

Liana size class diversity across three forest habitats

Janelle Burke

Department of Behavioral Biology, Johns Hopkins University

ABSTRACT

The purpose of this study was to see how forest edge, primary and secondary habitats affect average size and size class diversity of lianas in a cloud forest in Monteverde, Costa Rica. Three 625 m² sites were studied in primary and secondary forests, and along the edge of a forest. Exhaustive sampling of lianas was taken of four continuous plots within each habitat: all individuals were measured for PBH (perimeter at breast height). The primary forest was the most diverse according to the Shannon-Weiner index of diversity ($H' = 0.918$), and the oldest judging by mean perimeter (3.87 ± 0.34 cm). In terms of significant differences in diversity indices, the secondary habitat differed significantly from the edge and primary habitats, while the primary and edge did not. The mean age of the primary varied significantly from the other two habitats, while the secondary and edge did not show significant variation. Furthermore plot 1 varied significantly from plot 3 and 4 within the primary habitat. These results are probably a consequence of the ecotone qualities of the edge site and the small-scale heterogeneity of disturbance history within the primary site.

RESUMEN

Examiné diferencias entre tamaño y edad de las lianas en un bosque nuboso en Monteverde, Costa Rica. El propósito de este estudio era para ver como el crecimiento del borde, primario, y secundario se afecta diversidad de la clase del tamaño. Tres sitios de 625m² fueron estudiados en los bosques primarios y secundarios, y a lo largo del borde de un bosque. El muestreo exhaustivo de lianas fue tomado de cuatro diagramas continuos dentro de cada sitio por perímetro en la altura del pecho (PBH). El bosque primario era el más diverso según el índice de Shannon-Weiner de la diversidad ($H' = 0.918$), y la más vieja por el perímetro del medio (3.87 ± 0.34 cm). No todos los sitios variaron en una manera significativa a cada uno en términos de la clase edad de la diversidad y del tamaño. Esta es probablemente una consecuencia de las calidades como un *ecotone* del sitio el borde y la heterogeneidad en escala pequeña de la edad dentro del sitio primario.

INTRODUCTION

Lianas are a plant growth form that peak in species diversity in the tropics. They are a large part of the composition of tropical forests, contributing to the cloud forest integrity. It is not uncommon for lianas to produce 40% of the leaves and 25% of woody stem density (Haber 2000; Laurance *et al.* 2001; Schintzer & Bongers 2002). High transpiration rates also make them an important tropical nutrient cyler (Gerwing & Vidal 2002). These woody vines are adapted to ascend trees before sprawling across the

canopy, where they damage trees by weighing them down, block sunlight and absorb valuable nutrients from their hosts. Once a liana establishes itself on a tree, it provides an easier pathway for other climbers to wrap around (Forsyth & Miyata 1984), thus affecting forest structure by escalating even more tree damage.

More studies are focusing on liana growth at forest edges due to increased fragmentation created by deforestation in tropical forests (Laurance *et al.* 1998). The study of edges and their effects is essential to conservation because much of the remaining forest has a high edge to interior ratio. Abiotic changes on the edge include increased exposure to wind and sunlight. These conditions cause changes in species composition, population dynamics, and a rise in invasive species. While both changes in populations and abiotic factors lead to increased tree mortality and damage (Pimm 1998).

Lianas may compound edge effects by increasing tree mortality and damage already caused by increased exposure to wind and sun. Lianas are similar to pioneer species in their response to disturbances (Schintzer *et al.* 2000). Laurance *et al.* (1998) states that they are “light loving, and respond well to forest disturbances”. It is now well documented that liana abundance increases near forest edges, proliferating not only in numbers, but also in species richness (Haber 2000; Schnitzer & Bongers 2002). Liana abundance correlates negatively with tree biomass, showing they are likely to impede the regeneration of trees at forest edges (Laurance *et al.* 2002; Schintzer *et al.* 2000).

Not only the abundance, but also the sizes of lianas vary across habitats. A tangle of small lianas is an indicator of a forest edge, while lianas with large diameter are indicative of an older growth forest (Laurance *et al.* 2001). Though many studies have focused on species diversities within different forest types, there are not many studies documenting liana size class diversity (Gerwing & Vidal 1998). Forest fragments are known to lose species richness, and may also lose liana size class diversity (Pimm 1998). Classifying lianas by size may be another way to quantify diversity, age, and overall health of a forest.

