Habitat and diversity of cloud forest invertebrates

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ABSTRACT

This study addresses the effects of abiotic conditions on canopy soil macroinvertebrate diversity by examining five Pacific and five Atlantic slope trees near the Biological Station in Monteverde, Costa Rica. Trees were sampled using single rope climbing technique, and macroinvertebrate were separated from soil samples in Berlese funnels the same day of collection. The meta-community, both slopes as one community showed that Coleoptera, Hymenoptera, and Hemiptera : Homoptera are the major taxa present. The two communities failed to show significant differences in their diversity (modified t-test = 1.03, $p > 0.05$), richness, and evenness from abiotic conditions. Biotic conditions must be the dominating factor controlling species overlap (8 species) between slopes. This is most likely due to interspecific interaction of invertebrates with plants. Random assortment probably controls most of the invertebrate assemblage for each individual tree.

RESUMEN

Este estudio dirige los efectos de condiciones no bióticas en la diversidad de macroinvertebrate de tierra de dosel examinando cinco arboles pacífico y cinco árboles del atlánticos de la pendiente cerca de la Estación Biológica en Monteverde, Costa Rica. Los árboles se muestrearon utilizando una técnica de escalada con una sola cuerda y los macroinvertebrados fueron separados en muestras de suelo en túneles de Berlese el mismo día de la colección. La meta-comunidad de, ambas las pendientes como una comunidad mostró que Coleoptera, Hymenoptera, y Hemiptera: Homoptera son las taxa mayormente presentes. Las dos comunidades fallaron al mostrar las diferencias significativas en su diversidad (la T-prueba modificada = 1,03, P> 0,05), riqueza, y la uniformidad de condiciones no bióticas. Las condiciones bióticas deben ser el factor que domina o que controla la superposición de la especie (8 especie) entre cuestas. Esto es muy probable debido a la interacción de interspecific de los invertebrados con las plantas. La chistes bucion aleatoria controla probablemente la mayor parte de la colección del invertebrado para cada árbol individual.

INTRODUCTION

Many trees in tropical cloud forests harbor epiphytes that both create and maintain a layer of rotting organic matter along branches in the canopy. Epiphyte roots accumulate and hold plant litter but also contribute dead matter as they die or drop dead material on their host branches (Nadkarni and Matelson 1991). The presence of decaying matter encourages further growth of epiphytes and deposition of decomposing material; thus, a crown of organic humus begins to develop in these large canopy trees locked in place by the expanding root mass (Yanoviak et al. 2004).

These crowns of humus, much like the soil on the ground, are filled with decomposers and other organisms that are important to nutrient cycling (Wardle, et al. 2003). A study by Paoletii et al. (1991) comparing canopy and terrestrial soil invertebrates demonstrated that invertebrate family diversity and composition were similar, despite the different abiotic conditions between the two microhabitats. The study did reveal, however, that densities of macro arthropods were much greater in canopy soils. Although environmental conditions played a role in the density of arthropods between ground and arboreal soils, comparisons between two distinct canopy communities that experience different climatic conditions should provide insight if variable environmental conditions alter community density alone, or if they are responsible for community composition and diversity. I believe that a comparison of crown humus between two climatically different habitats would reveal a significant difference in arthropod abundance, if not also richness at the order level.

I propose to compare the composition diversity, abundance, and richness of invertebrate communities in canopy soil of trees located on windward and leeward slopes behind the Biological Station, in Monteverde, Costa Rica. Each slope has a significantly different habitat; the Pacific (leeward) being more seasonal and typically less wet than the aseasonal Atlantic (windward) slope (Clark et al. 2000). Wind and water levels are more exaggerated in canopy soil due to their exposed location at the top of trees, making them more vulnerable to changes in the environment. A study of canopy arthropod densities along a vertical stratification showed that arthropod populations peaked in size in the coolest and wettest part of the tree (Dial et al. 2006). Dramatic in soil moisture should create different levels of decomposition, which should have a strong influence on soil nutrient availability. This should alter diversity, abundance, richness, and composition for each slope's crown humus.

METHODS

I studied ten trees in the lower montane wet forest Holdridge life zone during the late dry season and very early wet season (April 9th-May 5^{th}) (Clark et al. 2000; Haber 2000). Five trees were selected on the Atlantic slope around 1680 m and five trees were selected on Pacific slope ranging from 1460-1700 m in the forest behind the Monteverde Biological Station Monteverde, Costa Rica. Trees were climbed based on their accessibility and possibly quantity of canopy soil available for extraction. I climbed each tree using a single rope technique (Moffett and Lowman 1995). I removed about one liter of soil from each tree by hand at heights ranging from nine to 18 m. Soil was removed from tree crotches and epiphytic root mats, with an emphasis on avoiding moss-covered soil.

