annotations were introduced into a excel

[5] Deuteromycetes is use informally, to denote species of Ascomycota and Basidiomycota in which sexual reproduction is unknown.

sheet and archived with the images taken for each specimen. Once documented, specimens were dried using specific techniques depending on the nature of the fungus, but in most of the cases an electric food dryer was used. Finally, they were stored using silica gel to prevent re-hydration of the specimens, growing of undesirable fungus contaminants and to prevent insect incursion (Figure 16).

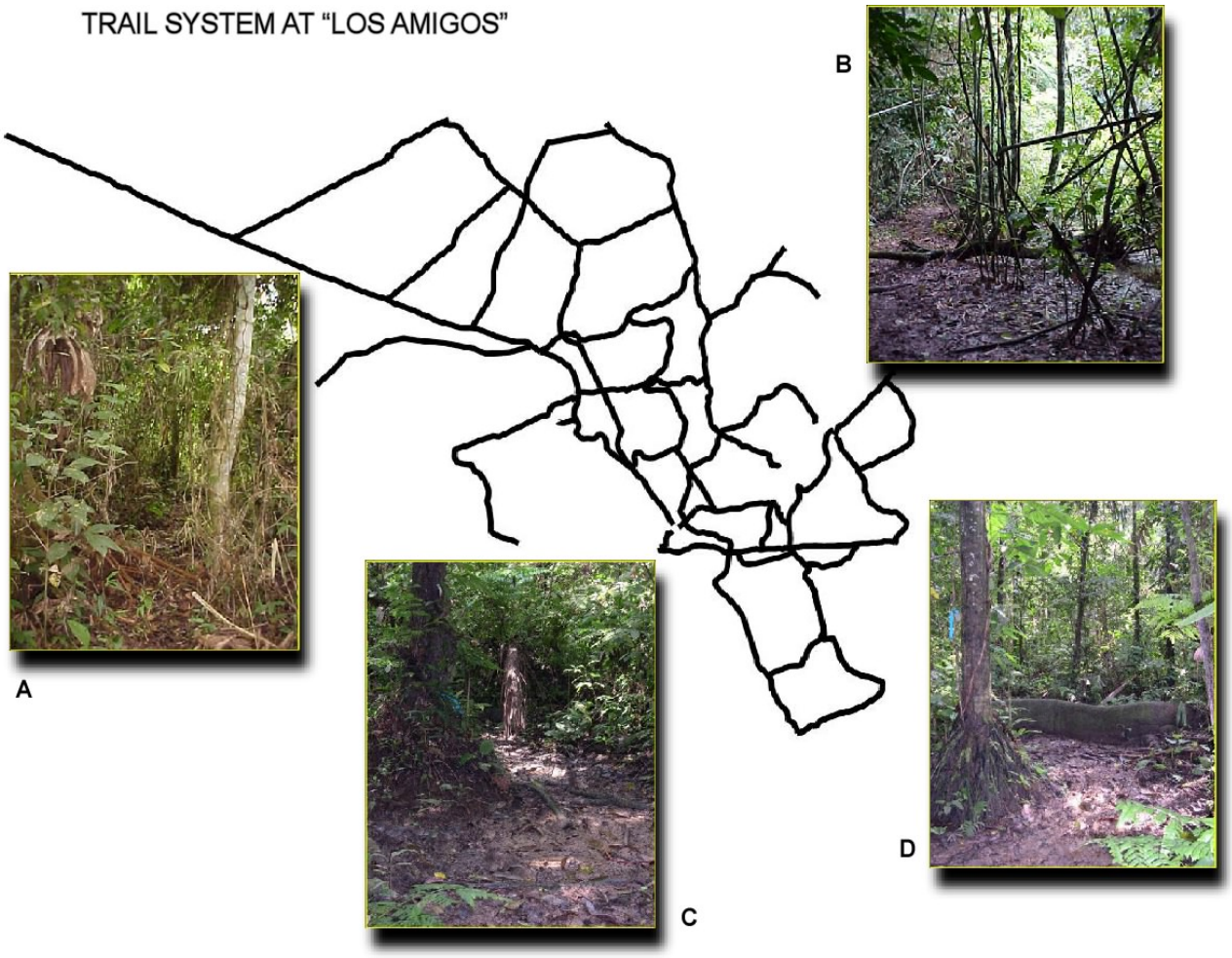


Figure 15. *Trail system at "Los Amigos"*. The more than 50 km of trails cover the main habitat present at the station's surroundings such as High terrace primary forest (A), high terrace secondary forest (B), floodland (C, D), bamboo patches, among others.

Figure 16. *Field work process.* A. "Los Amigos" Biological Station. B. Specimen collection. C. Field equipment. D. Trail's tag. E. Obtaining spore prints. F. Specimen documentation. G. Specimens drying process. H. Collection of the day waiting to be documented.

Diversity Analysis

For the long term plots used in the monitoring of the fungal community, the total area sampled in each habitat was 1000 m^2. The sampling area was distributed in two sub-samples or replicates of 20 x 25 m; therefore, the sampled area in each plot was 500 m^2. The size of the sampling area was chosen according to the variability of the plant community present in this type of forest. For very variable arborescent communities, 20 mm x 25 mm – 50 mm x 50 mm or even 100 x 100 m have been shown to be necessary (Walting *et al.*, 2005). The plots were located as randomly as possible, but accessibility was taken into account (Figure 17 - 18). The plots were inventoried three times, during a six months period, in average one time every two months during different seasons (Table1).

Figure 17. *Plot set-up*. A - B. Plot delimitation using biodegradable flag - tape. C. Specimens collected in one of the plots ready to be documented and processed. D. Plot tag to avoid disturbance by other scientists visiting the station. Each plot was GPS referenced as they were set.

	LOCATION	HABITAT	DATES VISITED
PLOT 1	Trail Daniela	High terrace – primary forest	June 27 August 10 November 15
PLOT 2	Trail Daniela	High terrace – primary forest	June 25 August 11 November 15
PLOT 3	Trail Aerodromo	High terrace – secondary forest	June 29 August 14 November 24
PLOT 4	Trail Aerodromo	High terrace – secondary forest	June 29 August 14 November 24
PLOT 5	Trail Cocha Lobo	Floodland – primary forest	July 7 August 17 November 25
PLOT 6	Trail Cocha Lobo	Floodland – primary forest	July 9 August 21 November 23

Table 1. *Plot location, habitat, and date of visit.* Each plot was visited three times in different seasons in order to monitor changes in the community.

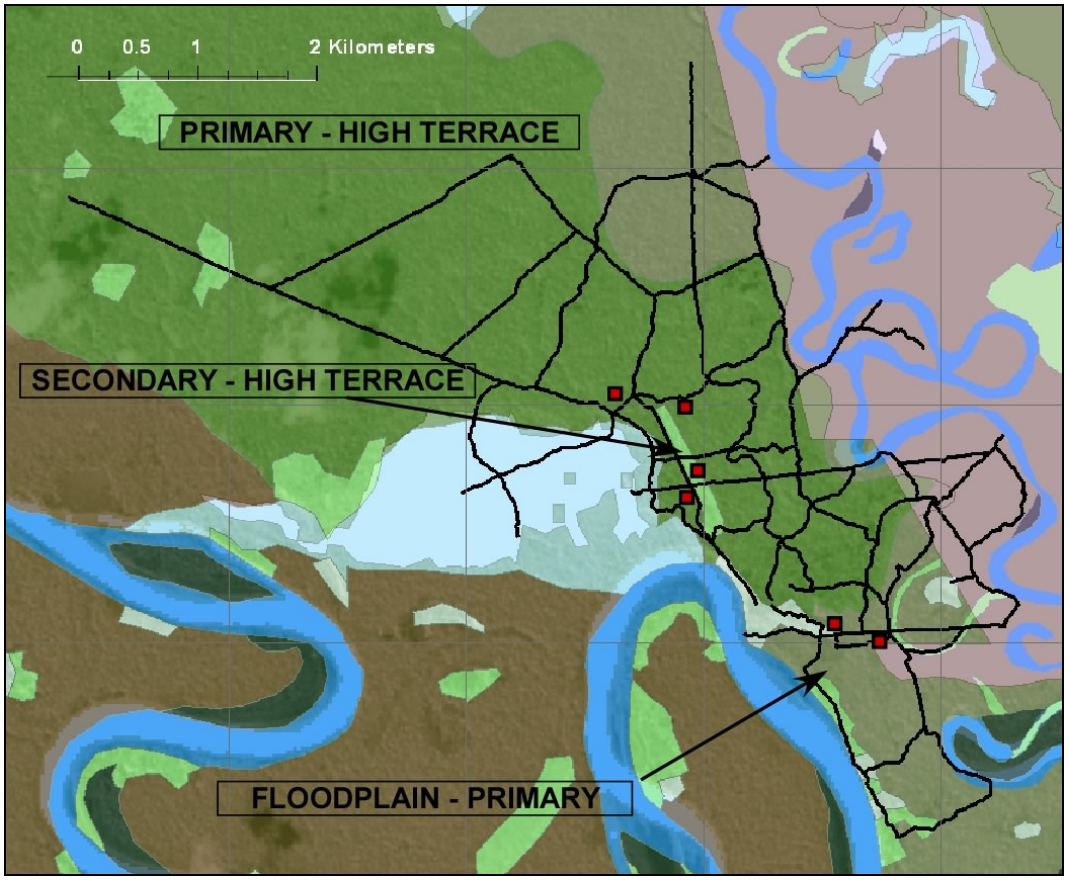


Figure 18. *Plot location.* In order to make comparisons between habitats, a set of 2 plots was located in each of the three main habitats: High terrace Primary Forest, High terrace Secondary Forest, and Floodplain or Floodland Primary Forest.

Identification of Macromycetes Species

When the field work was finished (Dec 2005), all the specimens were transported to BRIT and TCU where the identification process began (Figure 19). Identification was made using field data, macroscopic morphology, and microscopic characters of taxonomical value. Appropriate monographs, keys, and treatments were consulted. Many collaborators specialist in specific groups were involved in the identification process as

well as in the corroboration of the species' identification: Thomas Læssøe, Nigel Hywel-Jones, Clark Ovrebo, Luis Diego Gomez, and Juan Carlos Mata helped in this regard. The collections were deposited at San Marco's Herbarium (USM, Lima) as part of an agreement with the National Institute of Natural Resources (INRENA) to obtain the collection and export permits. Duplicates are deposited at BRIT Herbarium.

Systematics used

Fungi systematics is in continuously change especially with the molecular analyses and the phylogenetic relationships that are discovered every day. Many groups are being split, and some are being fused. The author chose a more conventional system based more on morphological characters than in molecular affinities between species. Nevertheless, in most of the cases, the classification dictated by the international organization "Index Fungorum" [6] was followed. The present work does not attempt to be a taxonomic treatment and the main purpose of classifying the species was to evaluate the diversity and build a database that can be useful for future projects. The use of systematics helps in the communication of the data obtained and at the same time gives an idea of how environmental factors can affect in the same way related groups of organisms.

[6] www.indexfungorum.org

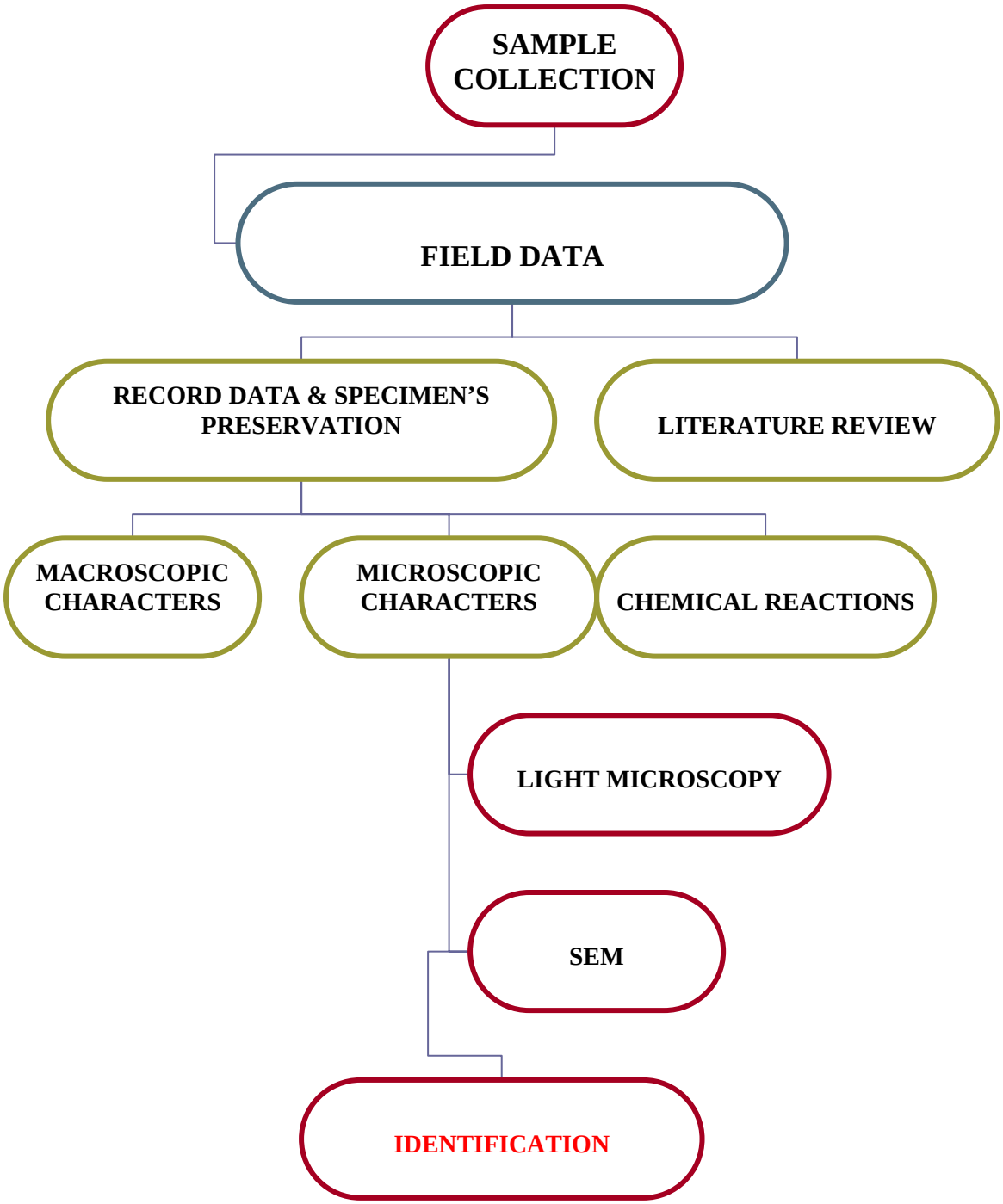


Figure 19. *Steps in the identification of fungal species.* Macroscopic data recorded during the sample collection is the most important step, which will ensure the correct identification of the specimen. In most of the cases , an analysis of the taxonomical important features under light microscopy are enough; however, there are some cases where especial techniques such as SEM and chemical reactions are necessary.

