Wet season macrofungi of the Caribbean slope in Monteverde, Costa Rica

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ABSTRACT

Despite its small size, Costa Rica harbors high fungal diversity. Although very little is known about fungi, they are beneficial to humans in the medicinal field and are also known to be important recyclers of nutrients in ecosystems. Their importance in our lives justifies further research concerning fungal communities. The purpose of our study is to investigate the community composition and species richness in a lower montane rain forest on the Caribbean slope at Monteverde, Costa Rica. Between the range of1550 m and 1850 m, we recorded abundance of different morphological forms, substrate types and also compared species richness to canopy coverage, elevation, and pH level. A total of 40 morphospecies were found, of which 50% were toadstools. Additionally, 55% were found growing on soil substrates. We found no substantial correlation between canopy cover and species richness. There was a statistically significant trend for lower species richness at higher elevations (Spearman Rank Test, Rho = -0.80, p = 0.03, n = 7), and a nearly significant trend for greater species richness with increasing pH levels (Spearman Rank Test, Rho = -0.70, p = 0.08, n = 7). We found that as distance between transects increased, there was a trend for lowered similarity in fungal species composition (Spearman Rank Test, Rho = 0.36, p = 0.11, n = 21). Variability in Caribbean slope fungal communities is most likely caused by differences in abiotic (e.g. temperature, soil pH, wind, light availability) and biotic factors. Different tree communities and/or volcanic conditions of the area may control these factors.

RESUMEN

A pesar de su pequeño tamaño, Costa Rica alberga una diversidad alta de hongos. Aunque se sabe muy poco acerca de los hongos, se sabe que son beneficiosos para los seres humanos en el campo de la medicina y son conocidos también por ser importantes recicladores de nutrimentos en los ecosistemas. Su importancia en nuestras vidas justifica más investigación con respecto a las comunidades de hongos. El propósito de este estudio es investigar la composición de la comunidad y la riqueza de especies en un bosque lluvioso montano bajo en la ladera Caribe de Monteverde, Costa Rica. Entre el ámbito de 1550 m y 1850 m, se registró la abundancia de diferentes formas morfológicas, tipos de sustrtatos y también se comparó la riqueza de especies con respecto a la cobertura del dosel, a la elevación, y al nivel del pH. Se encontró un total de 40 morfoespecies, de las cuales 50% fueron hongos tipo sombrilla. Adicionalmente, se encontró que un 55% estaban creciendo en sustratos con suelo. No encontramos una correlación sustancial entre la cobertura del dosel y la riqueza de las especies. Hubo una tendencia estadísticamente significativa para una menor riqueza de especies en elevaciones altas (Test de Spearman Rank, Rho = -0.80, p = 0.03, n = 7), y una tendencia casi significativa para una riqueza mayor de especies con niveles de pH en aumento (Test de Spearman Rank, Rho = -0.70, p = 0.08, n = 7). Encontramos que entre más aumenta la distancia entre los transectos, hubo una tendencia en la disminución de la similitud en la composición de las especies de hongos (Test de Spearman Rank, Rho = 0.36, p = 0.11, n = 21). La variabilidad en las comunidades de hongos en la ladera Caribe es causada lo más probablemente por diferencias en factores abióticos (e.g. temperatura, suelo, pH, viento, disponibilidad de luz) y bióticos. Diferentes comunidades de árboles y/o condiciones volcánicas pueden controlar estos factores.

INTRODUCTION

Fungi are of great ecological and anthropocentric importance but are one of the most understudied kingdoms. Fungi, along with bacteria, are major recyclers within the environment. They are capable of taking complex organic compounds and breaking them down into less complex building blocks, which can then be utilized by other organisms. Without fungi and bacteria, nutrients in dead and organic matter would lay trapped in dead material (Aurora 1996). Mycorrhizal fungi have complex relationships crucial to nutrient uptake of tropical plants (Janos 1983). In the medical world, fungi have been used in AIDS research, to combat cancer, and to produce penicillin (Mata 1999). Costs associated with wood rot and crop loss from fungi can be astronomical (Alexopoulos 1996).

To reap their benefits and control their damage, fungi must be first identified and their ecological relationships understood. There are approximately 100,000 identified species of fungi worldwide. This number is miniscule when compared to the 1.5 million species that experts believe may exist (Hawksworth 1991). The most notably understudied areas of the world are tropical and subtropical regions (Alexopoulos 1996). In Costa Rica roughly two thousand species have been identified but an estimated 40,000 to 70,000 species are believed to inhabit this small country (Mata 1999). With the numerous benefits associated with fungi, it is not difficult to justify further research concerning fungal communities.

