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ABSTRACT

The purpose of this study was to examine macrofungal community richness at different distances from the Quebrada Máquina in the cloud forest of Monteverde, Costa Rica. Twenty transects no closer than ten meters apart were tested. Each transect contained a 1X 1 m^2 plot positioned at zero, five, ten, fifteen, and twenty meters from the stream edge. Fungi were counted and photographed and weather and substrate type were recorded. I predicted to find more macrofungal richness closer to the river because of water and sunlight availability. However, using Friedman's method for randomized blocks, I found a Chi squared value of 9.18 (df = 4, $p > 0.05$), which shows no statistical significance in fungal community richness between the five different distances. However, graphing mean number of species found per distance, we can see a trend. It shows that fungal richness is highest at the middle distances. I also tested distribution of species on substrates, and found dead wood was the most common. A Chi squared Goodness of Fit Test (assuming substrate abundance was equal) showed that the distribution differed significantly from the expected distribution (Chi squared = 315.5, df = 5, $p < 0.001$). These results therefore imply that there may be more dead wood at the middle distances than at the closest and farthest distances, or that other conditions are more favorable to fungi there.

RESUMEN

El propósito de este estudio fue examinar la riqueza de la comunidad de macrohongos a diferentes distancias de la Quebrada Máquina en el bosque nuboso de Monteverde, Costa Rica. Veinte transeptos no más cercanos a diez metros fueron probados. Cada transepto contenía una cuadrícula de 1X $1m^2$ posicionada a cero, cinco, diez, quince, y veinte metros del borde del arroyo. Se contaron los hongos y se fotografiaron y se tomó además el clima y el tipo de sustrato. Predije encontrar mayor diversidad de macrohongos más cerca al río debido al agua y disponibilidad de la luz del sol. Sin embargo, usando el método de Friedman para los bloques aleatorizados, yo encontré un Chi cuadrado valor de 9.18 (df = 4, $p > 0.05$) que no muestra diferencia en la diversidad fúngica entre las cinco distancias diferentes. Sin embargo, al graficar el número promedio de especies encontradas por distancia, puedo ver una tendencia. Muestra que la diversidad fúngica es más alta en las distancias medias. Yo también probé la distribución de las especies en los substratos, y encontré la madera muerta es el más común. Un Chi Cuadrado con Prueba de Bondad y ajuste (asumiendo que la abundancia del substrato es igual) mostró que la distribución difirió significativamente de la distribución esperada (Chi-cuadrado = 315.5, el df = 5, $p <0.001$). Estos resultados implican por consiguiente que haya puede haber más madera muerta a las distancias medias que a las distancias más cercanas y lejanas, o que otras condiciones allí son más favorables para los hongos.

INTRODUCTION

Fungi are a diverse group of organisms that play an important role in the environment. They aid in recycling organic matter back into the ground to be reused by other organisms such as plants and animals (Mata 1999). They gain their nutrients in the form of carbon through absorption, not fixation. Due to this characteristic, fungi are able to utilize many different types of carbon sources as food (Alexopoulos et al. 1996). Some of these common substrates include dead wood, leaf litter, root tips, live trees, and soil.

Some environmental factors that affect fungal growth and community richness are moisture, temperature, pH, oxygen, and sunlight (Alexopoulos et al. 1996). Since fungi live in such close relations with their environment due to their absorptive diet, slight changes in some of these factors can cause a change in species composition and community richness. Also, different fungi thrive in different or stricter climates, which can change the fungal richness in an area. For example, most species of fungi have an optimal temperature range of 25˚ and 30˚ C. (Alexopoulos et al. 1996). Therefore, if this temperature constraint is not met, it will be difficult for many species to survive, which lowers community richness.

The purpose of this study was to examine how distance from a water source affects community richness of fungi in the cloud forest of Monteverde, Costa Rica. Different distances from the Quebrada Máquina should have different levels of moisture and sunlight. Although sunlight is not required, it may greatly enhance fungal growth through introducing reproductive structures (Alexopoulos et al. 1996). Moving away from the river, shade generally increases because there is more canopy cover from large trees. Also, moisture should decrease at greater distances as water in the soil drains downward toward the river. I predict that this combination will lower community richness of fungi as distance increases.

One substrate on which fungi are commonly found is dead wood. In a previous study conducted by a CIEE student, 58% of fungi found were on dead wood (Herz 2004). In tropical forests, dead wood represents a significant amount of carbon (Delaney et al. 1998). Therefore, more fungi should be found on decaying wood because it is one of the more abundant carbon sources, which would foster a greater richness. I expect this to also increase richness at the closer distances because most substrates, including dead wood, should fall or roll down towards the river.