Data Analysis

The specimens collected were classified to genus or to species level when enough literature about the group was available or when specialists could be consulted. Many species; however, were only divided into morphospecies and used for the diversity analyses. The data obtained from the inventory and from the classification of the collection in morphospecies was used to analyze the beta-diversity of the area (species richness).

Another way to think about beta diversity is to view it as a measure of the degree of similarity or difference in species composition between sites. In other words, beta diversity examines the degree of species turnover as one moves from habitat to habitat, from community to community, or along any ecological gradient. The fewer species the various sites or positions along the gradient share, the higher the beta diversity. Sporocarps were not quantified hence only indexes that use binary data (presence and absence) could be applied. The similarities between the fungal community of pairs of sites were estimated using two binary indexes: Sorenson qualitative (presence – absence) index and Jaccard index (Mueller *et al.,* 2004). The mentioned tests were made to compare the similarity of fungal morphotypes occurrence among sites. Both indexes have a scale, which goes from 0 to 1. The closest to one, the more similar the communities are in species composition.

$$\textbf{Sorenson} = C_2 = \frac{2j}{(a+b)}$$

Where: j = number of fungal morphotypes common to both sites.

a = the number of fungal morphotypes in site A.

b = the number of fungal morphotypes in site B.

$$\textbf{Jaccard} = JI = \frac{j}{(a+b-j)}$$

Where: j = number of fungal morphotypes common to both sites.

a = the number of fungal morphotypes in site A.

b = the number of fungal morphotypes in site B.

RESULTS

1. Overview of the Collection

A total of 305 macromycetes belonging primarily to Basidiomycota and Ascomycota were collected (Table 2). Basidiomycota was the largest sample, with 224 morphospecies representing 71% of the collections. Ascomycota presented 76 morphospecies and contributed with 27% of the total sample. Deuteromycetes are mostly represented by microfungi therefore only 5 (2%) were recorded.

GROUP	# COLLECTIONS	% COLLECTION
Ascomycota	76	27
Basidiomycota	224	71
Deuteromycetes	5	2
TOTAL	**305**	**100 %**

Table 2. *Summary of the collection.*

1.2 Structure of the fungal community:

1.2.1 Ascomycota composition

The Ascomycota[7] represented 27% of the collection, much less than the Basidiomycota (Table 3). Xylariaceae composed a numerically important group represented by more than 60% of the species, indicating that they are a major component of the Ascomycota mycoflora. *Xylaria* was the most representative genus, with more than 20 morphospecies. Other xylariaceous genera found in the area were *Hypoxylon*,

[7] Only macrofungi species were collected.

Camillea, Daldinia, Kretzschmaria, Phylacia, and Thamnomyces. *Camillea* was represented in the area by three species: *C. lepreurii, C. mucronata and C. venezuelensis*. *Thamnomyces* was only represented by *T. chordalis. Phylacia, Kretzschmaria, and Hypoxylon* did not show a great diversification in the region. Just one species from each genus was collected.

ASCOMYCETES		
Family	# of Collections	% of the Collection
Xylariaceae	49	64 %
Clavicipitaceae	22	28 %
Sarcoscyphaceae	3	4 %
Pyrenotemataceae	2	3 %
TOTAL	**76**	**100 %**

Table 3. *Ascomycota's family composition.*

The Clavicipitaceae, an arthropod-pathogen group, was the second family that showed more representatives within the Ascomycota. *Cordyceps* had most diversity. Fifteen species of *Cordyceps* were found, among them *C. australis* and *C. amazonica* were the most abundant. *Hypocrella* and *Torrubiella* are two clavicipitaceous fungi also collected in the area, but only one species from each one was recorded. Ten morphospecies of anamorphic entomopathogenic fungi were found belonging to the following genera: *Aschersonia, Akanthomyces, Paecilomyces (Isaria), Hymenostilbe, and*

Beauveria. *Paecilomyces tenuipes* was by far the most commonly found species, especially growing on lepidopteran pupae.

1.2.2 Basidiomycota composition

The Basidiomycota represented 71% of the collections and were composed mainly of the Agaricales and Poriales, with 48% and 25.5% of collections respectively (Table 4). Other Basidiomycota orders were not as diverse and, in some cases, were only represented by one species, such as Dacrymycetales and Nidulariales.

BASIDIOMYCOTA		
Family	# of Collections	% of the Collection
Agaricaceae	24	11
Auriculariaceae	4	2
Boletaceae	1	0.5
Clathraceae	1	0.5
Gomphaceae	2	1
Coprinaceae	2	1
Cortinariaceae	6	3
Dacrymycetaceae	1	0.5
Exidaceae	1	0.5
Ganodermataceae	7	3
Geastraceae	2	1
Hygrophoraceae	2	1
Lycoperdaceae	3	1
Nidulariaceae	1	0.5
Phallaceae	3	1
Pleurotaceae	3	1
Plutaceae	2	1
Polyporaceae	51	23
Ramariaceae	2	1
Strophoriaceae	1	0.5
Sclerodermataceae	1	0.5
Thelephoraceae	12	5
Tremellaceae	1	0.5
Tricholomataceae	65	29
Typhulaceae	1	0.5
Unknown	25	11

Table 4. *Basidiomycota's family composition.* The family with the most number of species was Tricholomataceae, followed by the Polyporaceae and Agaricaceae. Twenty-five morphospecies remained unclassified.

The Poriales (Polyporaceae *sensu lato*), which constituted 25% of the Basidiomycota, also showed a common neotropical composition. The majority presented a saprobic habit as wood decayers. Nevertheless, some species were collected apparently growing on living trees. Two families belonging to this order were found in the area[8]: Ganodermataceae and Polyporaceae. Polyporaceae had more representatives and was more abundant, with *Polyporus tricholoma* and *Favolus brasiliensis* as the most common species. Ganodermataceae was represented by 7 species: *Ganoderma applanatum, G. lucidum and Amauroderma trichodermatum* among others unidentified morphospecies. The first two species are wood-decayers, and the last one was collected growing on soil but its rhizomorphs were probably connected underground to a wood source. Boletales was neither abundant nor diverse in the study area. There was only two species collected from this order: *Gyrodon exiguus,* a saprobe and *Scleroderma sinnamariensis*[9], a mycorrhizal species. The latter was the only mycorrhizal fungi found in the area. The Phallales was composed by two families: Geastraceae and Phallaceae. Phallaceae was represented by four genera: *Mutinus (=Xylophallus), Phallus, Staheliomyces* and *Pseudocolus*.

The agaric flora composition found in the study area was characteristic of the Neotropics with Tricholomataceae and Agaricaceae dominating (Figure 20), while, in contrast to the temperate mycofloras, Coprinaceae, and Cortinariaceae are relative small groups. The Tricholomataceae was by far the largest family in numbers of representatives. Genera such as *Marasmius*, *Mycena,* and *Collybia* were well represented

[8] There might be more families within the collection as Corticaceae and Podoscyphaceae waiting to be identified.

[9] Recently included in the Boletales, Index Fungorum.

by many species. Some rare species were also reported, such as *Calocybe cyaenella*, which was only collected two times during the survey. On the other hand, some species showed to be abundant and very widely spread within the area, such as *Coprinus disseminatus* and some foliicolous species of *Marasmius*, such as *M. cladophyllus, M. haematocephalus*, and *M. rotuloides*.

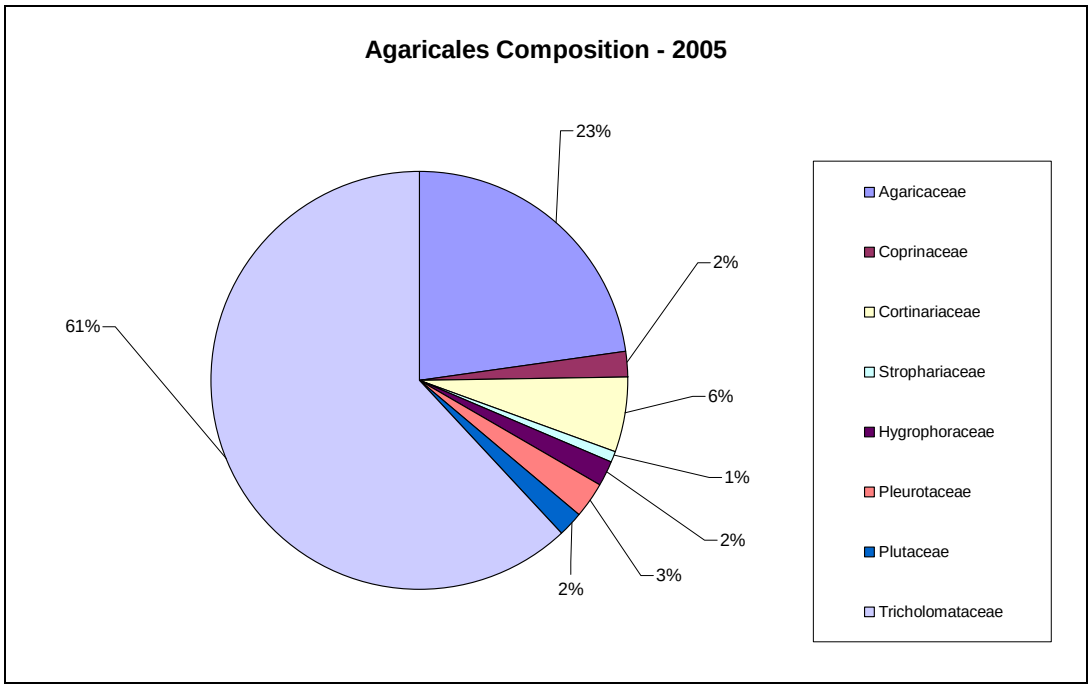


Figure 20. *Agaricales family composition at "Los Amigos" – 2005 (N = 105).* Like in most of the neotropical areas, the order Agaricales was mostly composed by the Tricholomataceae, representing 61%, followed by the Agaricaceae family with 23%.

2. Substratum preference

The majority of morphospecies (88.5 %) was only found growing on one type of substratum (Figure 21), 11.1% in two different types of substrata and just 0.4% of the morphospecies were collected in 3 different types of substrata. From the 305 morphospecies collected, the majority were found inhabiting the following substratum

categories: 46% logs; 20% branches; 20% leaves; 17 % soil (probably the rhyzomorphs some of these fungi were connected to a woody source); 10% leaves; and 9% insects.

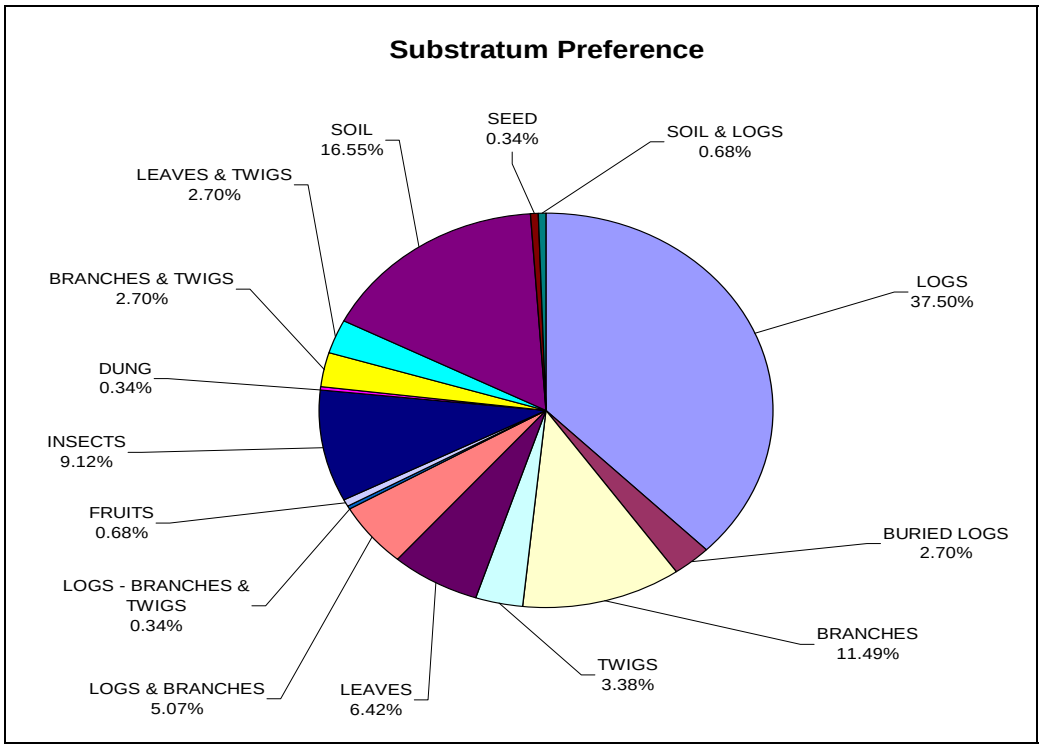


Figure 21. *Substratum preference distribution (N = 305).* The majorities of species presented a saprobe habit and were found growing on just one substratum: logs (37.5%), soil (16.5%), and branches (11.5%). Less that 1% of the collection inhabited three different substrates.

3. Identified species:

One hundred and thirteen species were identified, 70 belonging to the Basidiomycota, 40 to the Ascomycota, and 3 to the Deuteromycetes. Some of these identified species are considered new records for the area, for the country, and even for the continent. Forty eight species are new records for the country including:

Paecilomyces lilacinus, *Paecilomyces tenuipes*, *Camarops* aff. *scleroderma*, *Xylaria cubensis, Thamnomyces chordalis, Mutinus xylogenus* and *Hygrocybe miniata*. One of the species collected, *Pseudocolus fusiformis*, was recorded for the first time in South America (Gazis & Gomez, 2006).

For the complete list of identified species and the ones that constitute new reports for Peru, see Appendix 1.