In the Monteverde area of Costa Rica a number of studies have been done on fungal communities along the Pacific slope (e.g., McCracken 1995, Wales 1998, Ciocca 2000, Herz 2004). However, the Caribbean slope remains largely neglected and both abiotic and biotic components of this slope indicate that fungal communities would differ from those found on the Pacific slope. On the Caribbean slope rainfall is consistent throughout the year, creating a nearly aseasonal climate. This differs from the Pacific slope weather system, which includes a five to six month dry season. There is also variation in the vegetation harbored on the two slopes, as species composition differs profoundly. Also, while the Pacific slope has a mix of evergreen species and deciduous trees, the trees of the Caribbean slope are all evergreen (Haber 2000). Vegetation may regulate the amount and type of resources available for fungal communities, and influence topsoil properties. Fungal communities are also sensitive to variations in precipitation, for example Polypores are less susceptible to desiccation than other fungal species (Hering 1966, Watling 1981, Guzmán 1994, Loreau 2000, all in: Munguia et al. 2005, Ciocca 2006). These differences are likely large enough to create differences in fungal community composition. It is because of this variation that we think a study of fungal communities on the Caribbean slope is worthwhile.

The purpose of our study is to investigate the community composition and species richness in a lower montane rain forest on the Caribbean slope at Monteverde, Costa Rica. We link our community parameters to elevational gradients, pH level, species richness, and canopy coverage. By looking at elevational gradients in relation to species richness, soil pH levels and canopy coverage, we can investigate possible correlations between them. In addition to the above, we provide basic descriptions of the Caribbean fungal community in terms of the morphological forms, and the substrates used by these fungi.

MATERIALS AND METHODS

Starting from the Monteverde Biological Station, we walked along the Sendero Principal in the direction of the Squatter's Shack, located on the ridge of the Continental Divide. From there an unmarked trail was followed down the Caribbean slope. At 1550 m on the Caribbean slope, four separate, twenty-meter transects were drawn at approximately a constant elevation. For each transect we recorded canopy coverage with a spherical densiometer, and soil pH level using a pH meter. Any macrofungi encountered within two meters on either side of the transect was photographed, and information such as morphological form and substrate type were recorded. Transects were studied in pairs parallel to one another to insure there was no crossing of transects or repeat specimens recorded. Sets of transects were walked on opposite sides of the trail to further insure there was no crossover between data sets. Transects were laid every fifty-meters, up to 1850 m above sea level. In total, data were taken at seven different elevations.

We calculated beta diversity between all possible pairs of transects. The equation we used was: $\gamma = \alpha * \beta *$ number of habitats, where γ = total number of species in two transects, α = the average species in the two transects, and the number of habitats is two transects.

RESULTS

A total of 40 morphospecies were found on the seven transects. We found seven different growth forms and recorded the relative abundance of each (Figure 1). Toadstools and shelf fungi were the most common, comprising 1/3 of the total data set. Macrofungi were observed growing on three different substrates: dead wood, soil, and leaf litter (Figure 2). Fourteen morphospecies were found on dead wood, twenty-two on soil and four on leaf litter.

We compared species richness per transect (elevation) to canopy coverage, elevation and pH level. We found a positive trend for greater species richness with more canopy cover, although it was not significant (Spearman Rank Test, Rho = -0.58, p = 0.17, n = 7, Figure 3). There was a statistically significant relationship between species richness and elevation (Spearman Rank Test, Rho = -0.80, p = 0.03, n = 7, Figure 4). As elevation increased, species richness decreased. There was also nearly a statistically significant negative correlation between species composition and pH level (Spearman Rank Test, Rho = -0.70, p = 0.08, n = 7, Figure 4). As elevation increased, pH level also increased.

Lastly, we measured beta diversity values of fungal communities compared to distance between elevations. We found that as distance between transects increased, there was a trend for lowered similarity in fungal species composition (Spearman Rank Test, Rho = 0.36, p = 0.11, n = 21, Figure 5). These results were not statistically significant.

