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Database of the macrofungi of the Monteverde Reserve

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ABSTRACT

Fungi serve important roles in natural systems and have strong economic and social consequences for human populations. A database of the macrofungi of the Monteverde Reserve was created to ease identification and facilitate research on local macrofungi. The database includes 30 species, with 18 families and 22 genera represented. The database was organized in a system of nested folders, providing both morphological and taxonomic keys. Information files were created for each species, including digital photographs of specimens and spore prints (when applicable), and taxonomic, microhabitat, growth, and morphological data. This database provides a structure for future cataloguing and identification, with the goal of spurring fungal research in the area.

RESUMEN

Los hongos tienen funciones importantes en los sistemas naturales y tienen consecuencias económicas y sociales de importancia para las poblaciones humanas. Un banco de datos de los macrohongos de la reserva de Monteverde fue creado para facilitar la identificación y la investigación de la fauna local de hongos. El banco de datos incluye treinta especies, con dieciocho familias y veintidós géneros representados; los datos fueron organizados en un sistema de archivos jerarquizados, proporcionando claves morfológicas y taxonómicas. Los archivos de información creados para cada especie incluyen las fotografías digitales de los especímenes y las esporadas (cuando fue posible); así como también los datos morfológicos, taxonómicos, de microhábitat y la forma de crecimiento. Este banco de datos proporciona una base para la identificación y el ordenamiento sistemático con la meta de estimular la investigación de hongos en el área.

INTRODUCTION

The Kingdom Fungi represents the most diverse group of eukaryotic organisms in existence (Rossman et al 1998). Fungi differ from both plants and animals. Fungi lack chlorophyll, and are therefore unable to create their own food through photosynthesis, like plants. Fungi obtain nutrients by feeding on other organisms, but differ from animals because they lack capability of movement, nervous systems, and specialized organs (Arora 1986).

Fungi are essential for the functioning of ecosystems in multiple ways. Saprophytic fungi play a vital role in the breakdown and recycling of organic matter in ecosystems (Mata et al. 2003). Fungi also form symbiotic relationships with many other organisms; for instance, mycorrhizal fungi live in symbiosis with the roots of plants. Mycorrhizal fungi provide nutrients for their host plants, and in exchange receive carbohydrates from the host (Arora 1986). Fungi serve important ecological roles as parasites as well, feeding on the tissue of other living organisms. These fungi help regulate population growth of certain plant and animal species (Mata 1999).

Fungi have economic and social effects on human populations. Some parasitic fungi have deleterious effects on crops, leading to economic losses. Parasitic fungal infections can also threaten human health (Mata 1999). Fungi have many positive effects for humans as well. Many fungi are edible, providing food sources and economic benefits; other fungi can be utilized in industry. Fungi are used in the making of foodstuffs such as beer and wine and in the production of medicines such as penicillin (Mata 1999).

Fungi are understudied in general despite their biological, economic, and social importance. Only around 2,000 of an estimated 40,000 to 70,000 species of fungi in Costa Rica have been described (Mata 1999). Field guides for Costa Rican fungi do exist, but are limited to common species at the country level. No catalogue of fungal diversity existed for the Monteverde region prior to this study. The purpose of this project was to produce a database of macrofungi in the Monteverde Reserve. This database will be helpful to naturalists, students, and biologists working in the reserve and surrounding areas. It will be particularly useful for students, because it facilitates identification of species. This is important for student projects, which are often strictly limited by time constraints. The database will facilitate research on fungi, which could lead to a better understanding of ecosystem functioning and produce useful social or economic effects.

MATERIALS AND METHODS

Study Site

The study was performed in the Monteverde Reserve, focusing on the established trail system behind the Estación Biológica de Monteverde (Fig. 1). Sampling was non-random, and was restricted to an area within ten meters of either side of the trail. Initial sampling focused on sections of trails closest to the station. Particular attention was given to areas with abundant decomposing organic matter and high moisture levels. Surveying was not restricted to these areas however. Many sampling sites and individual specimens were included based on field observations provided by students and biologists working in the study site. Specimens were collected between October 22 and November 13, 2005.