4. Plot analysis

4.1 Individual Plot analysis

a. Plot 1 – high terrace primary forest I

The first sampling was conducted on June 28, 2005, a month when the total precipitation recorded was 217.6 mm. The number of morphospecies collected was 46. The community was mainly composed by Tricholomataceae (21%) and Polyporaceae (22%) followed by Xylariaceae (20%). The second sampling was conducted on August 10, 2005, a month when the total precipitation suffered a drop to 78.4 mm. The number of morphospecies collected at this time dropped as well to 11. The community was again mainly composed by Polyporaceae and Tricholomataceae. *Marasmius nigrobrunneus* was also collected in the first sampling, which suggest its adaptation two lower humid conditions. The third and last sampling was conducted on November 15, 2005, a month when the total precipitation increased to 191.4 mm; in addition, the previous month (October) presented the highest amount of precipitation (333.4 mm) contributing to the

soil's moisture. During this sampling 32 morphospecies were collected, and the community was primarily composed by Tricholomataceae. This time, Polyporaceae and Xylariaceae showed much less representatives counting with five species in each family. Just one from the 69 morphospecies was present during the three samplings dates: *Mycena sp.*

MACROFUNGI COMPOSITION OF PLOT - 1						
Taxon	**Samplings**					
	1		**2**		**3**	
Xylariaceae	9	20%	0	0%	5	16%
Clavicipitaceae	4	9%	0	0%	0	0%
Agaricaceae	4	9%	1	9%	2	6%
Tricholomataceae	10	21%	3	3%	17	53%
Polyporaceae	10	22%	5	46%	5	16%
Pyronemataceae	1	2%	0	0%	0	0%
Thelephoraceae	1	2%	0	0%	1	3%
Tremellaceae	1	2%	0	0%	0	0%
Agaricales	3	7%	2	18%	1	0%
Ganodermataceae	1	2%	0	0%	0	0%
Auriculariaceae	2	4%	0	0%	1	3%
TOTAL	**46**	100%	**11**	100%	**32**	100%

Table 5. *Macrofungi composition – PLOT-1.*

The following summary can be obtained from the plot's monitoring during 3 different seasons:

- There was just one species collected in the three samplings: *Mycena sp.* (P1_45) showing its ability to fructify during the year. This species presented a foliicolous habit and belongs to the Tricholomataceae.

- Some species recorded on the first sampling date were not found during the second collecting date and later reappeared during the third sampling. The latter pattern suggested that these species are probably conditioned to the quantity of rainfall and have a constricted range of optimal humidity conditions that allowed them to fructify. Fourteen

morphospecies present in the first sampling were also collected during the third sampling, mainly Xylariaceae and Tricholomataceae. Some of the species collected at the first and third sampling are: *Auricularia fuscosuccinea, Leucocoprinus bimbaumii, Marasmiellus nigripes, Marasmius crinis-equis, and M. cladophyllus*, suggesting their need of high levels of humidity to fructify.

- A total of 69 morphospecies were collected in the 1000 m^2 during the three samplings.

Macromycetes Diversity vs. Precipitation

The number of morphospecies strongly decreased (from 46 to 11) with the dropped of precipitation and increased again when it rose (from 11 to 31) (Figure 22).

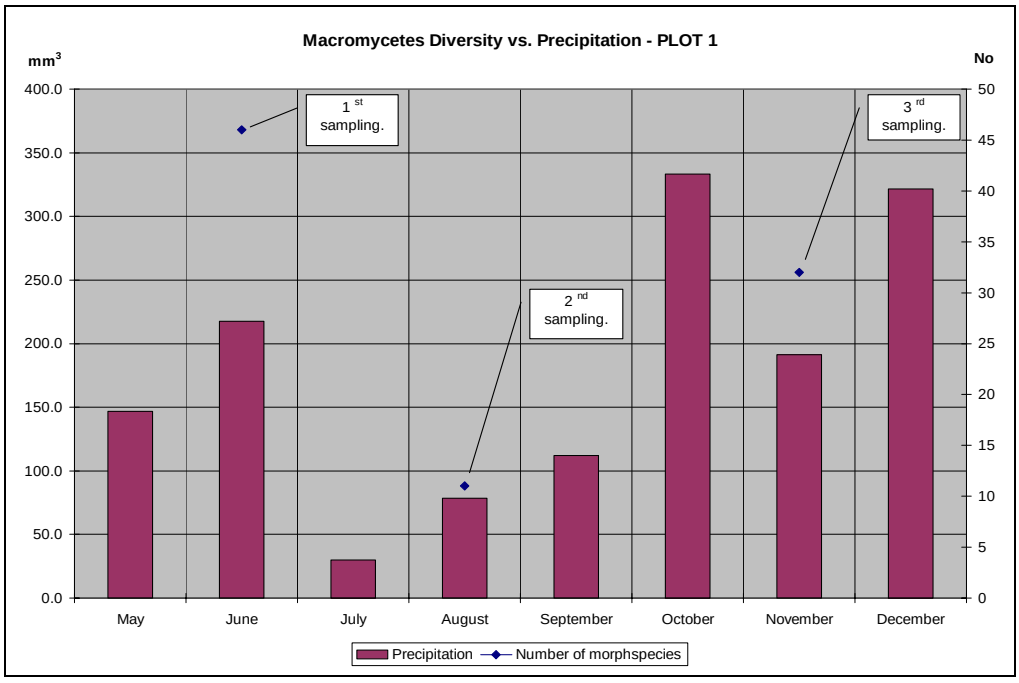


Figure 22. *Diversity changes vs. precipitation – PLOT 1.* The diversity of macromycetes dropped drastically as the precipitation diminished. In the third sampling the diversity increased as well as the precipitation. Notice that October is the month with highest precipitation which could contribute to the soil's humidity and to the increase of fructification.

b. Plot 2 – high terrace primary forest II

The first sampling was made on June 25, 2005, a month when the total precipitation recorded was 217.6 mm. The number of morphospecies collected was 44. The community was mainly composed by Tricholomataceae (33%) and Polyporaceae (20%) followed by Xylariaceae (14%). Clavicipitaceae also composed an important fraction making up 14% of the collection with five species of *Cordyceps*. The second sampling was conducted on August 11, 2005, a month when the total precipitation suffered a drop to 78.4 mm. The number of morphospecies collected this time dropped as well to 7. The community was composed by 3 species of Polyporaceae, 2 species of Tricholomataceae, one species of *Xylaria* (*X. hypoxylon*), and one clavicipitaceous anamorph *Paecilomyces tenuipes*. *Marasmius rotuloides*, *Xylaria hypoxylon*, and *Paecilomyces tenuipes* were also present in the first sampling, suggesting their adaptation to lower levels of humidity. The third and last sampling was conducted on November 15, 2005, a month when the total precipitation increased to 191.4 mm; in addition, the previous month (October) presented the highest amount of precipitation (333.4 mm) contributing to the soil's moisture. Thirty-seven morphospecies were collected, and the community as in the previous cases was mainly composed by Tricholomataceae (36%), Xylariaceae (12%), and Polyporaceae (11%). Three from the 74 morphospecies collected were present during the three samplings dates: *Marasmius rotuloides*, Polyporaceae sp.7, and *Xylaria hypoxylon* (very common and abundant in the area).

MACROFUNGI COMPOSITION PLOT - 2						
Taxon	**Samplings**					
	1		**2**		**3**	
Xylariaceae	7	16%	1	14%	6	16%
Pezizales	1	2%	0	0%	1	3%
Agaricales	0	0%	0	0%	3	8%
Cortinariaceae	0	0%	1	14%	1	3%
Agaricaceae	1	2%	0	0%	2	5%
Tricholomataceae	14	33%	1	14%	13	36%
Psathyrellaceae	0	0%	0	0%	2	5%
Polyporaceae	9	20%	3	44%	4	11%
Thelephoraceae	3	7%	0	0%	2	5%
Ganodermataceae	0	0%	0	0%	2	5%
Pluteaceae	0	0%	0	0%	1	3%
Clavicipitaceae	6	14%	1	14%	0	0%
Tremellaceae	1	2%	0	0%	0	0%
Lycoperdaceae	1	2%	0	0%	0	0%
Geastraceae	1	2%	0	0%	0	0%
TOTAL	**44**	100%	**7**	100%	**37**	100%

Table 6. *Macrofungi composition PLOT 2.*

The following summary can be obtained from the plot's monitoring during 3 different seasons:

- *Marasmius rotuloides* and *Xylaria hypoxylon* were two species collected in the three sampling dates, showing their ability to fructify along different seasons. Both are very common and abundant species in the area.

- Some species recorded in the first sampling date were not found during the second collecting date and later reappeared during the third sampling. The latter pattern suggested that these species are conditioned to the quantity of rainfall and have a constricted range of optimal humidity conditions that allowed them to fructify. Some examples of species that were found fructifying in the first sampling and then reappeared at the third sampling were: *Marasmiellus nigripes*, *Xylaria telfairii*, and *Marasmiellus sp.1*, suggesting their need for more humidity in order to fructify.

- A total of 74 morphospecies were collected in the 1000 m^2 during the three samplings.

Macromycetes Diversity vs. Precipitation

The number of morphospecies strongly decreased (from 44 to 7) with the dropped of precipitation and increased again when it rose (from 7 to 37) (Figure 23).

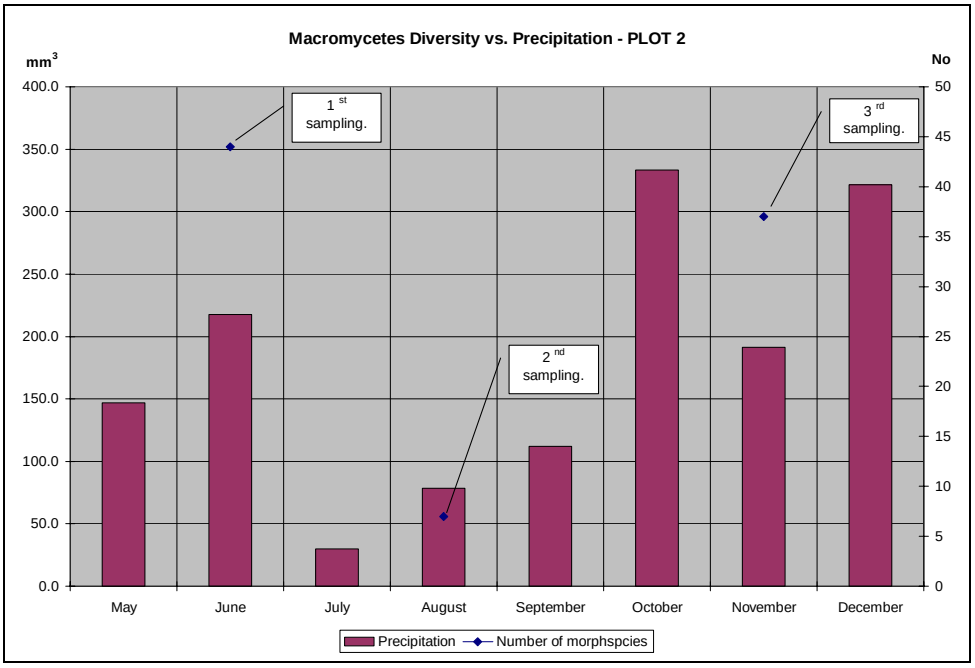


Figure 23. *Diversity changes vs. precipitation – PLOT 2.* The diversity of macromycetes dropped drastically as the precipitation diminished, in the third sampling the diversity increased as well as the precipitation. Notice that October is the month with highest precipitation which could contribute to the soil's humidity and to the increase of fructification.

c. Plot 3 – High terrace secondary forest I

The first sampling was made on June 29, 2005, a month when the total precipitation was 217.6 mm. The number of morphospecies collected was 38. The community was mainly composed of Tricholomataceae (28%), Polyporaceae (20%), and

Xylariaceae (18%). The second sampling was conducted on August 14, 2005, a month when the total precipitation suffered a drop to 78.4 mm. The number of morphospecies collected this time dropped as well to 16. The community was again composed mainly by three groups: Polyporaceae (30%), Xylariaceae (19%), and Tricholomataceae (13%). Eight of the 38 species collected in the first sampling were found again in the second sampling, showing their adaptation to lower humidity. The third and last sampling was done on November 24, 2005, a month when the total precipitation increased to 191.4 mm; in addition, the previous month (October) presented the highest precipitation rate (333.4 mm) contributing to the soil's moisture. Thirty morphospecies were collected, and the community as in the previous cases was composed by Tricholomataceae (74%), Xylariaceae (13%), and Polyporaceae (13%). Just one from the 68 morphospecies overall collected was present during the three samplings dates: *Kretszchamaria clavus.*

MACROFUNGI COMPOSITION PLOT 3						
Taxon	**Samplings**					
	1		**2**		**3**	
Xylariaceae	7	18%	3	19%	4	13%
Clavicipitaceae	4	11%	2	13%	0	0%
Agaricaceae	2	5%	0	0%	0	0%
Tricholomataceae	11	28%	2	13%	22	74%
Polyporaceae	8	20%	5	30%	4	13%
Pezizales	1	3%	0	0%	0	0%
Thelephoraceae	1	3%	2	13%	0	0%
Geastraceae	1	3%	0	0%	0	0%
Pleurotaceae	1	3%	0	0%	0	0%
Ganodermataceae	1	3%	1	6%	0	0%
Phallaceae	1	3%	0	0%	0	0%
Lycoperdacee	0	0%	1	6%	0	0%
TOTAL	38	100%	16	100%	30	100%

Table 7. *Macrofungi composition – PLOT 3.*

The following summary can be obtained from the plot's monitoring during 3 different seasons:

- *Kretszchamaria clavus* was the only species collected in the three samplings, showing the ability to fructify along the year, although it can be a slow grower.
- Some species recorded in the first sampling date were not found during the second collecting date, and later reappeared during the third sampling. The latter pattern suggested that these species are probably conditioned to the quantity of rainfall and have a constricted range of optimal humidity conditions that allowed them to fructify. Some examples of species that were found fructifying in the first sampling and then reappeared at the third sampling were: *Marasmiellus nigripes*, *Marasmius rotuloides*, and *Marasmius cladophyllus* suggesting their need for more humidity in order to fructify.
- A total of 68 morphospecies were collected in the 1000 m^2 during the three samplings.

Macromycetes Diversity vs. precipitation

The number of morphospecies strongly decreased (from 38 to 16) with the dropped of precipitation, and increased again when it rose (from 16 to 30) (Figure 24).