MATERIALS AND METHODS

Study Sites

This study was conducted along the Quebrada Máquina in Monteverde. Transects were restricted to an elevational range of 1,460 m to 1,560 m and were no fewer than ten m apart in distance. Also, the study sites needed to be accessible up to 20 m from the river, but in relatively undisturbed habitats. This premontane wet forest has an average rainfall of about 2.5 m per year (Clark et al. 2000). These data were collected during the wet season, from July 26 through August 1, 2008.

Collection Methods

An altimeter was used to find 20 transects within the correct elevational range. Each transect was perpendicular to the river and consisted of five 1 X 1 m^2 plots at zero, five, ten, fifteen, and twenty m from the water's edge. Once a transect was selected, I marked the first plot at the river's edge (zero meters) and counted the macrofungi on all substrates, such as dead wood, live trees, leaf litter, soil, root tips, and rocks, up to eye level. I then moved five m further away from the stream to choose the second 1 X 1 m^2 plot. I continued this process up to a distance of 20 m from the river. The fungi were photographed and the substrate, amount of canopy cover, and weather were recorded. Also, an attempt was made to identify the species of fungi found.

Once all the data were collected, a Friedman's method for randomized blocks was used to see if there was a statistical difference in the number of fungi species at different distances from the water. Also, the mean number of species per distance and standard error were calculated to view any possible trends in fungal growth. Finally, I used a cumulative species curve to evaluate whether my sample was an exhaustive representation of the community.

RESULTS

A total of 33 species were found within the 20 transects. Five species were found at the zero m distances, seven were found at the five m distances, 13 were found at each of the ten and 15 m distances, and four were found at the 20 m distances. Four species were identified at the genus level, four at the species level, and one at the family level using Mata (1999) and Mata (et al. 2003). Also, there were six different substrate types including dead wood, live trees, rocks, soil, leaf litter, and end of root systems. Twenty-one of the 33 species were found on dead wood, seven on leaf litters, two on soils, and one each on a live tree, a rock, and root tips. The total Chi squared value for these data was 315.5 (Table 1; $p < 0.001$, df = 5). This value was calculated assuming all substrate types were equally abundant in the forest.

The data were analyzed using Friedman's method for randomized blocks. The Chi squared value was 9.18 (df = 4; $p > 0.005$). The mean number of species ranged from 0.20 (SE = 0.10) to 0.65 (SE = 0.11); see Fig. 1. A cumulative species curve was graphed and a polynomial of best fit was added to show if the sampling was representative (Figure 2).

DISCUSSION

This study examined fungal community richness in the Monteverde cloud forest at different distances along the Quebrada Máquina. I predicted to find higher richness at the closest distance because of increased sunlight and moisture. However, the results show that this prediction was not supported by the statistical analysis. Although there is no statistical difference between the richness at the five different distances, a trend can be seen in Figure 1. There is a peak in number of species around the middle distances (10 and 15 m) rather than at the closest or farthest distances. Also, the total Chi squared value for distribution of species on substrates shows the high variance from the expected number of species per substrate type. Finally, when looking at the cumulative species curve (Figure 2), the number of new species starts to plateau when moving up in plot number, suggesting that sampling was exhaustive because few new species were found as sampling continued.

These results imply that there may be more dead wood at 10 m and 15 m from the stream edge or that conditions there are more favorable for fungal growth than at zero m and 20 m. This could be a result of the rate at which the dead wood rots. According to

Delaney (1998), quantity of dead wood peaks in moist areas rather than wet or dry areas. In the very wet areas, dead wood rots more quickly than in the moist areas. Knowing that dead wood is an important and abundant source of carbon for fungi, having less right near the wet water edge, due to more rapid rotting, could be an explanation for why there is less richness at the closest distance and more richness in the middle, more moist plots.

Another possible reason for this trend could be the position of fallen canopy trees. These large, rotting trees provide abundant substrates for many fungi. They also create gaps in which sunlight can reach the forest floor (Longman et al. 1987). Since many of these trees fall towards the river, they are in more moist areas, which is favorable for most fungal growth. Also, the parts of the trees closest to the water will rot faster, leaving larger sections farther from the water. This is optimal for many species because there is also abundant sunlight available to aid in growth.

A third possible reason could be that the microclimate under the canopy is more stable at the middle distances than at the extremes. Soil that is exposed, as seen closer to the river, becomes more weathered which affects the growth of some organisms (Osborne 2000). This may also explain why there were fewer species found at the 20 m distances, where most of the plots were right on the edge of the hillside where erosion could be high.