DISCUSSION

In our study we found 40 morphospecies of macrofungi in total. The most common morphological type was toadstool fungus, which comprised 50% of our specimens, while shelf fungi only comprised 25%. This differs from a previous study done by Ciocca (2000), where she found approximately 37% of her specimens to be shelf fungi. This difference could be understood by the fact that Ciocca conducted her study during the dry season in Monteverde; shelf fungi are better adapted to drier conditions, which could explain why she would have found a larger proportion of these compared to other fungal morphologies on the Pacific slope. In contrast, fungi on the aseasonal Caribbean slope, which has a relatively higher amount of precipitation, would not harbor such a large fraction of desiccation-resistant growth forms.

The fungal community of the Caribbean slope was observed mainly on soil substrates (55% of our specimens), which differed from past studies on both the Pacific and Atlantic slopes. Williams (2006) found the majority of her specimens, 83.3%, growing on dead wood substrate. Her study was conducted during the dry season, a period that receives little wind-borne mist on the Pacific slope, which would explain why a higher percentage of her specimens might have been restricted to moisture-absorbent, dead wood substrates (Haber 2000). Another past study, conducted by Herz (2004) on the Caribbean slope, found only 10% of the recorded specimens on soil substrate, and 58% on dead wood. This pattern could be explained by a variation in the amount of dead wood available to fungal communities at different times. Tree falls are both spatially and temporally patchy. For example, a storm that caused an unusual amount of tree falls could have occurred previous to the Herz study, thus providing macrofungi with a larger amount of dead wood substrate than available during our survey.

We also found species richness to vary greatly between transects, with anywhere from three to eleven species at each. We did not find this variation to be significantly related to canopy coverage. This differs from a past study in which a trend for greater species richness in forested areas as opposed to light gaps was observed (McCracken 1995). An explanation could be that McCracken was studying more extreme differences in canopy cover conditions (complete canopy cover versus completely open light gaps), while our canopy coverage ranged from 54 to 82 %. Hence the difference in results between the two studies could be accounted for by differences in the range of canopy coverage considered.

We did, however, find a significant relationship between species richness and elevation, with fewer species at higher elevations. Herz (2004) ruled out the possibility of variability in dead wood characteristics (e.g. decay and moisture of fallen logs) at different elevations on the Caribbean slope as being the cause of this relationship. She found that the amount of decay and moisture content of fallen logs did not vary with changes in elevation. Ciocca (2000) found no correlation between species richness and elevation. However, our results suggest that soil pH could influence how many species are fruiting at any given time. As elevation increased, pH increased and species richness decreased. Possible explanations for why soil acidity would decrease with increasing elevation include variable forest composition and patchiness of volcanic ash. Different species of trees, which have varying elevational ranges, have diverse effects on soil chemistry. It is possible that lower elevations contain assemblages of trees that increase the acidity of the soil. Volcanoes in close proximity to Monteverde, such the highly active Arenal, may also have an effect on pH level. After an eruption, volcanic ash, which is basic, would fall on the tops of the surrounding mountains, thereby changing the soil pH of that area.

Lastly, we found that as distance increases between transects, there is less similarity in fungal community composition. This increasing variability in communities would most likely be caused by greater differences in abiotic (e.g. temperature, soil pH, wind, light availability) and biotic (e.g. tree communities) factors. However, Ciocca (2000) did not find a similar trend in her study of the Caribbean slope. One possible reason for this is that she conducted her study over a longer period of time and was able to collect a larger sample size. Adding to this sample size is essential for drawing any definitive conclusions. Future studies concerning the variability of species composition as a factor of distance would be useful in determining which abiotic/biotic factors, if any, influence fungal communities.