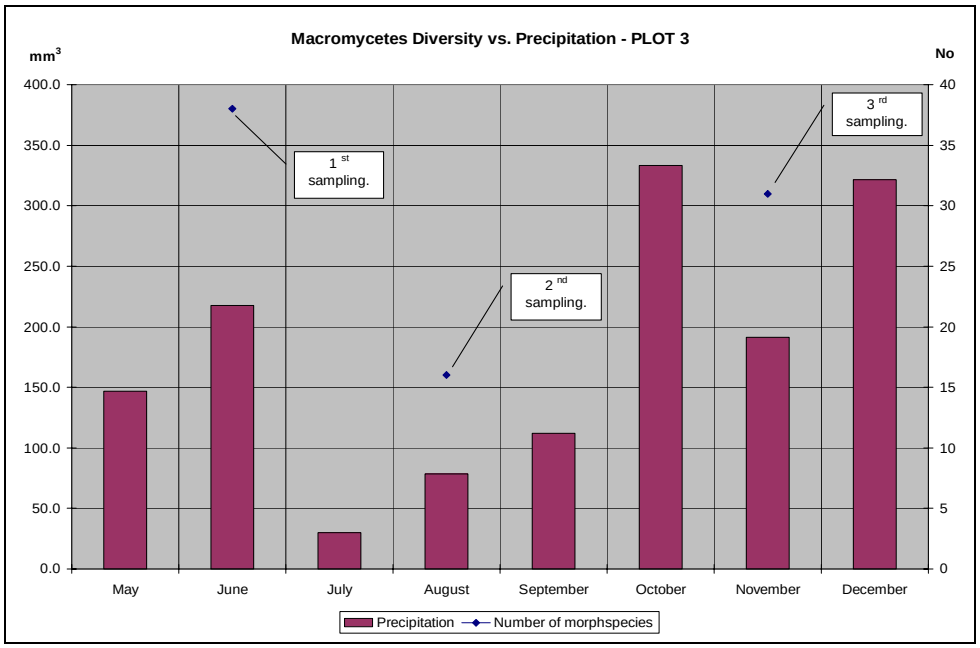


Figure 24. *Diversity changes vs. precipitation – PLOT 3.* The diversity of macromycetes dropped drastically as the precipitation diminished, in the third sampling the diversity increased as well as the precipitation. Notice that October is the month with highest precipitation which could contribute to the soil's humidity and to the increase of fructification.

d. Plot 4 – High terrace secondary forest II

The first sampling was made on June 29, 2005, a month when the total precipitation was 217.6 mm. The number of morphospecies collected was 20. The community was mainly composed by Tricholomataceae (40%), Polyporaceae (20%), and Xylariaceae (5%). The second sampling was conducted on August 14, 2005, month when the total precipitation suffered a drop to 78.4 mm. The number of morphospecies collected this time dropped dramatically to just two: *Thamnomyces chordalis* and a polypore species (*P4_17)*. The last two mentioned species were collected in the first and second sampling showing their adaptation to lower humidity. The third and last sampling was conducted on November 24, 2005, month when the total precipitation increased to 191.4 mm; in addition, the previous month (October) was the month that presented the

highest precipitation rate (333.4 mm) contributing to the soil's moisture. Five morphospecies were collected, two species belonging to Tricholomataceae, two species belonging to Polyporaceae, and one species of *Xylaria*. Two morphospecies from the 21 overall collected were present during the three samplings dates: *Thamnomyces chordalis* and a polypore species *(P1_17).*

MACROFUNGI COMPOSITION PLOT 4						
Taxon	**Samplings**					
	1		**2**		**3**	
Xylariaceae	1	5%	1	50%	1	20%
Clavicipitaceae	2	10%	0	0%	0	0%
Agaricaceae	1	5%	0	0%	0	0%
Tricholomataceae	8	40%	0	0%	2	40%
Polyporaceae	4	20%	1	50%	2	40%
Thelephoraceae	1	5%	0	0%	0	0%
Pleurotaceae	1	5%	0	0%	0	0%
Agaricales	1	5%	0	0%	0	0%
Clavariaceae	1	5%	0	0%	0	0%
TOTAL	**20**	100%	**2**	100%	**5**	100%

Table 8. *Macrofungi composition PLOT – 4.*

The following summary can be obtained from the plot's monitoring during 3 different seasons:

- This is the plot that presented the lowest number of morphospecies being the second sampling the smallest collection. Only two species were found in the second sampling, which were present in the first and third sampling as well.

- No new morphospecies appeared in the third sampling (when the precipitation increased), contrary to the other plot cases.

- A total of 21 morphospecies were collected in the 1000 m^2 during the three samplings.

Macromycetes Diversity vs. precipitation

The number of morphospecies strongly decreased (from 20 to 2) with the dropped of precipitation and had a small increase (from 2 to 5) when it rose (Figure 25).

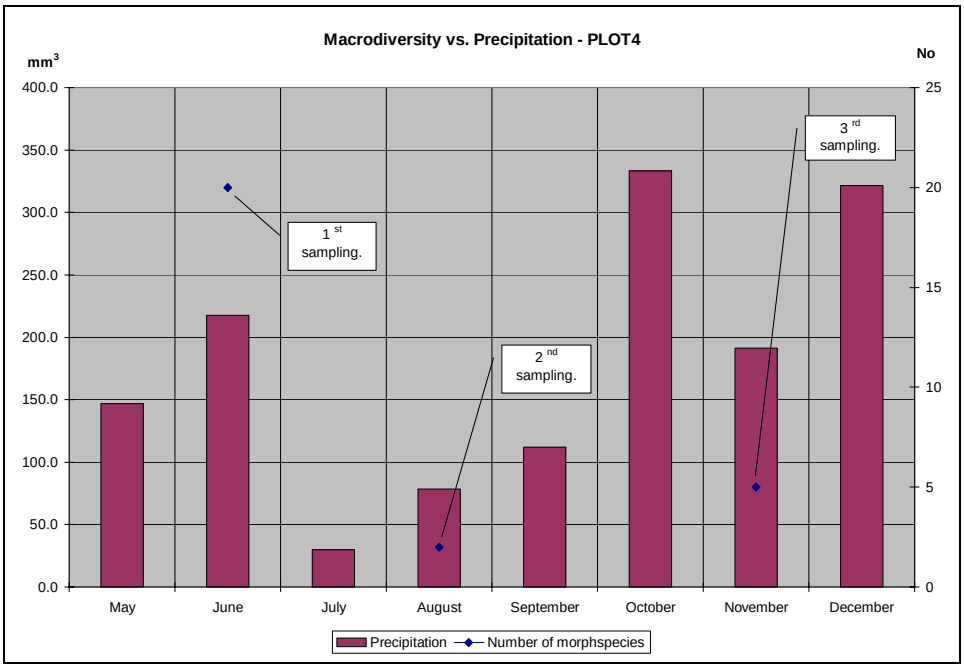


Figure 25. *Diversity changes vs. precipitation – PLOT 4.* The diversity of macromycetes dropped drastically as the precipitation diminished, in the third sampling the diversity recovered with the increase of precipitation. Notice that October is the month with highest precipitation which could contribute to the soil's humidity and to the increase of fructification.

e. Plot 5 – floodland primary forest I

The first sampling was made on July 7, 2005, a month when the total precipitation was 29.9 mm. The number of morphospecies collected was 34. The community was mainly composed by Tricholomataceae (34%), Xylariaceae (21%), and Polyporaceae (18%). The second sampling was conducted on August 17, 2005, a month when the total precipitation suffered a drop to 78.4 mm. The number of morphospecies collected this time dropped to 25 morphospecies. The composition was led by Xylariaceae (32%),

Polyporaceae (24%), and Tricholomataceae (16%). The third and last sampling was conducted on November 25, 2005 when the total precipitation increased to 191.4 mm; in addition, October was the month that presented the highest precipitation rate (333.4 mm) contributing to the soil's moisture. The number of morphospecies collected was 20. Tricholomataceae made up 30%, Polyporaceae 20%, and Xylariaceae 20%. Seven from the 51 morphospecies overall collected were present during the three samplings dates: *Paecilomyces tenuipes, Coprinus disseminatus, Phylacia poculiformis, Kretzschmaria clavus, and Ganoderma applanatum* are some examples.

MACROFUNGI COMPOSITION PLOT 5						
Taxon	**Samplings**					
	1		**2**		**3**	
Xylariaceae	7	21%	8	32%	4	20%
Clavicipitaceae	1	3%	3	12%	1	5%
Agaricaceae	2	6%	1	4%	1	5%
Tricholomataceae	12	34%	4	16%	6	30%
Polyporaceae	6	18%	6	24%	4	20%
Lycoperdaceae	1	3%	0	0%	0	0%
Thelephoraceae	1	3%	0	0%	0	0%
Schyzophyllaceae	1	3%	0	0%	0	0%
Pezizaceae	1	3%	0	0%	0	0%
Ganodermataceae	1	3%	1	4%	1	5%
Auriculariaceae	1	3%	1	4%	2	10%
Plutaceae	0	0%	1	4%	0	0%
Pyronemataceae	0	0%	0	0%	1	5%
TOTAL	**34**	100%	**25**	100%	**20**	100%

Table 9. *Macrofungi composition PLOT – 5.*

The following summary can be obtained from the plot's monitoring during 3 different seasons:

- Even though July was the month with the lowest precipitation, was the sampling date presenting more morphospecies.

- New morphospecies that were not present in the first two samplings appeared in the third sampling. Some examples include: *Scutellinia asperrima, Marasmiellus nigripes, and Marasmius rotuloides.*

- A total of 51 morphospecies were collected in the 1000 m^2 during the three samplings.

Macromycetes diversity vs. Precipitation

While in the rest of the plots the number of morphospecies increased with the increment of precipitation, in PLOT 5, the number of morphospecies decreased as the precipitation increased (Figure 26).

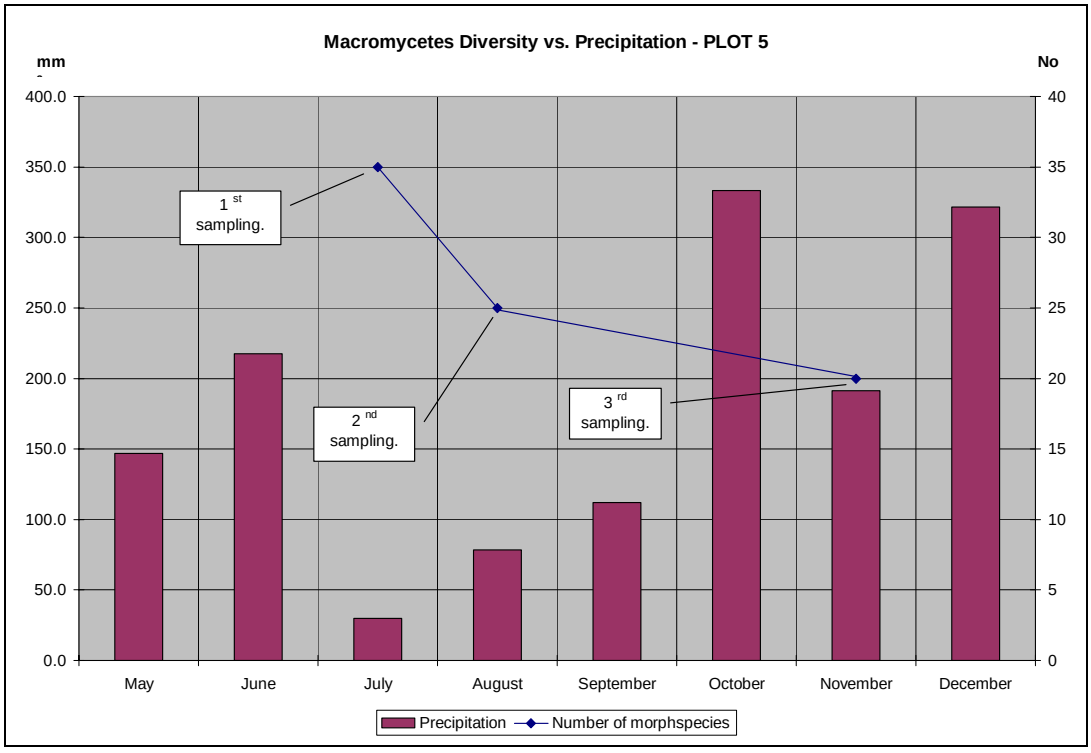


Figure 26. *Diversity changes vs. precipitation – PLOT 5.* The number of species decreased with the increase of precipitation

f. Plot 6 – floodland primary forest II

The first sampling was made on July 9, 2005, a month when the total precipitation was 29.9 mm. The number of morphospecies collected was 45. The community was mainly composed by Tricholomataceae (25%), Xylariaceae (25%), and Polyporaceae (15%). The second sampling was conducted on August 21, 2005, month when the total precipitation suffered a drop to 78.4 mm. The number of morphospecies collected this time dropped strongly to 17 morphospecies. The composition was led by Polyporaceae (28%), Xylariaceae (24%), and Tricholomataceae (18%). The third and last sampling was conducted on November 23, 2005, month when the total precipitation increased to 191.4 mm; in addition the previous month (October) presented the highest precipitation rate (333.4 mm) contributing to the soil's moisture. The number of morphospecies collected was 22. Tricholomataceae made up 44%, Polyporaceae 14%, and Xylariaceae 28%. Three from the 58 morphospecies overall collected were present during the three samplings dates: *Kretszchamaria clavus, Xylaria sp.4 (P6_34), and Polyporaceae sp.3 (P6_30).*

MACROFUNGI COMPOSITION PLOT 6						
Taxon	Samplings					
	1		2		3	
Xylariaceae	11	25%	4	24%	4	18%
Clavicipitaceae	2	4%	1	6%	1	5%
Agaricaceae	3	7%	2	12%	0	0%
Tricholomataceae	11	25%	3	18%	10	44%
Polyporaceae	11	25%	5	28%	3	14%
Hygrophoraceae	1	2%	0	0%	0	0%
Thelephoraceae	2	4%	0	0%	0	0%
Sarcoscyphaceae	2	4%	0	0%	2	9%
Auriculariaceae	1	2%	0	0%	0	0%
Pyrenotemataceae	1	2%	0	0%	0	0%
Pleurotaceae	0	0%	1	6%	0	0%
Ganodermataceae	0	0%	1	6%	1	5%
Clavariaceae	0	0%	0	0%	1	5%
TOTAL	**45**	100%	**17**	100%	**22**	100%

Table 10. *Macrofungi composition PLOT 6.*

The following summary can be obtained from the plot's monitoring during 3 different seasons:

- In the case of PLOT 6 as in the case of PLOT 5 the sampling started on July instead of June as the rest of the plots. July was a very dry month with a total rainfall of 29.9 mm. However, even though July was the month with lowest precipitation, it was the sampling date presenting the highest number of morphospecies.

- New morphospecies not present in the first two samplings, appeared in the third sampling such as *Marasmius haematocephallus, Marasmiellus nigripes, Marasmius rotuloides,* and *Ramaria sp.1 (P6_60).*

- A total of 51 morphospecies were collected in the 1000 m^2 during the three samplings.

Macromycetes diversity vs. Precipitation

The number of morphospecies declined from the first sampling to the second one, even though there was an increase in the amount of precipitation. Later, in the third sampling the number of morphospecies increased (there was an increased in precipitation too) but never reach the number recorded in the first sampling (Figure 27).