Collection Methods

Each species was photographed in situ with a digital camera, and field data were recorded prior to collection. Microhabitat conditions including relative humidity, light availability, percent of canopy coverage, and elevation were recorded using a moisture meter, light meter, spherical densiometer, and altimeter respectively. Substrate type, weather conditions, collection date, abundance, growth habit, and surrounding vegetation were also recorded. Samples were collected using a trowel. Cuts were made several centimeters below the base of the specimen, according to the technique described by Mata 1999. A portion of the substrate was included with the specimen when possible. Several specimens of each species, including different sizes, were collected when available to aid in identification (Arora 1986). Samples were wrapped in paper and transported in plastic baskets.

In the lab, additional digital photographs were made using a photo mat background. Micrographs of fertile surface characteristics were taken for many species using a dissecting microscope, a camera adapter, and a digital camera. Morphological characteristics were measured and recorded (Appendix A). Spore prints were attempted for each species by placing the pileus (Fig. 2) of the specimen on white paper and covering it with a glass or container (Mata 1999). Data for each specimen were recorded manually, then transferred to the computer as Word files (Database CD, enclosed).

Identification

Identification of species was accomplished by two methods. Species were identified on-site using available literature (Mata 1999; Mata et al. 2003) when possible. Digital photos of remaining specimens and spore prints were sent to Milagro Mata Hidalgo and Loengrin Umaña Tenorio at INBio for identification.

Database Construction

The database was constructed using a format of nested folders similar to the pollen database created by Maria Jost (Jost 2004). Separate folder systems were established to allow species to be identified based on both taxonomic and morphological information. Taxonomic divisions were made beginning with families and continuing to species names. Morphological divisions were made first on basic form, then size, and then color. An example picture of the particular folder characteristic was provided to aid in searching. A file was created for each species including digital photographs of samples, a digital photograph of the spore print (when applicable), taxonomic information, and morphological, habitat, and growth data.

RESULTS

A total of thirty species were included in the database (Appendix B). Eighteen families, including 22 genera, were represented. Thirteen specimens were definitively identified to species name. An information file was created for each species (Fig. 3), and the final database was stored on a compact disc (Database CD, enclosed).

Database organization and use

The database is organized into separate keys for identification based on taxonomic information and morphological characteristics. The taxonomic key is straightforward, beginning with folders for each family and continuing down to individual species name. The individual folder for each species includes the final PowerPoint information file (Figure 3), a folder of full-size digital photos, and the raw data sheet for the specimen. The final PowerPoint information file for each species includes all microhabitat, growth, and morphological data recorded for the species, as well as digital photos of the species and its spore print (when applicable).

The morphological key is designed so that each folder division creates limiting characteristics, eventually ending at the species name. Each folder includes a photographic example of the folder characteristic. The first division is based on basic form (mushroom, earth tongue, ear-shaped, cup, shelf, hanging bell/cup, globoid/cerebriform, bird's nest). The next folder division differs among forms, since the practicality of characteristics varies among forms. An example of the morphological key, using *Lactarius indigo* (Russulales: Russulaceae) is as follows:

1. 'Database of the Macrofungi of the Monteverde Reserve' folder (Database CD)
2. 'Morphological key' folder
3. Identify basic form (using example photos from each basic form folder if necessary)
4. Select the 'Mushrooms' folder after identifying the basic specimen form as mushroom
5. Note the next division characteristic, large vs. small (determined by diameter of mature pileus)
6. Select 'large' folder
7. Note specimen color (blue) and choose 'blue' folder
8. Check example photo, and then select '*Lactarius indigo*' folder
9. Open *Lactarius indigo* PowerPoint file; compare photos, microhabitat, growth, and morphological data
10. Refer to full-size digital photos in the '*Lactarius indigo* photos' folder, and the raw specimen data sheet if desired

Observed trends

Some general trends were apparent in collection. Visible abundance and species richness of fungi tended to be higher according to collection site characteristics. Higher variety of species and higher numbers of individuals were found in sites with decomposing wood and high moisture. Twenty-two of the 30 species were observed to be growing in a substrate of decomposing wood, and 24 of the 28 microhabitats for which the variable was measured had relative humidity of greater than 80%. An increase in visible species richness also occurred just after extended periods of heavy rain. Drastic increases in abundance were observed for *Coprinus disseminatus* (Agaricales: Coprinaceae) and the Genus *Mycena* (Agaricales: Tricholomataceae) after long periods of rain.