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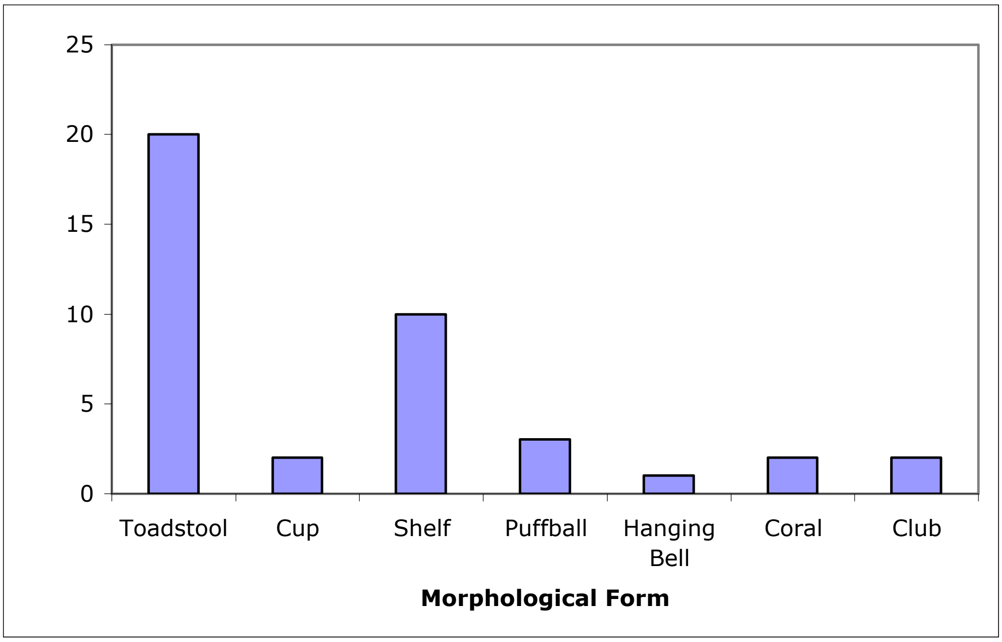

Figure 1. The number of specimens found of each morphological form on the Caribbean slope of the Continental Divide near Monteverde, Costa Rica from 1550 – 1850 m. Toadstools comprised 50% of the 40 morphospecies found.

Figure 2. Frequency of fungi species found on various substrates on the Caribbean slope of the Continental Divide near Monteverde, Costa Rica from 1550 – 1850 m. More species were found on soil and dead wood substrates than leaf litter. Out of the 40 morphospecies, 55% were found on soil substrate.

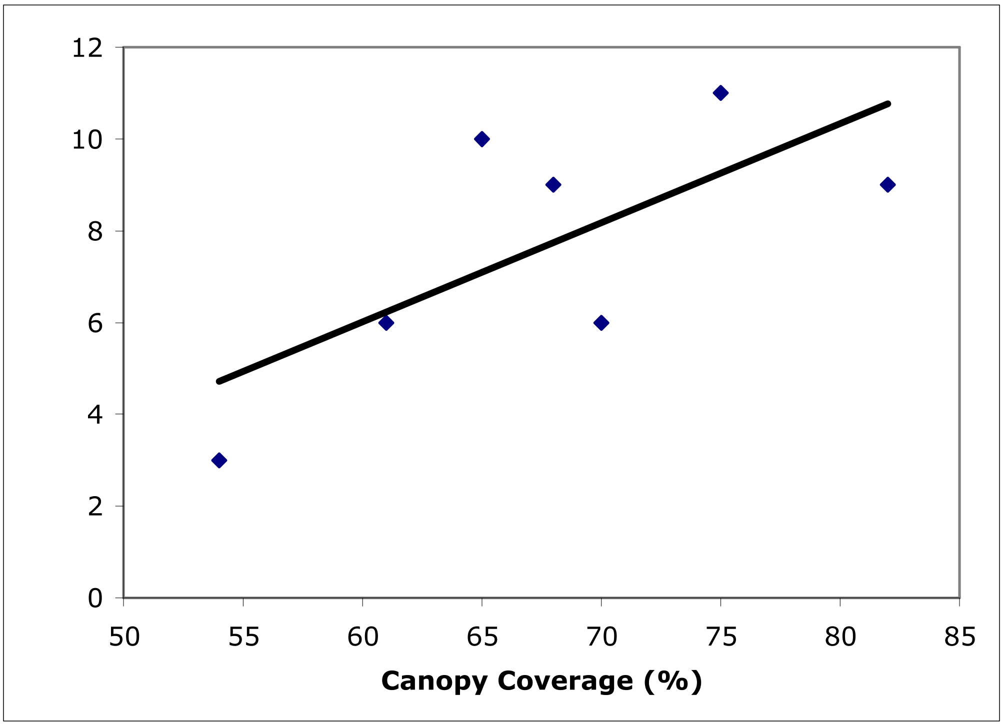

Figure 3. Fungal species richness compared to percent canopy coverage on the Caribbean slope. There was a positive trend for greater species richness with more canopy cover.