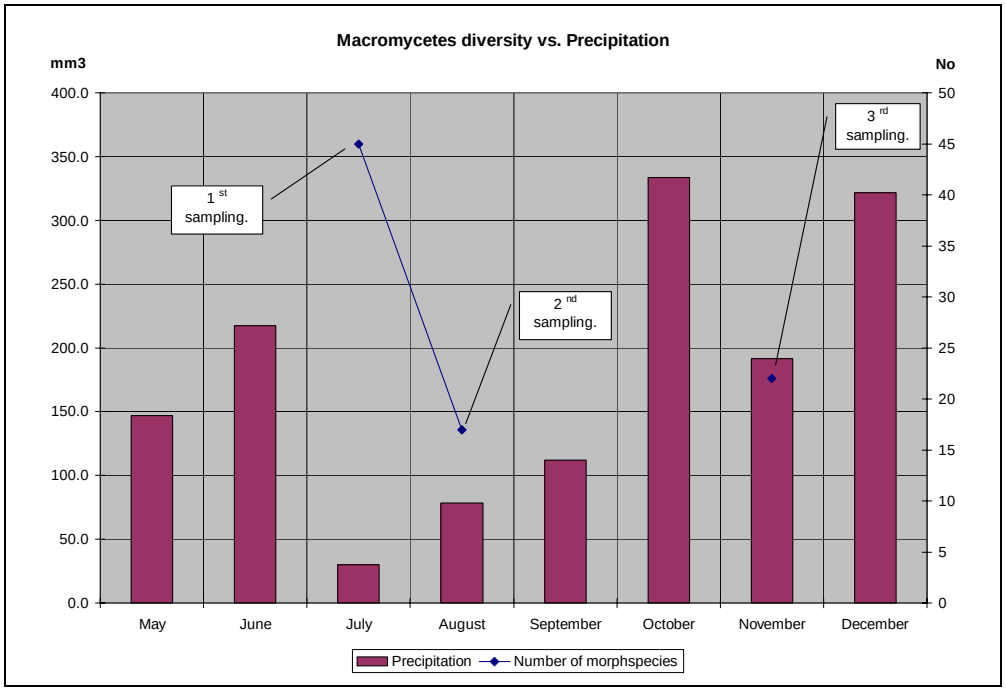


Figure 27. *Diversity changes vs. precipitation – PLOT 6.*

4.2 Comparison between plots.

a. Species Richness comparison:

Species richness for each plot was calculated dividing the number of species collected in the plot by its area. The plot with the most morphospecies hence the most

diverse, was PLOT 2 followed by PLOT 1, both located in high terrace primary forest (Figure 28). PLOT 3 also presented a high number of morphospecies matching PLOT 2 with 68 morphospecies in 1000 m^2. However, its replica (PLOT 4) located as well at high terrace secondary forest, presented only 21 morphospecies.

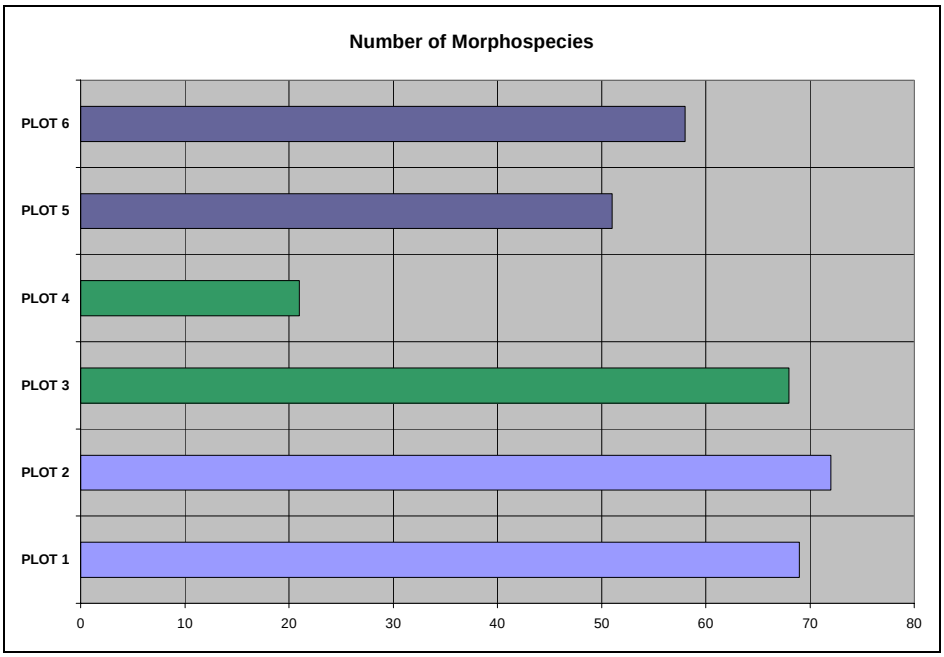


Figure 28. *Total number of morphospecies in each plot.*

b. Species Richness fluctuation

There was a clear trend followed by the first four plots, located in high terrace primary and secondary forest (Figure 29). They all presented a drop in species richness as the precipitation rate decreased (from the first sampling to the second), and in all of them the species richness increased when the precipitation rose (from the second sampling to the third). The latter does not mean that the species were absent during the dry season; it means is that they were not fruiting during that period. In the cases of the plots located in floodland primary forest (PLOT 5 & 6) the situation was the opposite. The highest

number of morphospecies was recorded in the first sampling (the driest month) and decreased as the precipitation increased.

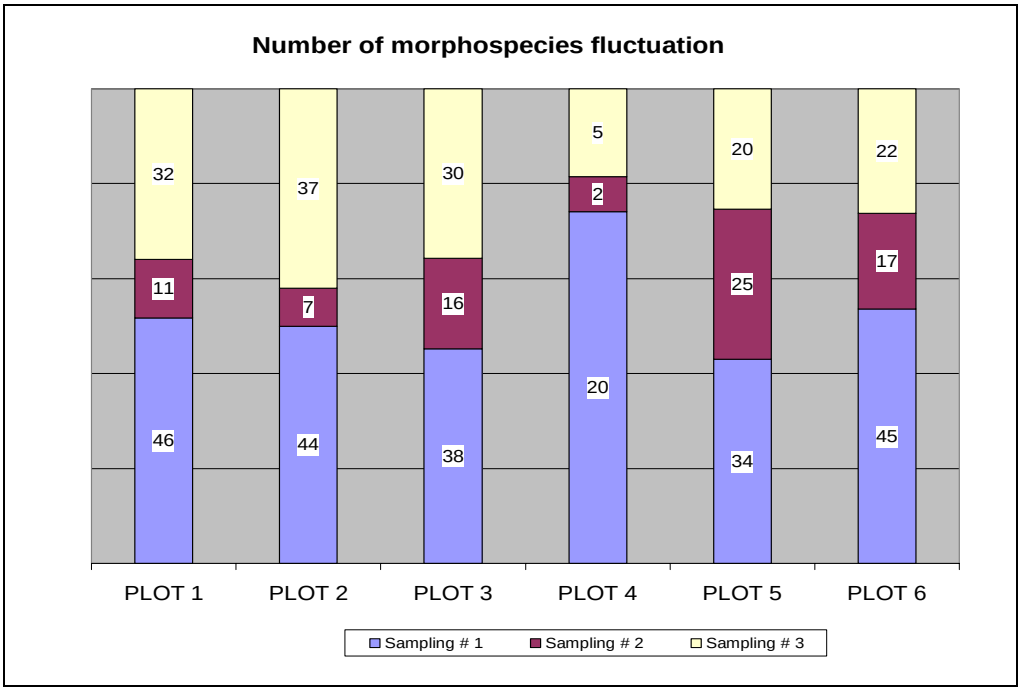


Figure 29. *Number of morphospecies fluctuation in each plot through the three sampling dates.*

c. Major taxonomic groups' fluctuation

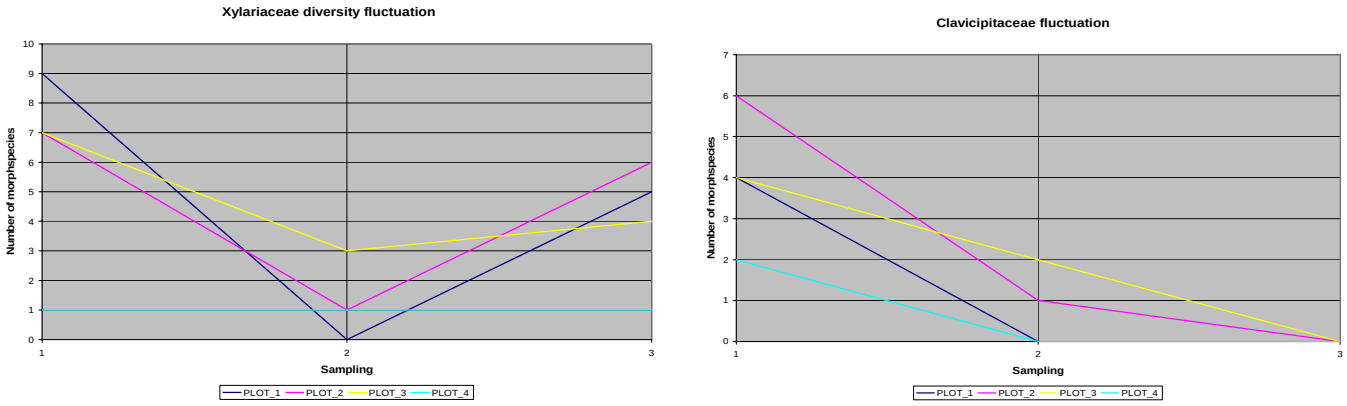
In the primary forest, Xylariaceae presented a dramatic decrease in species number with the decrease of precipitation. It recovered its diversity when precipitation increased. In the case of the high terrace secondary forest habitat the change was not as dramatic; however, the number of species dropped as well in the second sampling. (Figure 30, a).

Clavicipitaceae suggested a need for high humidity levels to fructify because their number dropped and even disappeared from some of the plots when the precipitation decreased. The decrease in number occurred in both habitats, and they did not recover completely with the increase of precipitation (Figure 30, b).

Tricholomataceae experienced the same pattern as xylariaceous species, which is understandable since the majority of this macrofungi are fleshy and require a high water content to produce a fruiting body (Figure 30, c).

Polyporaceae, even though most of their representatives have a woody consistency, showed also a decrease in species number with the drop of precipitation (Figure 30, d).

a) ***b)***



c) ***d)***

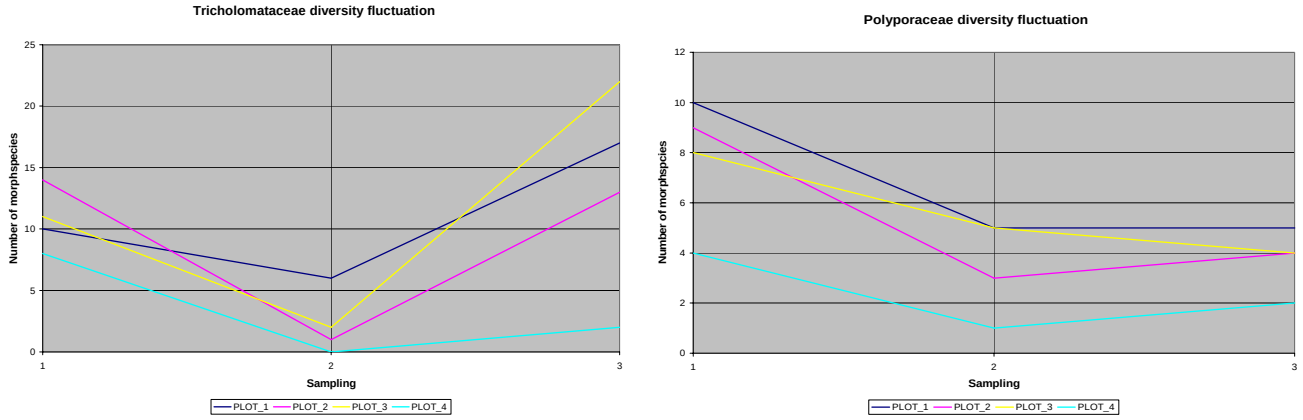


Figure 30. *Fluctuation of the principal groups of macromycetes along the three sampling dates.* ***a)*** Xylariaceae fluctuation, ***b)*** Clavicipitaceae fluctuation, ***c)*** Tricholomataceae fluctuation, and finally ***d)*** Polyporaceae fluctuation.

4.3 Similarity between plots

DATA:

Number of morphspecies	
PLOT 1	69
PLOT 2	72
PLOT 3	68
PLOT 4	21
PLOT 5	51
PLOT 6	58

Table 11. *Number of species present in each plot.*

SPECIES IN COMMON					
	PLOT 1	**PLOT 2**	**PLOT 3**	**PLOT 4**	**PLOT 5**
PLOT 1					
PLOT 2	18				
PLOT 3	23	24			
PLOT 4	11	9	12		
PLOT 5	18	19	19	5	
PLOT 6	25	27	25	8	26

Table 12. *Number of species in common between plots.*

The macromycetes´s community composition among sites presented low similarity when using Jaccard and Sorenson indexes. The most similar sites according to these indexes were PLOT 5 and PLOT 6 with 0.48 (Sorenson) and 0.31 (Jaccard); both plots set in the same type of forest: floodland primary forest. However, the last did not occur for all the replicas. Some plots located in different habitats were more similar than with their replicas located in the same habitat. For instance, PLOT 1 located in high terrace primary forest was more similar to PLOT 6 located in floodland primary forest

than with PLOT 2 located in the same habitat. The same occurred between PLOT 3 and PLOT 6 showing a greater similarity than PLOT 3 and PLOT 4 located in the same habitat.

The plot which shared the highest number of morphospecies with the rest of the sample units was PLOT 6. Conversely, PLOT 4 was most dissimilar community (according to both indexes), sharing the lowest proportion of morphotypes with the other sites.

a. Sorenson Quality Index:

SORENSON					
	PLOT 1	**PLOT 2**	**PLOT 3**	**PLOT 4**	**PLOT 5**
PLOT 1					
PLOT 2	0.26				
PLOT 3	0.34	0.34			
PLOT 4	0.24	0.19	0.27		
PLOT 5	0.30	0.31	0.32	0.14	
PLOT 6	0.39	0.42	0.40	0.20	0.48

Table 13. *Sorenson's similarity indexes between plots.*

b. Jaccard similarity index:

JACCARD'S INDEX					
	PLOT 1	**PLOT 2**	**PLOT 3**	**PLOT 4**	**PLOT 5**
PLOT 1					
PLOT 2	0.15				
PLOT 3	0.20	0.21			
PLOT 4	0.14	0.11	0.16		
PLOT 5	0.18	0.18	0.19	0.07	
PLOT 6	0.25	0.26	0.25	0.11	0.31

Table 14. *Jaccard similarity indexes between plots.*

c. Absence – Presence analysis of selected species:

Marasmiellus nigripes showed its common occurrence and abundance at the study site, being encountered in the six plots. This was expected since it has a wide distribution in the Neotropics. Nine species were collected in five of the sites, some of them: *Marasmius cladophyllus, Coprinus disseminatus, Kretzschmaria clavus, Marasmius rotuloides, and Xylaria hypoxylon*. And nine species were found in four of the six sites some of them: *Cordyceps australis, Favolus brasiliensis, Ganoderma applanatum, Marasmius haematocephalus, and Paecilomyces tenuipes*. On the other hand, some species were collected only in one of the plots such as *Schizophyllum commune* (collected only at PLOT 5), and *Hygrocybe* aff. *miniata* only (collected only at PLOT 6). The habitat that showed the highest number (6) of clavicipitaceous species was the high terrace primary forest and the habitat that presented less number was the primary floodland forest. However, they were more abundant in the high terrace secondary forest.

5. Habitat Comparison

So far, the comparison has been done only between plots or sites individually. But, a set of two plots were located in each of the three proposed habitats: high terrace primary forest, high terrace secondary forest, and floodland primary forest. Therefore, they can be used as replicas in order to compare habitats.