For further study, I would suggest doing more specific testing on pH and oxygen levels in the soil. Both of these factors, as mentioned before, affect fungal growth. Also, I would look at how sunlight directly affects growth by comparing open areas (less canopy cover) to closed areas (more canopy cover). Finally, further study on the importance of dead wood as a substrate for fungi should be considered. Being a very common substrate does not necessarily mean that it is more abundant. It could imply that it is a better source of carbon for fungi, which would enhance growth, and, in turn, increase richness. Perhaps further examination of all of these factors combined could give a more exact answer as to why there is a tendency of higher fungal community richness at 10 m and 15 m from the stream.

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LITERATURE CITED

Alexopoulos, C.J., C.W. Mims, and M Blackwell. 1996. Introductory Mycology, ed. 4. John Wiley & Sons, Inc., U.S.A., pp. 28-31.

Arora, David. 1986. Mushrooms Demystified, 2nd ed. Ten Speed Press, Berkeley.

Clark, K.L., Lawton, R.O., and Butler, P.R. 2000. The Physical Environment. Monteverde, Ecology and Conservation of a Tropical Cloud Forest. N.M. Nadakarni and N.T. Wheelwright, editors. Oxford University Press, Oxford, pp. 15-30.

Delaney, M., S. Brown, A.E. Lugo, A.Torres-Lezama, and N. Bello Quintero. 1998. The Quantity and Turnover of Dead Wood in Permanent Forest Plots in Six Life Zones of Venezuela. Biotropica 30(1):2-11.

Herz, K. 2004. Fungal species richness in relation to substrate penetrability and moisture on the Atlantic slope. CIEE. Spring Tropical Ecology and Conservation.

Longman, K.A. and J. Jeník. 1987. Tropical forest and its environment, 2nd ed. Longman Scientific & Technical: 37-39.

Mata, M. 1999.Macrohongos de Costa Rica, Vol. 1. Instituto Nacional be Biodiversidad (INBio), Santo Domingo de Heredia, Costa Rica, pp. 11-26.

Mata, M., R. Halling, and G.M. Mueller. 2003. Macrohongos de Costa Rica, Vol. 2. Instituto Nacional de Biodiversidad (INBio), Santo Domingo de Heredia, Costa Rica, pp. 8-26.

Osborne, P.L. 2000. Tropical Ecosystems and Ecological Concepts. Cambridge University Press:40-43.

TABLES AND FIGURES

Table 1. Distribution of species on different substrates and corresponding total Chi square value

Substrate	**Observed frequency**
dead wood	21
live tree	1
leaf litter	7
root tip	1
rock	1
soil	2
Total Chi squared value	315.5