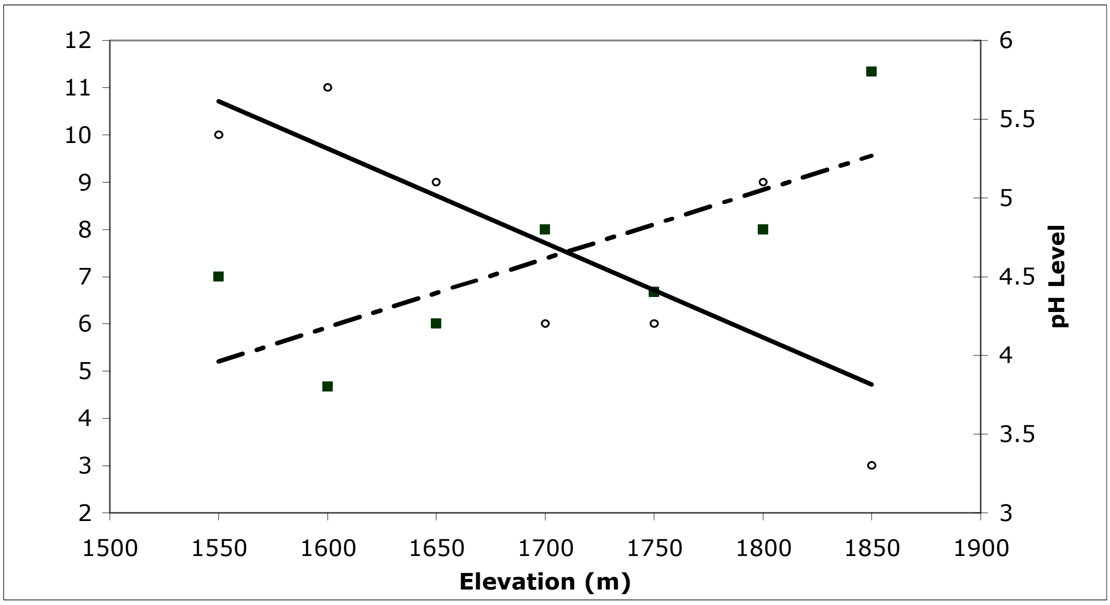

Figure 4. Elevation compared to fungal species richness and pH level. Solid line and empty circles refer to species richness and dashed line and solid squares refer to pH level. There was a statistically significant relationship between species richness and elevation. There was nearly a statistically significant negative correlation between species composition and pH level.

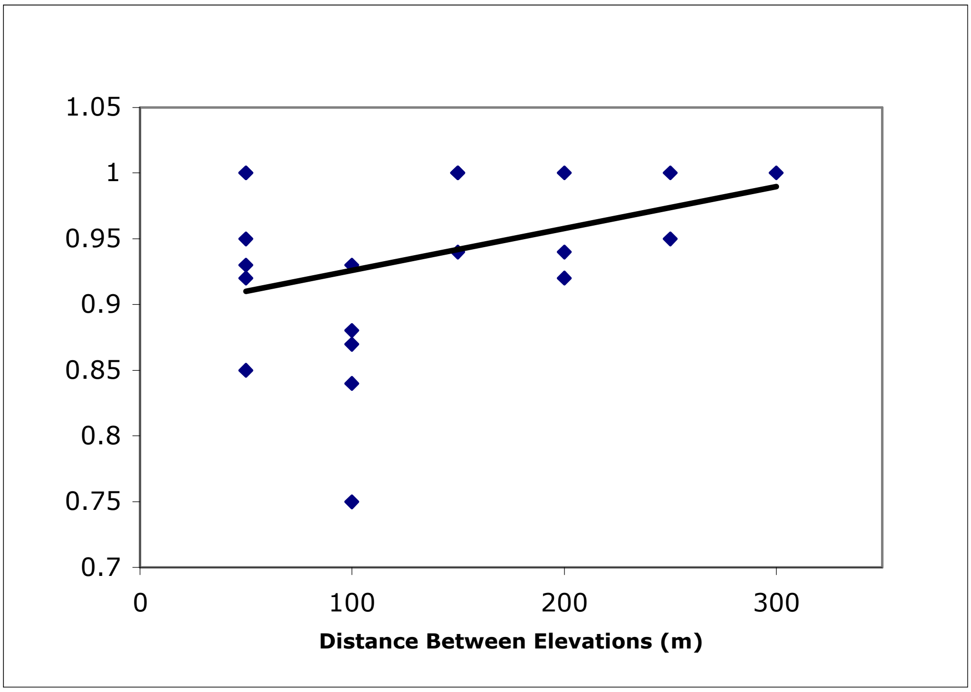

Figure 5. Beta diversity values of fungal communities compared to distance between elevations. As distance increases between elevations, the lower the similarity in fungal species composition.