The species accumulation curves for all forest types were far from reaching their asymptotes (Figures 31 & 32). Thus, the species ensemble was not completely sampled in any of the habitats.

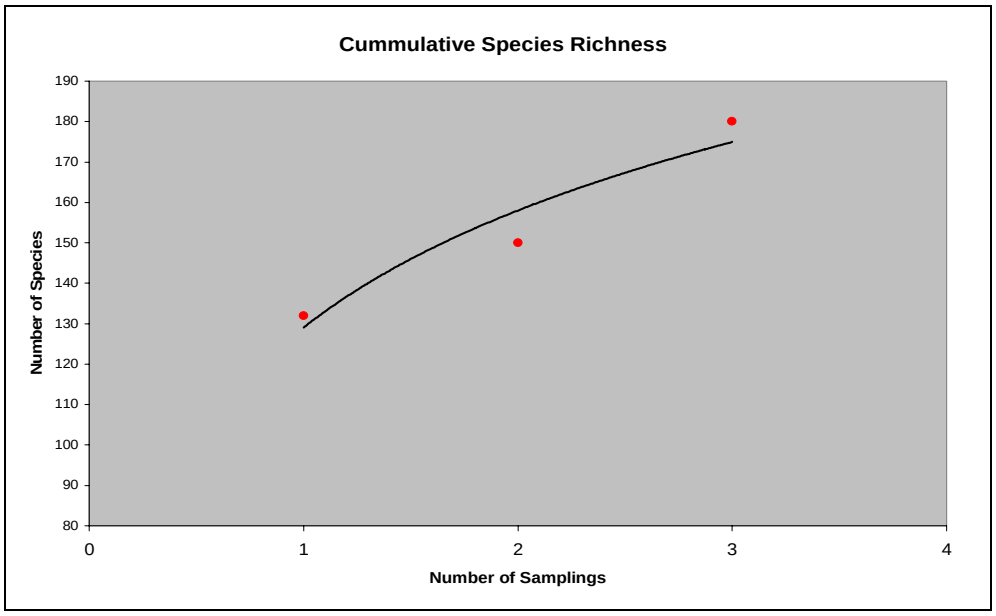


Figure 31. *Macromycetes cumulative species richness curve.* The black line is the followed trend and tells us that the species number increases with every collection date and that will probably increase more with more collection dates.

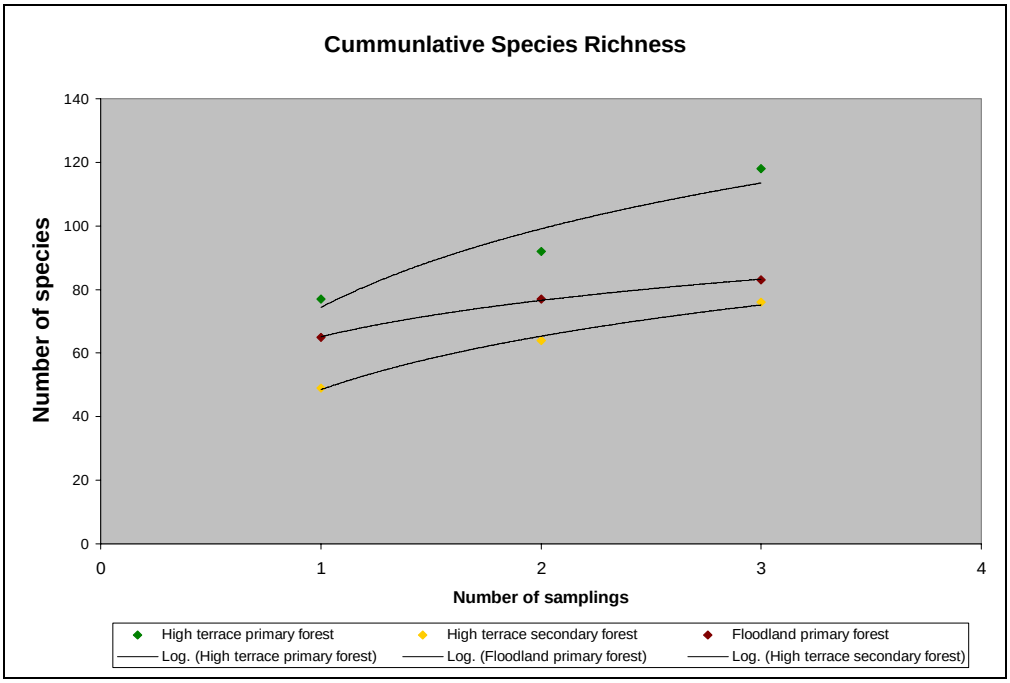


Figure 32. *Cumulative species richness curve of macromycetes for each habitat separately.* The cumulative species number curve at the high terrace primary forest showed to be still increasing at the third sampling date however for the two other habitats the curve seemed to be stabilizing and reaching there asymptote.

5.1 Species richness comparison between habitats

The high terrace primary forest housed the highest number of species (118), followed in number by the floodland primary forest (83), and by the high terrace secondary forest (76) (Figure 33).

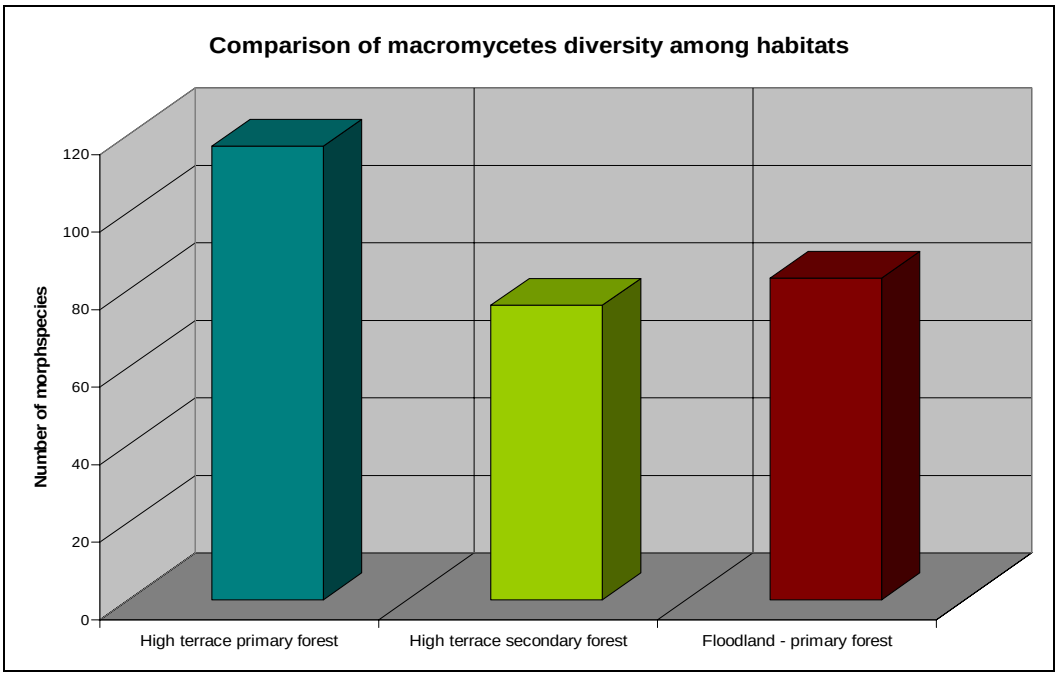


Figure 33. *Number of morphospecies in each habitat.* The high terrace primary forest habitat was the site presenting a higher number of species, followed by the Floodland primary forest and at last by the high terrace secondary forest.

5.2 Community structure comparison between habitats

From the family composition analysis, the three habitats were found to be very similar. All of them were mainly composed by three major families: Tricholomataceae, Polyporaceae, and Xylariaceae. Tricholomataceae was the most diverse group in the first and third sampling dates, for the three habitats; however, during the second sampling

(when the precipitation dropped) the community suffered a change in composition. During the second sampling date Polyporaceae and Xylariaceae took first place in number of representatives. These results were expected since Xylariaceae and Polyporaceae (*sensu lato*) have structural defenses against dehydration and can fructify or maintain their fruiting bodies during dry periods.

Some groups were more diverse in a particular habitat. For instance, members of the Clavicipitaceae family presented more species in the high terrace primary forest; the same occurred for Tricholomataceae and Xylariaceae members. On the other hand, some groups did not present a high diversity but a high abundance in a particular habitat. For example, as was said before, Clavicipitaceae was found to be more diversified in the high terrace primary forest; however, was found to be more abundant in the high terrace secondary forest. A few species were only found in a particular habitat as in the case of *Hygrocybe miniata*, *Xylaria globosa*, and *Scleroderma sinnamariensis*, which were only collected in floodland primary forest.

5.3 Similarity between habitats

The high terrace primary forest and the high terrace secondary forest shared 20 species, the high terrace primary forest and the floodland primary forest shared 22 species, and the high terrace secondary forest and the floodland primary forest shared 7 species (Figure 34). Twenty four species occurred at the three sites such as *Coprinus disseminatus, Cordyceps australis, Favolus brasiliensis, Ganoderma applanatum, Kretzschmaria clavus, Marasmiellus nigripes, and Marasmius cladophyllus* among

others. The ultimate generalist seemed to be *Kretzschmaria clavus* (Ascomycota) and *Marasmius nigripes* (Basidiomycota), found inhabiting the threes sites.

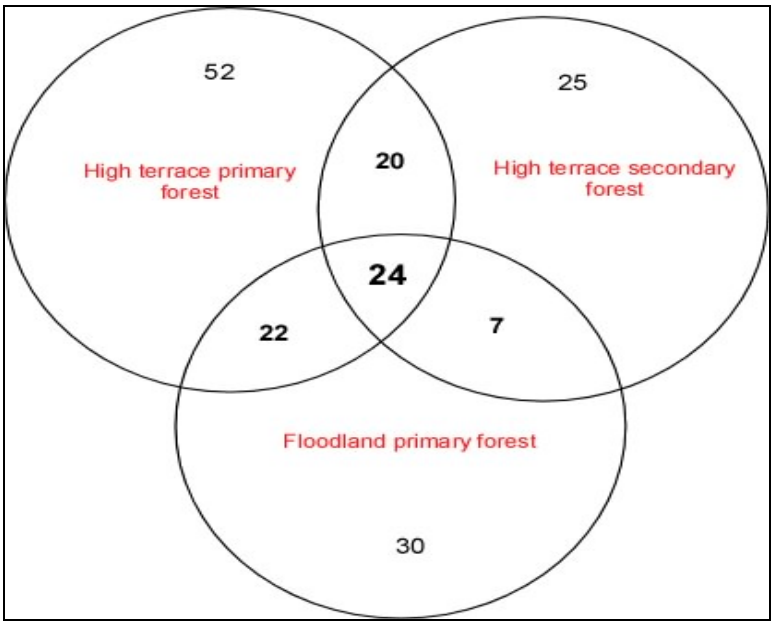


Figure 34. *Number of macromycetes species occurring exclusively in each forest type and the ones shared among forest types.* Twenty four species were shared by the three main habitats, showing their adaptability to different environment conditions. The less similar habitats were the high terrace secondary forest and the Floodland primary forest; and the more similar habitats were the high terrace primary forest and the Floodland primary forest.

All the results obtained from the similarity indexes among habitats fell below 0.50 (Table 16 & 17), indicating that the habitats are not significant similar in species composition. Therefore, beta diversity can be considered as high. Only one assumption can be made from the comparison analysis: the high terrace secondary forest habitat is more similar to the high terrace primary forest than is to the floodland primary forest (0.47 vs. 0.39 respectively).

SORENSON		
	HIGH TERRACE PRIMARY FOREST	HIGH TERRACE SECONDARY FOREST
HIGH TERRACE PRIMARY FOREST		
HIGH TERRACE SECONDARY FOREST	0.48	
FLOODLAND PRIMARY FOREST	0.46	0.39

Table 15. *Sorenson's index results for the three habitats.*

JACCARD INDEX		
	HIGH TERRACE PRIMARY FOREST	HIGH TERRACE SECONDARY FOREST
HIGH TERRACE PRIMARY FOREST		
HIGH TERRACE SECONDARY FOREST	0.30	
FLOODLAND PRIMARY FOREST	0.30	0.24

Table 16. *Jaccard index results for the three habitats.*

DISCUSSION

Macromycetes were found to be highly diverse at the species level. Nevertheless, these results should be considered as preliminary data since it will take a much longer and a more standardized project to accurately calculate all the macrofungal species present in a complex area like the one studied. The cumulative species – accumulation curve for macrofungi is estimated to reach the asymptote after 8 – 12 years of sampling (Muller *et al.*, 2004). During the project, the species accumulation curve was not reached

in any of the habitats sampled, indicating that more sampling effort is needed in order to accurately estimate species diversity in these forests. Using the 5:1 plant to macrofungi ratio proposed by Muller *et al.* and considering an amount of 2000 angiosperms, the estimated for the number of macrofungi at the study area was 400 species. Nonetheless, the sampling technique was effective in describing the general patterns of community structure and it is important to mention that fewer new species for the inventory were being found as the collecting trip was approaching its end. Even if the complete number of morphospecies was not accurately determined, a preliminary inventory gave us the information necessary to start building a potential database as well as an idea of the biodiversity of the region, information necessary to start a conservation plan that will lead us to preserve this valuable resource. Therefore, we hope that this project serves as the foundation for future taxonomic and ecological research in the area.

Basidiomycota showed to be more diverse within the collection (71%); however, it should be pointed that only the species belonging to the artificial group "macromycetes" were object of study. In most ecological studies, where saprobic (especially wood-inhabiting) macromycetes are targeted, Basidiomycota appear to be the most frequently collected. However, Ferrer, collected a greater number of Ascomycota, although that could be related to the tree species she was sampling (Ferrer, 2001). In general, Ascomycota is known to be very diverse in the tropics; but because it includes many microfungi species, Basidiomycota appeared to be more diverse. Therefore, it can only be stated that Basidiomycota showed a higher diversity in macromycetes. Nevertheless, Ascomycota macromycetes are still a very important group of decomposers. They grow in great numbers over dead logs and branches. Xylariaceae

composed a numerically important group similar to the rest of the Neotropics as has been demonstrated in other studies (Læssøe, 1999; Rogers, 2000). In this survey, they represented more than 60% of the species, indicating that they are a major component of the Ascomycota mycoflora. *Xylaria* was the most representative genus, with more than 20 morphospecies. Many of these species have been recorded as varieties, since this genus is highly polymorphic. Species look very similar in the field, and variations within species are caused by environmental factors such as nutrient availability or the substrate's water content. A clear example of the last phenomenon was illustrated by *X. telfairii*, a very common species found growing on dead logs along the majority of the trails. The common variety presents a light brown crust color; however, the same species can be phenotypically different, showing crust colors that can go from white to dark brown. *Daldinia* species were also difficult to distinguish and identify. This genus (as *Xylaria*) is very polymorphic in shape, size, and color; hence, these characters have to be employed very carefully when identification keys are used. *Phylacia, Kretzschmaria and Hypoxylon* did not show a great diversification in the region, contrasting with other neotropical studies. Just one species from each genus was recorded. Probably there were more species inhabiting the area but were overlooked since they tend to be cryptic. The latter especially happens in *Hypoxylon* species, which grow as a crust, covering the dead host and making their field detection and differentiation very difficult.