DISCUSSION

Explanation of Trends

The observed trends of high abundance and high diversity in sites containing decomposing wood and high moisture levels are consistent with general fungal biology. Decomposing wood provides an abundant and easily accessible nutrient source, which fungi require. Also, all fungi need free water to carry out metabolic processes and prevent dessication of hyphae (Alexopoulos et al. 1996).

Suggestions for Future Research

The database produced through this project represents only a very small fraction of the fungal diversity in the Monteverde Reserve. This work should serve as a base on which future researchers can build with the goal of eventually including as many of the species of macrofungi in the reserve as possible. Specifically, collection and cataloguing should be carried out in the dry season, since species composition most likely differs significantly with various levels of water availability. Also, research should be devoted to the natural history of individual species, to gain a better understanding of the factors governing the growth of these species, and the effects of these species on surrounding species and ecosystem functioning.

ACKNOWLEDGEMENTS

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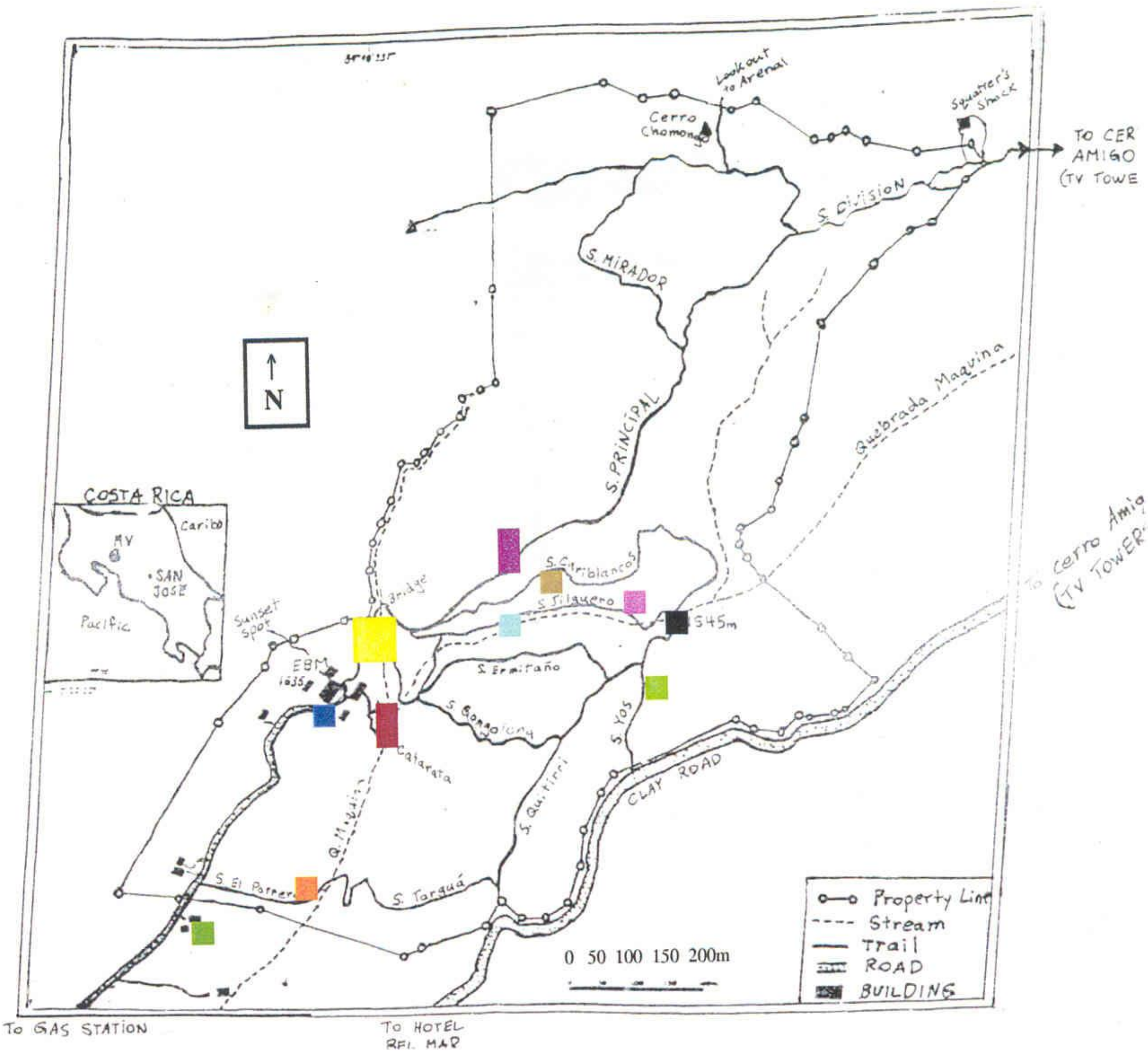