On the day of collection, I placed the soil in a Berlese funnels set-up, which was six plastic funnels with light bulbs (70 watts) suspended above them and allowed the sample to sit for 24 hours (Southwood 1978). After 24 hours, I removed the soil and sorted the dried remains by hand for remaining invertebrates. All other invertebrates were collected from the Berlese funnel collection bottle. Invertebrates were placed in collection vial with alcohol, and the dry soil samples were stored in plastic bags and both were labeled with their corresponding slope.

After invertebrates were separated from the soil mats, I used a dissecting scope and classified them to Class, Order, and morphospecies. I also did soil tests on the dry soil for nitrogen, potassium, pH, and phosphorous using a La Motte soil testing kit and classified amounts in a qualitative form (e.g. trace, low, medium, high) with a corresponding numerical value for quantitative tests.

I calculated a Sorenson's similarity index value, evenness, species richness. I also conducted a Shannon-Weiner test for the meta-community, each slope, and each tree individually. I did a modified t-test using the H' values from the Shannon-Weiner test between the two slopes. I calculated species area curves for each slope for the cumulative number of new species found in the order that the trees were sampled.

RESULTS

The diversity of between the Pacific slope (H' = 3.10) and the Atlantic slope (H' = 2.99) was not significantly different (Modified t-test, $t = 1.03$, $p > 0.05$). I calculated H', evenness, total number of individuals, and species richness for each slope, and each individual tree (Table1, Figures 1, 2). Sorenson's quantitative diversity index for the Atlantic and Pacific slopes ($C_N = 0.282$) showed some overlap in the diversity of species on each slope. I tabulated and calculated overlapping species of each community and their Order's relative percentages in regards to overall canopy composition (Table 2). A species area curve (Figure 3) shows the cumulative species acquisition after sampling ten canopy soils.

Soil tests showed variable pH and phosphorous levels and uniformly low nitrogen and high potassium concentrations across all canopy soils concentrations in all canopy soils regardless of slope (Table 3). At the community level I calculated Spearman's Rank correlations for species richness, evenness, abundance, and diversity to see if the pH, potassium, nitrogen, and phosphorous and height had any relationship to species richness, evenness, abundance, or diversity; no trend was found for any parameter (Table 4). I also did the same correlation test for the Orders Coleoptera and Hemiptera: Homoptera versus the soil chemistry and height, and again, no trend was found (table 4).

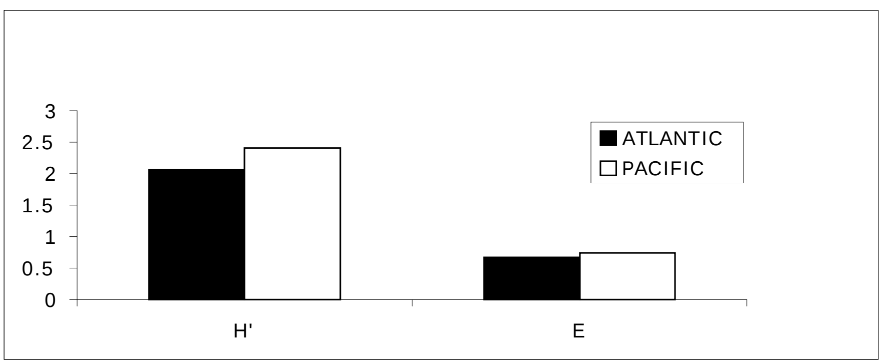

Figure 1. The Shannon-Weiner diversity index (H') and eveness (E) values for Atlantic and Pacific canopy soil macroinvertebrate communities in a cloud forest near Monteverde, Costa Rica. (N = 5 trees for each slope)

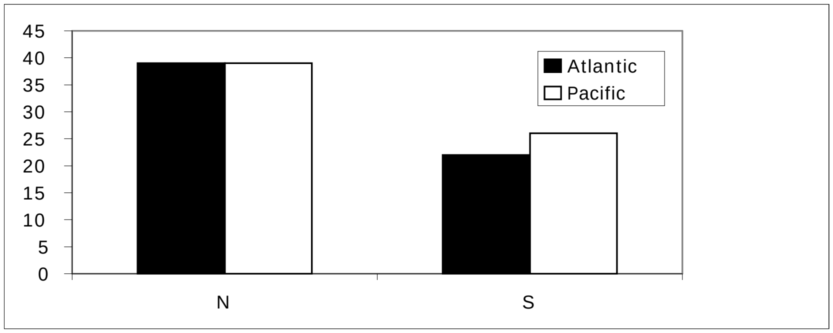

Figure 2. The number of individuals (N) and the number of species (S) for the Atlantic and Pacific canopy soil macroinvertebrate communities in a cloud forest near Monteverde, Costa Rica. (n = 5 trees for each slope).