Fungi can present an anamorphic (asexual) or a teleomorphic (sexual) state, depending on their reproduction strategy. Anamorphic states cycles faster and can infect more host in a shorter period. An interestingly high number of anamorphic xylariaceous and clavicipitaceous species were collected. Conversely, to temperate areas, the

teleomorphic state is prevalent in the tropics since the available substrate for colonization is greater. Nevertheless, two xylariaceous and ten clavicipitaceous anamorphs species were recorded. Xylariaceous anamorphs such as *Moelleroclavus penicilliopsis* (anamorph of *X. penicilliopsi*) or *Xylocoremium flabelliforme* (anamorph of *X. cubensis*) were collected in 2005 but were not recorded for 2003 (Gazis, 2005). The last could be a consequence of the unusual dry conditions present during 2005, which addresses the environmental differences between those years, showing how environmental factors as precipitation influences the occurrence of macrofungal species.

Almost all the members of the Xylariaceae found in this survey presented a saprobic habit and did not show an obvious host preference, probably because of the variety of substrates available for colonization. However, even with this great number of substrates available in a subtropical rainforest, competition between fungi is intense. Therefore, macromycetes species need to exploit different substrates and xylariaceous species are known to be commonly latent invaders of "stressed" hosts (Whalley, 1985; Rogers, 2000). Species that have the ability of switch between a saprobic and a parasite habit (facultatives) get a new ecological niche to exploit, which creates an advantage over the saprophytic macromycetes. A few species were found inhabiting a non-decayed wood substrate; instead, they were found growing on seeds (*Mycena* - P6_34) or on living branches such as *Daldinia* (RGM_0201). Besides, those two collections, no more parasites were directly observed[10]; however, two other species collected in the area

[10] Sometimes it is difficult to distinguish dead material from living material. A log along a trail can be considered as dead however the core tissue can still be alive and present a suitable substrate for biotrophs macromycetes.

Xylaria cubensis and *Kretzschmaria clavus* are known to be facultative parasites, switching from dead to living material (Rogers, 2000).

Two groups Agaricales (48%) and Poriales (25.5%) mainly composed Basidiomycota. The agaric flora composition found in the study area was characteristic of the neotropics with Tricholomataceae and Agaricaceae dominating, while, in contrast to the temperate mycofloras, Coprinaceae, and Cortinariaceae were relative small groups. The Tricholomataceae was by far the largest family in numbers of representatives, which agree with the results found by Ovrebo (1996) in La Selva (Costa Rica); Dennis in Venezuela, and Pegler in the Lesser Antilles. Some genera such as *Marasmius*, *Mycena*, and *Collybia* were well represented by many species. These genera were not only diverse in species number but also abundant, widely distributed within the area. *Coprinus disseminatus*, *M. cladophyllus*, *M. haematocephalus*, and *M. rotuloides* were species that showed to be abundant and spread within the area. On the other hand, some species were classified as rare, considering the number of times they were encountered. Two of these species were *Calocybe cyaenella* (Tricholomataceae), only collected 2 times during the survey, and *Mutinus xylogenus* (Phallaceae), only encountered once.

Members of the Basidiomycota were found to be in general saprobes, especially wood decayers. Several species were recorded to grow on soil; however, a closer looked revealed, in the majority of the occasions, their connection to a woody source. Some times the wood is buried or in an advanced stage of decaying process, appearing to be humus or soil. Nevertheless, some species were truly growing on soil, such as the case of lepiotaceous species. From all the collection, just one species of mycorrhizal macromycetes were recorded, *Scleroderma sinamarensis* a member of the Boletales. The

latter is one of the more obvious differences between the agaric composition of tropical and temperate forests. In temperate forests ecosystems, mycorrhizal macromycetes are very common and key species in the maintenance of plant community, building a symbiotic relationship, especially for nutrient uptake. Macromycetes in tropical forests ecosystems are also key stones species, but conversely, they intervene in the maintenance of the plant community by recycling, transforming, storing nutrients making them available for plant absorption.

Tropical decomposer fungi are frequently restricted to particular size classes and types of substrata (Hedger, 1985; Lodge 1997). Lodge (1995) documented in her study at El Verde, Puerto Rico, that almost all decomposers fungi were restricted to one or at most two similar types of substrata. The same results were obtained from this project; 88.5% of the morphspecies were found in just one type of substratum; 11.1% in two different types of substrata and not even 1% of the morphospecies was collected in 3 different types of substrata. From the substratum's class analysis, the majority of the morphospecies were found growing on logs followed in preference by branches. In addition, leaf litter was also found to be an important substrate suitable for macromycetes colonization. This substrate was especially important for a very diverse and abundant genus, *Marasmius*, a foliicolous or lignocolous species.

The analysis of the fungal community composition in the $500m^2$ sub-plots revealed similarities and distinct differences among habitats. Plots were analyzed and described individually as a community; however, pairs of plots were set in each habitat hence at some point they were considered replicas. The plot that presented the highest number of macromycetes species was PLOT 2 located within the high terrace primary

forest followed by PLOT 1, located in the same habitat. The number of morphospecies was very similar between plots located in the same habitat; however, an important difference in number of species was found between PLOT 3 and PLOT 4 even though, they were located relatively close to each other. PLOT 3 presented 68 morphospecies while PLOT 4 presented only 21. This difference in number was probably related to differences in number of suitable substrates for fungi colonization such as decaying logs and dead branches.

When plots were grouped and compared by their habitat location, the highest diversity of macromycetes was found to be at the high terrace primary forest with 123 species. Secondly, the floodland primary forest habitat with 83 species in total. The high terrace secondary forest habitat was ranked in third place being the less diverse habitat with only 67 species in total. The results from this experiment, agree with the scheme that undisturbed areas have greater diversity. Pristine areas have showed to hold more number of species; therefore, they should be target for conservations purposes. Higher diversity at primary forest was a probably a result of the larger variety of resource sizes available for colonization, while in secondary forest more small diameter trees and branches are present. For instance, PLOT 1 and PLOT 2 presented more wood material and of greater diameter (branches, logs) comparing to PLOT 3 and PLOT 4. These results accorded with the ones obtained by Ferrer (2001) were she found a positive correlation between the sizes of the resource and the number of fungal morphotypes. Nevertheless, PLOT 3 (high terrace secondary forest) showed a relative high diversity, which might be explained by the abundance of suitable leaf litter substrate for members of the genus *Marasmius*, which constituted a high percentage of the samples found within this plot.

Habitats showed similarities in family composition, having Tricholomataceae, Polyporaceae, and Xylariaceae dominating within the three habitats. However, they showed to have a peculiar species composition since they only shared 24 species in total. Some of the species collected in the three habitats were *Coprinus disseminatus*, *Cordyceps australis*, *Favolus brasiliensis*, *Ganoderma applanatum*, *Kretzschmaria clavus*, *Marasmiellus nigripes*, and *Marasmius cladophyllus*. From the shared species, the ultimate generalists seemed to be *Kretzschmaria clavus* from the Ascomycota and *Marasmius nigripes* as from the Basidiomycota since were collected at the six plots. The mentioned species were found to be not only widely distributed in the three main habitats, but also present in a high local abundance. The factors that make the populations of these species both abundant and with a board tolerance to a range of physical conditions are still unknown. Future work, which analyzes the genetic structure of widely distributed species vs. site-specific species, will decode this mystery. On the other hand, some species were only found exclusively in one of the habitats, such as *Hypocrella gaertneriana* (high terrace secondary forest), *Polyporus udus*, *Hygrocybe miniata* and *Scleroderma sinnamariense* (floodland primary forest), or *Marasmius nigrobrunneus* (high terrace primary forest).

The results obtained from the similarity indexes among habitats also reflected that each habitat has a unique species composition. All of the results obtained from the similarity indexes (Jaccard and Sorenson) fell below 0.50, indicating that the habitats are not significantly similar in species composition. Therefore, beta diversity can be considered as high.

Abundance data was not addressed in this project; however, some general annotations were done while sampling. For instance, although high terrace primary forest presented a higher number of morphospecies, those species were not abundant. Contrary, the majority of the species present at high terrace secondary forest were present in a relative high number of fruiting bodies. This particular pattern was obvious, for instance, in the clavicipitaceous fungi. Diversity of this group was higher at high terrace primary forest but a small amount of specimens was recorded in each collection. Contrary, they were not as diverse in the high terrace secondary forest but abundant. For instance, in several occasions more than five specimens of *Cordyceps australis* were recorded in a single collecting date.

The opportunistic collections made for the inventory were consistent with the results obtained from the plot analysis. Trails located along the high terrace primary forest habitat provided more number of species to the collection.

One of the hypotheses of this project was that the number of morphospecies, in all the habitats, varies with the amount of precipitation. It was predicted that the number of morphospecies is positively correlated to the amount of rainfall, therefore it was expected a decrease in species diversity along with the decrease of precipitation. This was true for high terrace primary forest and for the high terrace secondary forest, where the number of morphospecies decreased dramatically from the first sampling to the second sampling (lower amount of precipitation). Interesting was the case of the floodland primary forest, where the diversity pattern showed a different trend. More morphospecies were collected during the driest month and the number of collections decreased as the monthly precipitation increased. Apparently, in this habitat, there is a negative correlation between

number of macromycetes and precipitation levels. This phenomenon could be a result of the excess soil's moisture, which accumulates, saturating the soil. The latter can affect dramatically the fructification of macromycetes as well as the existence of their mycelia since the excess of water content reduces the decay process and decreases the quantity of available oxygen (Delaney *et al.*, 1998).

This is the first effort to evaluate a Peruvian macrofungal community, which involved not only the compilation of the species present in the area, but also the comparison between communities among the main habitats present at the station. Several macromycetes collected in this project constituted new records for the region and even for the country. Forty-eight species are considered as new records for the region and for the country, increasing the checklist of Peruvian macromycetes (Appendix II). Particularly interesting was the case of *Pseudocolus fusiformis*, a member of the Phallaceae. *P. fusiformis* was one of the rare species found in the area only collected once during the six months of fieldwork, and was never previously recorded for the Amazon. Another example was *Mutinus xylogenus*, which was only known to inhabit the Guiana. The collection of these two species has been already published in a scientific journal (Gazis & Guzman, 2006). Building a list of macromycetes species is one of the most important outcomes of this project because it helps scientists in the evaluation of the Peruvian – Amazon biodiversity, in the identification of "hot biodiversity spots," which could be proposed as conservation sites, and finally in the construction of a database for future mycological research in the region.

CONCLUSIONS

This study was designed to evaluate and monitor the macromycetes community at Los Amigos Biological Station. Some of the goals accomplished are a checklist of the species present in the area, an overview of the community composition at the three main habitats and of the changes in the community among different seasons.

The macromycetes at the area were found to be highly diverse at the species level. The fungal family composition found in the area was typical of Neotropical areas and similar to the ones found in the lowland regions of Brazil, Venezuela, and Ecuador. The inventory of morphospecies was built with opportunistic collections made through the majority of the trails located at the biological station in addition with the morphospecies found in the plots. More than three hundred morphospecies of macromycetes belonging primarily to Basidiomycota and Ascomycota were recorded. Basidiomycota was the most abundant group which made up 71% of the collections compared to Ascomycota, which only represented 27%. Within the Ascomycota, representatives from the Xylariaceae were the most common encountered. The Tricholomataceae was the most commonly found within the Basidiomycota, especially the genera *Marasmius*, *Marasmiellus*, and *Gymnopus*.

Analysis of fungal community composition in the 500 m^2 plots revealed distinct differences in fungal communities among high terrace primary forest, high terrace secondary forest, and floodland primary forest. A small number of species (both Ascomycota and Basidiomycota) were generalist. These species are also widely

distributed in several places within the neotropics. In addition, some species were found to inhabit only one type of habitat.

The highest diversity of both fungal groups was found on high terrace primary forest; however, the asymptote of morphospecies accumulation curves was not reached for any of the habitats. Previous work on tropical macromycetes community revealed that diversity is positively correlated with local abundance and diversity of substrates. Higher diversity in old growth forests is related to larger variety of resource sizes, while secondary forests only contains small diameter trees and branches. In this study, the obtained results agreed with the last statement; high terrace primary forest is the habitat presenting more quantity of logs and branches, therefore it is the habitat containing more available and suitable substrata.

Similarity indexes (Jaccard and Sorenson) showed that the species composition vary among habitats; however they had a similar family composition. All of them were mainly composed by three families: Tricholomataceae, Polyporaceae, and Xylariaceae. According to the similarity indexes used, none of the habitats presents a similar macrofungal community composition.

The amount of precipitation influenced the macromycetes abundance and the community composition. For the high terrace primary and secondary forest, a positive correlation was found. Species diversity diminished with the decrease of precipitation amount. On the other hand, in the floodland habitat, the opposite trend was found. Species diversity decreased with the increase of precipitation amount.

Most of the species presented a decomposer habit, being the majority wood decayers. When the substrate was broken down into classes, it was found that the favorite substrate for decomposers was logs followed by soil and branches. Leaf litter was found to be also an important substrate, especially for the genus *Marasmius*.

The outcomes from this project have implications for conservation of fungal diversity since deforestation is a constant threat in the Amazon, increasing every day. Logging is one of the activities driven deforestation in the area. This activity implies the disturbance of the forest with the removal of logs (and other suitable substrate for fungi) in their search for precious wood material. In recent years, conservationists in temperate zones have worked in a red list of macromycetes in order to preserve the regions holding this species. This measure should also be adopted in the conservation policy of Neotropical forests. The results presented here are hoped to be useful in that regard.

This study is only a small part of a much larger an integrated project (AABP), which tends to evaluate the biodiversity of the Peruvian southeastern region in many areas and dimensions. Plant community, phenology, climate, insects, and even mammals diversity and distribution are evaluated and monitored by this project. All sub-projects are interconnected and created to be shared among members of the team. The project has designed a fieldwork system (series of protocols) and a network useful to evaluate high diversity areas. Data obtained from the different sub-projects are also available for external researchers through online digital databases.