- ♦ *Cyathus striatus*
- ♦ *Lactarius indigo*
- ♦ *Auricularia delicata, Coriolopsis polyzona*
- ♦ *Boletellus ananas, Xylaria sp.* *Russula sp., Mycena sp.* *Campanella sp., Russula sp.* *Polyporus tenuiculus*
- ♦ *Xylaria sp., Mycena sp.* *Cortinarius sp (?), F. Sclerotiniaceae (?)* *Hypholoma sp.*
- ♦ *Cookeina (venezuelae?), Ganoderma sp.* *Auricularia auricula*
- ♦ *Hygrocybe cantharellus, Trametes sp.* *Trichaptum sector*
- ♦ *Hygrocybe sp., Hygrocybe miniata* *Pseudohydnum gelatinosum*
- ♦ *Gymnopilus sp.*
- ♦ *Rigidoporus sp., Ganoderma sp. (?)*
- ♦ *Entonaema liquescens, Coprinus disseminatus*

FIGURE 1. Map of the study area with collection sites for individual species highlighted. Monteverde, Costa Rica, Oct. 22 - Nov. 13, 2005.

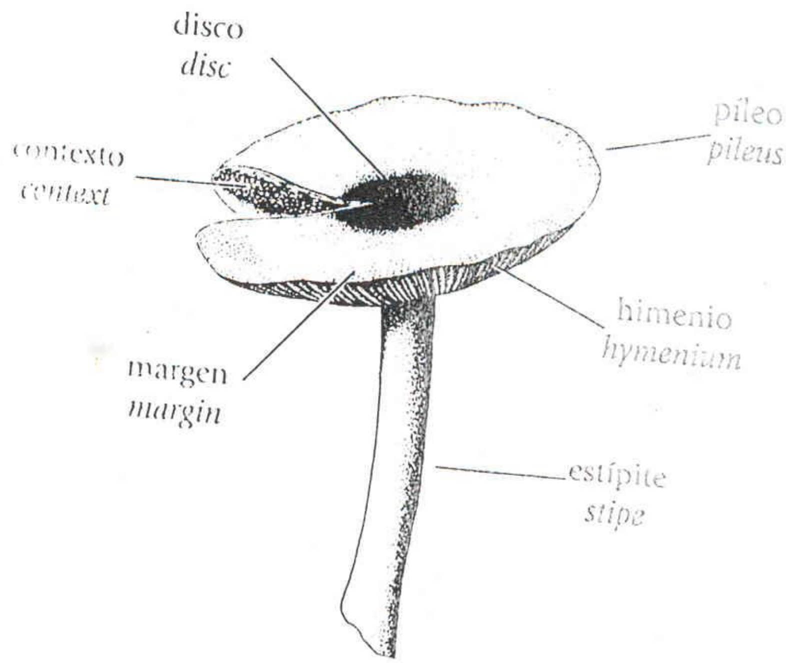

FIGURE 2. Illustration of vocabulary associated with a conventional mushroom (Mata, 1999).