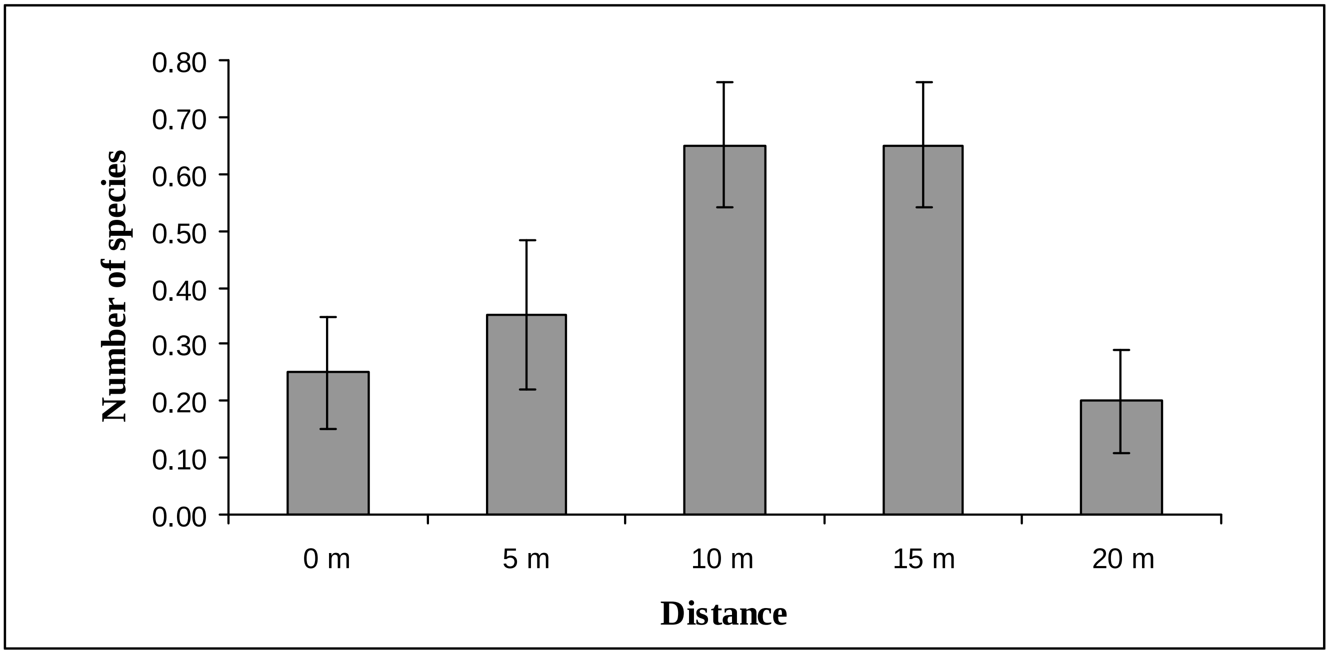

Figure 1. Mean number of species versus distance of plots and standard error. A slight trend is seen in that there are more species at middle distances.

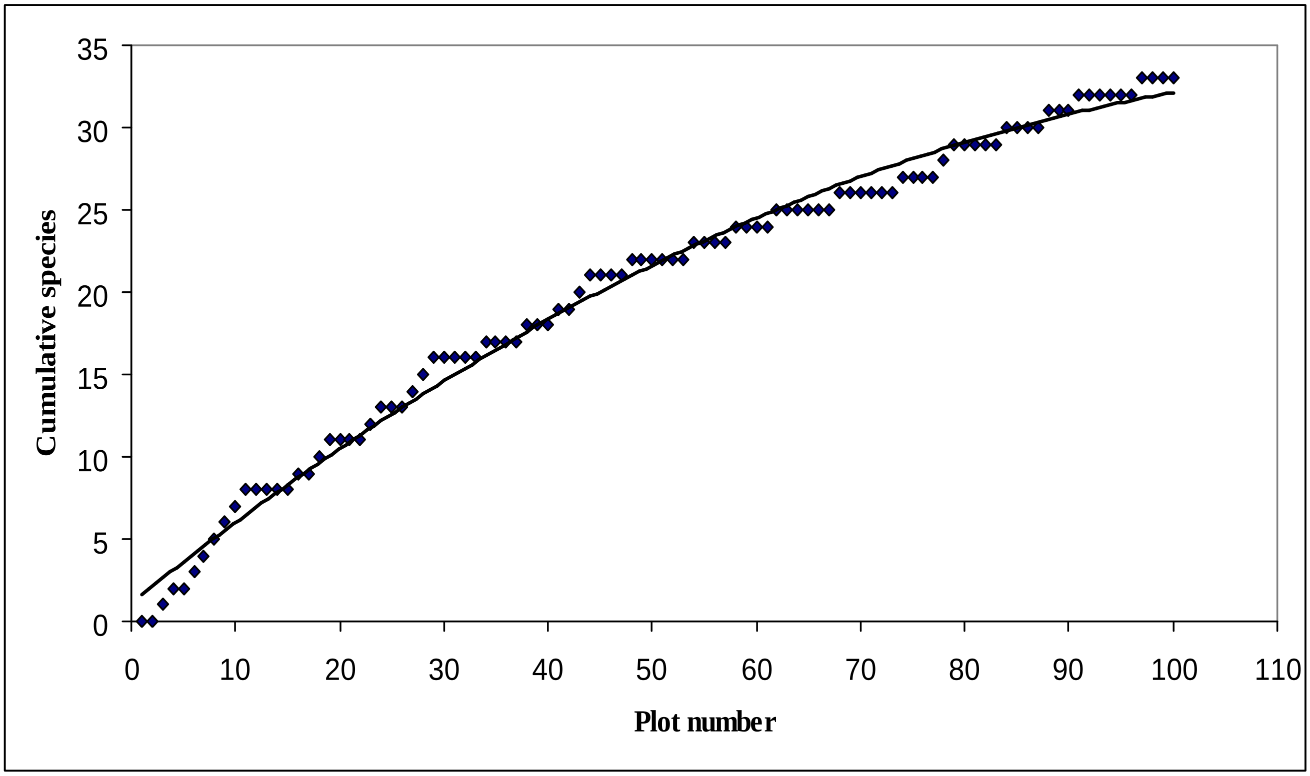

Figure 2. Cumulative species curve. Plot number refers to the one by one meter area used five times in each of the twenty transects, totally 100 plots. The points were graphed using a scatter plot and a polynomial of best fit was added. The equation for this polynomial is $y = -0.002x2 + 0.5094x + 1.1214$.