Appendix I: List of identified species

ASCOMYCOTA

Clavicipitaceae

Akanthomyces pistillariiformis (Pat.) Samson & Evans
Aschersonia basicystic Berk. & M.A. Curtis
Ascopolyporus polychorus A. Møller
Beauveria bassiana (Bals.-Criv.) Vuill.
Cordyceps aff. chlamydosporia H.C. Evans
Cordyceps amazonica Henn.
Cordyceps australis Speg.
Cordyceps dipterigena Berk. & Broome
Cordyceps locustiphilla P. Henn
Cordyceps militaris Fries
Cordyceps aff. submilitaris Henn.
Cordyceps tuberculata (Lebert) Maire
Cordyceps unilateralis (Tul.) Sacc.
Coryceps aff. neovolkiana A. Møller
Hypocrella gaertneriana A. Møller
Paecilomyces lilacinus (Thom) Samson
Paecilomyces tenuipes (Peck) Samson
Torrubiella aff. superficialis Kobayasi & Shimizu

Xylariaceae

Camarops aff. scleroderma (Mont.) Nannf.
Camillea lepreurii Mont.
Camillea mucronata Mont.
Camillea venezuelensis (J.H. Mill.) Dennis
Daldinia concentrica var. eschscholzii (Ehrenb.) Rehm
Kretzschmaria clavus (Fr.) Sacc.
Moelleroclavus penicilliopsis Henn.
Phylacia poculiformis (Mont.) Mont.
Thamnomyces chordalis Fr.
Xylaria aff. coccophora Mont.
Xylaria cff. tuberoides Rehm.
Xylaria comosa (complex) Mont.
Xylaria comosoides Laessøe
Xylaria cubensis (Mont.) Fr.
Xylaria globosa (Spreng. ex Fr.) Mont.
Xylaria hypoxylon (L.) Grev.
Xylaria moelleroclavus Rogers, Ju & Hemmes
Xylaria obovata (Berk.) Berk.
Xylaria polymorpha (Pers.) Grev.
Xylaria telfairii (Berk.) Sacc.
Xylocoremium flabelliforme (Schwein.) J.D. Rogers

Nectriaceae

Calostilbe striispora (Ellis & Everh.) Seaver

Pyronemataceae

Scutellinia asperrima (Ellis & Everh.) Le Gal

Sarcoscyphaceae

Cookeina speciosa (Fr.) Dennis
Cookeina tricholoma (Mont.) Kuntze

BASIDIOMYCOTA

Phallaceae

*Phallus indusiata (*Vent.) Desv.

Pseudocolus fusiformis (E. Fisch.) Lloyd

Staheliomyces cinctus E. Fisch.

Xylophallus xylogenus (Mont.) E. Fisch.

Geastraceae

Geastrum saccatum Fr.

Nidulariaceae

Cyathus striatus (Huds.) Willd.

Tricholomataceae

Calocybe cyanella Singer ex Redhead & Singer

Collybia aff. dryophilus (Bull.) Murrill

Collybia trinitatis Dennis

Favolaschia calocera R. Heim

Favolaschia sprucei (Berk.) Singer

Filoboletus gracilis (Klotzsch ex Berk.) Singer

Gerronema retiarum (Berk.) Singer

Gymnopus aff. neotropicus (Singer) JL Mata

Marasmiellus nigripes (Schwein.) Singer

Marasmiellus volvatus Singer

Marasmius cladophyllus Berk.

Marasmius crinis – equi F. Muell. ex Kalchbr.

Marasmius haematocephalus (Mont.) Fr.

Marasmius nigrobrunneus (Pat.) Sacc.

Marasmius rhabarbarinus Berk.

Marasmius rotuloides Dennis

Oudemansiella canarii (Jungh.) Höhn

Agaricaceae

Agaricus aff silvaticus Schaeff.

Coprinus disseminatus (Pers.) Gray

Coprinus plicatilis (Curtis) Fr.

Leucoagaricus fragilissimus (Rav.) Pat.

Leucocoprinus birnbaumii (Corda) Singer

Macrolepiota procera (Scop.) Singer

Cortiniariaceae

Gymnopilus chrysopellus (Berk. & M.A. Curtis) Murrill

Gymnopilus aff. subearlei R. Valenz, Guzmán & J. Castillo

Hygrophoraceae

Hygrocybe miniata (Fr.) P. Kumm.

Pterulaceae

Pterula aff. typhuloides Corner

Tremellaceae

Tremella mesenterica Retz.

Tremella fuciformis Berk.

Tremella foliacea Pers.

Auriculariaceae

Auricularia delicada (Fr.) Henn

Auricularia fuscosuccinea (Mont.) Henn.

Auricularia mesenterica (Dicks.) Pers.

Auricularia polytricha (Mont.) Sacc.

Exidiaceae

P*seudohydnum gelatinosum* (Scop.) P. Karst.

Dacrymycetaceae

Dacryopinax spathularia (Schwein.) G.W. Martin

Polyporaceae

Amauroderma trichodermatum Furtado

Favolus brasiliensis (Fr.) Fr

Ganoderma applanatum (Pers.) Pat.

Ganoderma lucidum (Curtis) P. Karst.

Lentinus crinitus (L.) Fr.

Lentinus velutinus Berk.

Lenzites erubescens (Berk.) Sacc.

Polyporus elegans Fr.

Polyporus tricholoma Mont.

Polyporus trichomallus Berk. & Mont.

Polyporus udus Jungh.

Polyporus varius (Pers.) Fr.

Pycnoporus sanguineus (L.) Fr.

Stereum hirsutum (Willd.) Pers.

*Trametes versicolor (*L.) Lloyd

Schizophyllaceae

Schizophyllum commune Fr.

Sclerodermataceae

Scleroderma sinnamariense Fr.

Thelephoraceae

Cotylidia spectabilis (Lév.) Courtec.

Hymenochaete damicornis (Link) Lév.

Podoscypha bubaline D.A. Reid

Podoscypha fulvonitens (Berk.) D.A. Reid

Podoscypha venustula (Speg.) D.A. Reid

Pleurotaceae

Pleurotus concavus (Berk.) Singer

Pleurotus d'jamor Corner

Boletaceae

Gyrodon exiguus Singer & Digilio

Clavariaceae

Ramaria reticulate (Berk. & Cooke) Corner

Appendix II: List of new records for Peru

ASCOMYCOTA

Clavicipitaceae

Beauveria bassiana (Bals.-Criv.) Vuill.
Cordyceps aff. chlamydosporia H.C. Evans
Cordyceps aff. submilitaris Henn.
Cordyceps unilateralis (Tul.) Sacc.
Paecilomyces lilacinus (Thom) Samson
Paecilomyces tenuipes (Peck) Samson
Torrubiella aff. superficialis Kobayasi & Shimizu

Xylariaceae

Camarops aff. scleroderma (Mont.) Nannf.
Kretzschmaria clavus (Fr.) Sacc.
Moelleroclavus penicilliopsis Henn.
Thamnomyces chordalis Fr.
Xylaria aff. coccophora Mont.
Xylaria aff. tuberoides Rehm.
Xylaria comosoides Laessøe
Xylaria cubensis (Mont.) Fr.
Xylaria globosa (Spreng. ex Fr.) Mont.
Xylaria moelleroclavus Rogers, Ju & Hemmes
Xylocoremium flabelliforme (Schwein.) J.D. Rogers
Xylophallus xylogenus (Mont.) E. Fisch.

BASIDIOMYCOTA

Phallaceae

Pseudocolus fusiformis (E. Fisch.) Lloyd
Staheliomyces cinctus E. Fisch.

Tricholomataceae

Calocybe cyanella Singer ex Redhead & Singer
Collybia aff. dryophilus (Bull.) Murrill
Collybia trinitatis Dennis
Favolaschia calocera R. Heim
Gymnopus aff. neotropicus (Singer) JL Mata
Marasmius crinis-equi F. Muell. ex Kalchbr.
Marasmius nigrobrunneus (Pat.) Sacc.

Agaricaceae

Agaricus aff silvaticus Schaeff.
Leucoagaricus fragilissimus (Rav.) Pat.
Leucocoprinus birnbaumii (Corda) Singer

Cortiniariaceae

Gymnopilus chrysopellus (Berk. & M.A. Curtis) Murrill
Gymnopilus aff. subearlei R. Valenz, Guzmán & J. Castillo

Hygrophoraceae

Hygrocybe miniata (Fr.) P. Kumm.

Pterulaceae

Pterula aff. typhuloides Corner

Tremellaceae

Tremella fuciformis Berk.

Tremella foliacea Pers.

Auriculariaceae

Auricularia mesenterica (Dicks.) Pers.

Exidiaceae

P*seudohydnum gelatinosum* (Scop.) P. Karst.

Dacrymycetaceae

Dacryopinax spathularia (Schwein.) G.W. Martin

Polyporaceae

Polyporus elegans Fr.

Polyporus udus Jungh.

Polyporus varius (Pers.) Fr.

Stereum hirsutum (Willd.) Pers.

Sclerodermataceae

Scleroderma sinnamariense Fr.

Thelephoraceae

Cotylidia spectabilis (Lév.) Courtec.

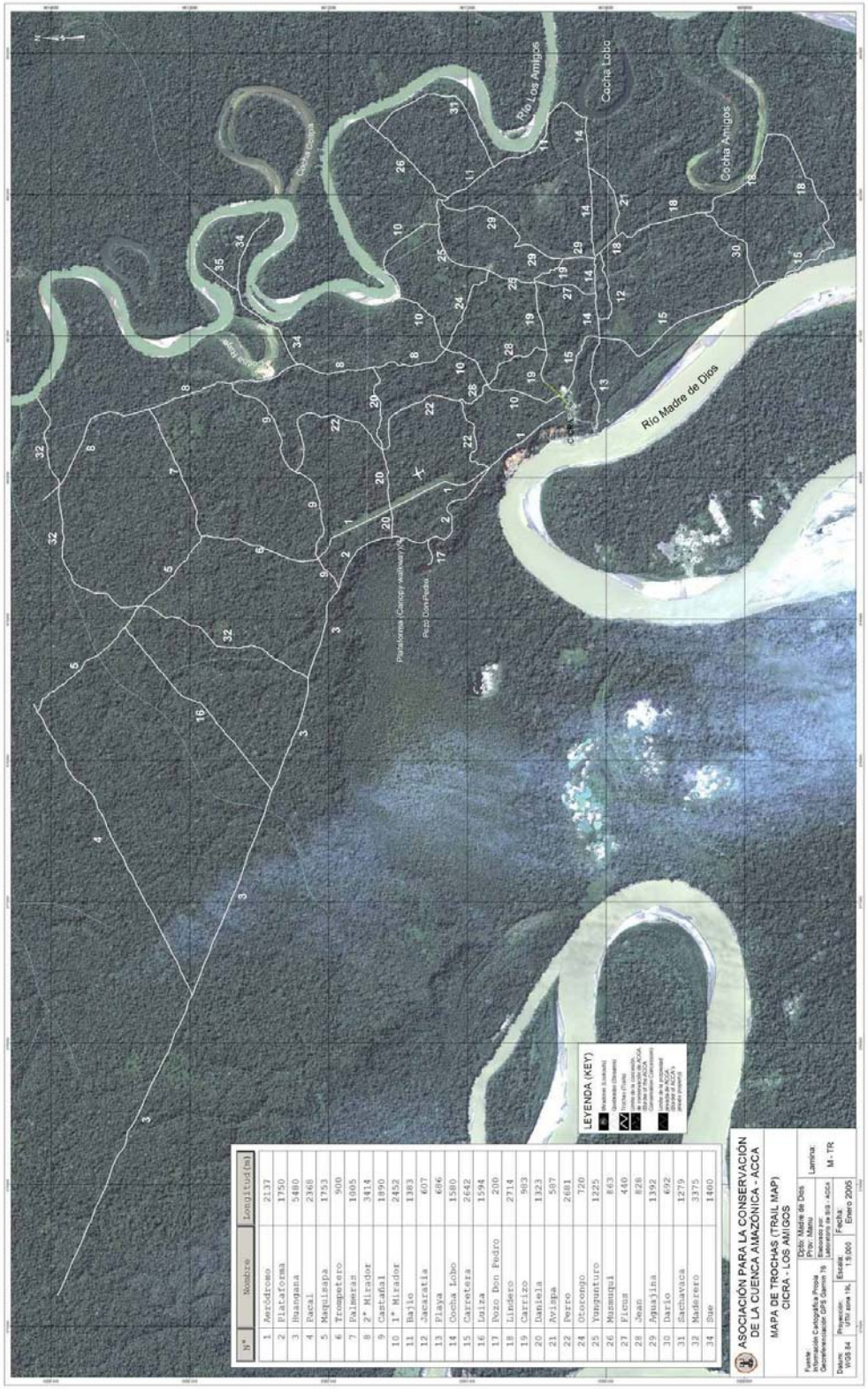
Boletaceae

Gyrodon exiguus Singer & Digilio

Clavariaceae

Ramaria reticulate (Berk. & Cooke) Corner

Appendix III: Trail system – Los Amigos Biological Station



N°	Nombre	Longitud(m)
1	Aeródromo	2137
2	Plataforma	1750
3	Huangana	5480
4	Dacal	2366
5	Maquisapa	1753
6	Trompetero	900
7	Palmeras	1005
8	2° Mirador	3414
9	Castañal	1890
10	1° Mirador	2452
11	Bajío	1383
12	Jaguatia	607
13	Playa	696
14	Cocha Lobo	1580
15	Carretera	2642
16	Laiza	1594
17	Pozo Don Pedro	200
18	Lindero	2714
19	Carrizo	983
20	Daniela	1323
21	Aviapa	587
22	Perro	2681
24	Otorongo	720
25	Yanguturo	1225
26	Mosmiqui	863
27	Ficus	440
28	Jean	828
29	Aguajina	1392
30	Dario	692
31	Sachavaca	1279
32	Madereo	3375
34	Sue	1400

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VITA

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EVALUATION OF THE MACROFUNGAL COMMUNITY AT LOS AMIGOS BIOLOGICAL STATION, MADRE DE DIOS, PERU

by Romina Gazis, M.S, 2007
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Macrofungi represents a diverse group of taxa which play an important role in nutrient cycling. Little is known about their diversity, community organization, variation in time and space, and their role within the ecosystem. This study was designed to evaluate the diversity, composition, and ecological importance of macromycetes belonging to the Basidiomycota and Ascomycota. The project was conducted at a lowland Amazonian rainforest area in the southeastern region of Peru, within the Amazon basin in the Madre de Dios province. The study was divided into two main parts: (1) an inventory involving opportunistic collections made to document the species present, and (2) a quantitative comparison between the three major habitats of the region, primary high-terrace forest, secondary high-terrace forest, and primary floodplain forest, using a system of plots that were sampled during the different seasons. This is the first study to evaluate the macrofungal communities of a lowland Amazonian forest in Peru. Three hundred and five morphospecies were collected from Los Amigos Biological Station (Peruvian Amazon lowland subtropical rainforest) indicating a high diversity. The fungal family composition found in the area was typical of Neotropical areas and similar to the

ones found in the lowland regions of Brazil, Venezuela and Ecuador. Forty eight species are presented as new records for the country.

Similarity indexes showed that the species composition varied among habitats; however all of them were mainly composed of three families: Tricholomataceae, Polyporaceae, and Xylariaceae. The amount of precipitation influenced the macromycetes abundance and community composition. The outcome from this study will be stored as a mycological database that will be available to mycologists who plan to do research in this region. Also, the species documented will increase our knowledge of biodiversity held in this region of the world.