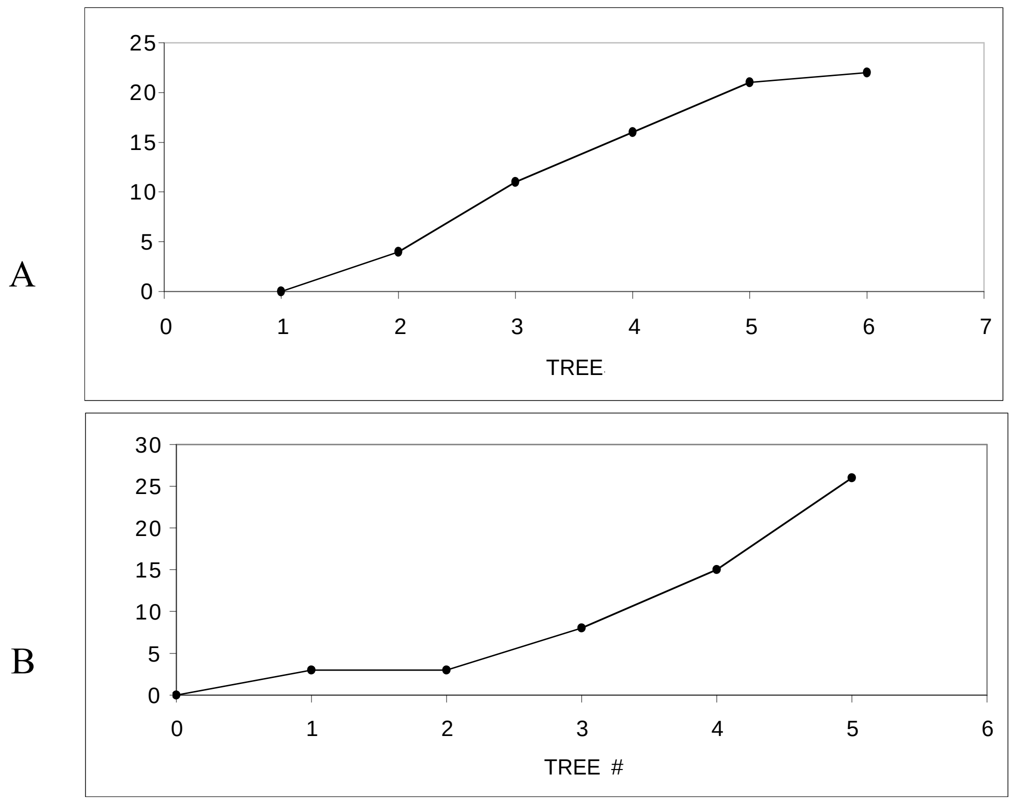

Figure 3. These species area curves show the rate of cumulative species accumulation in the order the trees were sampled in (n = 5 trees). The top graph (A) is for the Atlantic slope species accumulation and the bottom graph (B) is for the Pacific slope. Samples were taken from a cloud forest near Monteverde, Costa Rica.

Table 1. Values for the Shannon-Weiner diversity test (H'), evenness (E), number of individuals (N), and number of species (S) for Pacific(P1-P5) and Atlantic(A1-A5) slope canopy soil macroinvertebrate communities in a cloud forest near Monteverde, Costa Rica. (n = 5 trees for each slope).

	H'	E	N	S
P1	0.34	0.10	4	3
P2	0.00	0.00	0	0
P3	0.67	0.20	9	5
P4	0.76	0.23	10	7
P5	1.20	0.37	16	11
A1	0.52	0.17	4	4
A2	0.81	0.26	7	8
A3	0.72	0.23	7	7
A4	0.95	0.31	9	8
A5	0.28	0.09	3	3
OverallAtlantic	2.99	0.97	39	24
Overall Pacific	3.10	0.95	39	26

Table 2. The number of shared species between Atlantic and Pacific slope canopy soil macroinvertebrates from a cloud forest near Monteverde, Costa Rica. The relative percentages of shared species in regards to both communities' S is presented in the far right column. Beetles and their larvae are responsible for the largest percentages.