Boletellus ananas

•**Family: Xerocomaceae**

•**Collection Date:** 5 November 2005
•**Collection Time:** 12:23 pm
•**Weather conditions:** sunny, partly cloudy
•**Microhabitat Conditions at Collection Site:**

–Type of substrate: tree root (covered in moss)
–Relative humidity: 78%
–Light availability: 275 lux
–Canopy cover (%): 94.02
–Elevation: 1527 m
–Surrounding vegetation: *Geonoma* sp, *Quercus* sp, Bryophyta, Pteridophyta, Araceae
–Abundance: low (2)
–Observed growth habit: clustered

- **Morphological Characteristics (of collected samples):**
  - Basic form: mushroom
  - Shape of pileus: convex
  - Diameter of pileus: 11 cm
  - Color of mature sample: pileus is brownish in center; scales get more reddish-maroon towards margin, cream-colored background; grayish-white stipe; white porous bulb at base of stipe
  - Shape of margin (using longitudinal section): plane
  - Texture of margin: entire
  - Surface texture of pileus: peeling scales (triangular) cover pileus and curl upwards, pileus is spongy
  - Color of context: yellow (bruises blue)
  - Hymenium or fertile surface characteristics:
    - Color: yellow (bruises blue)
    - Texture: porous
  - Stipe characteristics:
    - Shape: abruptly bulbous
    - Size: 14.5 cm long, 1.7 cm wide
    - Color: gray
    - Position: central
- **Color of spore print:** dark brown
- **Color of bruising:** context and fertile surface bruise blue

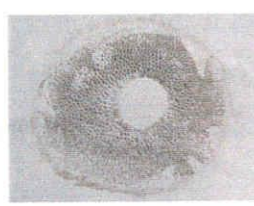

FIGURE 3: Example of the PowerPoint information file created for each species in the database. This is the actual database file for *Boletellus ananas*. Monteverde, Costa Rica, Oct. 22 - Nov. 13, 2005.

APPENDIX A: Specimen Data Sheet

Date: ____________________ Time:_____________________

Weather Conditions:____

Microhabitat Conditions:

- Type of substrate: ____
- Relative humidity: ___________________
- Light availability______________________
- Canopy cover (%):____________________
- Elevation: ___________________________
- Surrounding vegetation:____

  ____
- Abundance: ____
- Observed growth habit: ____

Morphological Characteristics:

- Basic form: ____
- Shape of pileus: ____
- Diameter of pileus: ________________________
- Presence of stipe:____________________________
- Shape of stipe: ______________________________
- If no stipe, length and width of pileus:____
- Color of mature sample: _______________________
- Color of young specimen:______________________
- Shape of margin (using longitudinal section): ____
- Texture of margin: ____
- Surface texture of pileus: ____
- Color of context: ____

- Hymenium or fertile surface characteristics:
  - Color: ________________________
  - Texture:______________________
  - Type of juncture with stipe (for those with lamellae): _________________________________
  - Space between gills: ____
  - Presence of lamellulae:____
- Stipe characteristics:
  - Shape: _____________________________
  - Size: _______________________________
  - Color:_______________________________
  - Position_____________________________
  - Presence of annulus: _____________________________________
  - Location of annulus: ______________________________________
  - Color of annulus: ____
  - Presence of volva:____
  - Shape of volva:____
  - Color of volva: ____
  - Texture of volva: ____
  - Color of spore print: ____________________________________
  - Color of bruising: _______________________________________

APPENDIX B: Families and Species of Fungi Included in Database

Auricularia auricula	Auricularia auricula
	Auricularia delicate
Coprinaceae	Coprinus disseminates
Coriolaceae	Coriolopsis polyzona
	Trametes sp.
	Tricchaptum sector
Cortinariaceae	Cortinarius sp. (?)
	Gymnopilus sp.
Exidiaceae	Pseudohydnum gelatinosum
Ganodermataceae	Ganoderma sp.
	Ganoderma sp. (?)
Hygrophoraceae	Hygrocybe cantharellus
	Hygrocybe miniata
	Hygrocybe sp.
Marasmiaceae	Campanella sp (?)
Meripilaceae	Rigidoporus sp.
Nidulariaceae	Cyathus striatus
Polyporaceae	Polyporus tenuiculus
Russulaceae	Lactarius indigo
	Russula sp.
	Russula sp.
Sarcoscyphaceae	Cookeina (venezuelae?)
Sclerotiniaceae	Sp.
Strophariaceae	Hypholoma sp.
Tricholomataceae	Mycena sp.
	Mycena sp.
Xylariaceae	Entonaema liquescens
	Xylaria sp.
	Xylaria sp.
Xerocomaceae	Boletellus ananas