Shared Species	Pacific	Atlantic	Totals	Overall Percentage
Beetle Larvae	3	2	5	0.06
White Spotted Beetle	2	1	3	0.04
Tiny Long Snout Beetle	2	1	3	0.04
Elongated Beetle	4	3	7	0.09
Striped Spider	1	1	2	0.03
Spiny Third Leg	1	1	2	0.03
Centipede	1	1	1	0.01
Millipede	1	3	4	0.05

Table 3. Soil data for ten soil samples collected from a cloud forest near Monteverde, Costa Rica. The numbers next to the qualitative descriptions in Phosphorous are a ranking of 1-3, with regards to each trees relative concentration in terms of their description. The far left column shows Atlantic slope trees (A1-A5) and the Pacific Slope trees (P1-P5).

	Nitrogen	Phosophorous	Potassium	pH
A1	Trace	Medium(2)	Very High	5.2
A2	Trace	High(3)	Very High	4.6
A3	Trace	Low(1)	Very High	4.8
A4	Trace	High(3)	Very High	7.4
A5	Trace	Medium(2)	Very High	5.2
P1	Trace	Low(1)	Very High	5.2
P2	Trace	Medium(2)	Very High	4.6
P3	Trace	Low(1)	Very High	4.3
P4	Trace	Low(1)	Very High	5.1
P5	Trace	Medium(2)	Very High	4.8

Table 4. Spearman's Rank correlations comparing soil chemistry with its effects on species richness, diversity, evenness and overall abundance of canopy soil collected from Monteverde, Costa Rica. It also looked for any patterns associated with the Orders Coleoptera and Hemiptera. The p-values for all these correlations were above 0.05, with no significant relationship.

	Rho Value		
	P	pH	Height(m)
S	0.31	-0.04	0.18
H'	0.29	0.01	0.17
E	0.29	0.01	0.17
N	-0.10	-0.10	-0.09
Coleoptera	-0.14	0.34	-0.07
Hemiptera	-0.17	0.68	-0.03

DISCUSSION

There are three levels to analyze this diversity data, at the meta-community level, the local level with slope comparisons, and then at the individual level with tree-to-tree comparisons. The meta-community, both slopes as one community, had a composition that was dominated at the Order level by three major taxa, Coleoptera, Hymenoptera, and Hemiptera:Homoptera. This domination matches current known abundances of insect Orders (Arnett et al. 1981). Species area curves show that not enough sampling has taken place, but there has been enough sampling to show that the invertebrates are at or very close their theoretical distributions.

At the local community level, each slope is a community, Shannon-Weiner diversity values, evenness, species abundance, and species richness can be compared. These values did not differ between the communities significantly. The difference between the two local communities was what types of morpho species were present. There was an overlap of eight morpho species between the two communities. Commonness within the community appears to not determine overlap, because abundant taxa and non-abundant taxa are present. Abiotic conditions probably did not result in the overlap of each slope. Besides soil moisture, each side was significantly the same in terms of their soil chemistry. There was a presence of a notable beetle population in both communities. This may be related to possible host specific interactions between beetles and epiphytes that are present in both communities (Odegaard 2000). The other species present may be there through random chance, although Odegaard in 2000 does mention in his study that it is a possibility that community structure in a tree may be dependent on the presence of certain organisms.

At the individual community level, each tree represents a single community that, due to sampling, is separate from other study trees. These individual communities varied quite a bit in their individual abundances and richness. Correlations revealed that the height of sample, pH, and phosphorous were not related to diversity, evenness, richness and abundance values. Nor were the Orders Coleoptera and Hemiptera:Homoptera related to abiotic conditions. This puts an emphasis that these trees assemblages are not dominated by abiotic conditions, but probably by random chance and biological interactions. While many physical pathways such as lianas may connect these two communities, it appears that each individual patch of soil's invertebrates is not dominated by mere connections alone (Paoletti et al. 1991). Random assortment is possible, but colonization rates of the canopy soil may influence each tree's soil diversity (Moran and Southwood 1982; Wardle et al. 2003). If colonization is the main driving force then size of the soil and its relative age in the tree would be factors in how many species would be present in the soil. A biological explanation is possible, but there was no strong trend of certain individuals being present across all the samples like there was at the local community level with the beetles, random assortment is probably the most logical and easier explanation (Moran and Southwood 1982).

Aseasonality and seasonality may not be a contributor to strong changes in the soil chemistry that may influence the diversity of the two communities. The lack of significant difference between the two communities shows that biological factors affect to these communities. There was evidence that some beetles are related to possible biological assorting due to possible host specific interactions due to their presence on both slopes. The possibility of a stochastic model existing for the assembly of a general tree is quite possible, due to the variation of recorded of each tree.

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