I hypothesize that the diversity in size classes will vary between primary, secondary and edge habitats. I predict that class richness and evenness will be highest in primary forest, due to old age of growth and limited disturbance effects. I predict that secondary forest and edge – affected fragments will exhibit lower diversity as well as greater stem abundance due to the younger growth and increased disturbance conditions. The age differences, as determined by liana size, between the forest types will be distinct. Thus liana site diversity may be a way to quantify the state and age of a forest.

METHODS

This month long study, from April-May 2003, was conducted on the property of La Estación Biológica Monteverde, Puntarenas, Costa Rica. This area is described as Lower Wet Forest with an altitude of 1500 m (*sensu* Holdridge). Data were collected from April-May 2003.

HABITAT SELECTION – Three habitat sites, each 625m², were chosen based upon forest growth type and accessibility. The primary forest site was selected 700 m behind the station. The secondary forest sample was 400 m behind the station (to avoid edge effects which can penetrate 300 m into the interior). The edge habitat was chosen alongside a pasture near the station. Each habitat was divided into four smaller continuous plots. The secondary plots were 12.5 x 12.5 m. Edge and primary habitats were rectangular and had plots arranged in linear 10.5 x 15 m segments.

LIANA SAMPLING – An exhaustive census of all lianas in each plot and habitat was taken. Liana perimeter was measured in centimeters at breast height and marked to prevent redundancy. Vines and hemiepiphytes were disregarded. Then size classes were assigned to each liana to allow an ample amount of classes. Lianas were classified by size class starting from < 1 cm, and going up by increments of 1 cm until > 20 cm. Lianas over 20 cm were considered a class of their own.

STATISTICAL ANALYSES – A Shannon-Weiner index calculated H' (diversity) and E (evenness) between sites (Zar 1984). A pairwise comparison statistically compared H' values for differences. A one-way ANOVA compared the average sizes of each habitat and the plots within the primary forest habitat.

RESULTS

A total of 400 lianas were measured: 120 in the edge, 142 in the primary and 138 in the edge site (Table 1). Pairwise comparisons of H' using a modified t-test showed a significant variation of liana size class diversity between primary and secondary forest and significant difference between secondary forest and edge (Figure 1). A one-way ANOVA showed a significant difference in mean perimeter of lianas between the primary forest and the edge and the primary and secondary forest (Figure 2). This measure of mean age variance was also showed a significant difference between the plots 1: 3 and 1: 4 of the primary forest (Figure 3; Fisher's PLSD $p = 0.0141$; $p = 0.0143$). Within the primary site, the H' values also varied between plots: plot 1 = 1.07, 2 = 0.790, 3 = 0.626, and 4 = 0.784. The Edge and secondary plots did not show significant variation between plots (One-way ANOVA, secondary $p = 0.4258$, edge $p = 0.8197$).

DISCUSSION

This study investigated the differences in liana size class diversity and mean liana age across three habitats. The size class diversity of the secondary forest was significantly lower than the edge and primary as expected, however edge and primary forest diversity did not differ significantly. The primary habitat had a higher mean size than did the other two habitats, and it also varied between plots within the site due to small – scale heterogeneity.

I expected there to be a significant difference in the diversity of size classes between primary and edge habitats because of the differences in abiotic factors of lianas varies across habitats (Ibarra-Manríquez & Martínez – Ramos 2002). Instead, I found that there was no significant difference between the two (Figure 1). This lack of difference may be due to the history and conditions of the habitat site chosen. The edge disturbance created by fragmentation allows ideal conditions for liana proliferation due to increased sunlight. Because this disturbance occurs on a short temporal scale, the new proliferation of lianas will be the same age. This is true for the clear-cutting regrowth of the secondary forest as well. I thought this would create a lower evenness in the edge due an abundance of lianas within the same size class.

The edge habitat exhibited larger perimeters of lianas within more size classes than expected (Figure 2). The presence of large lianas are usually only found in old growth forests due to their slow annual growth in diameter (Gerwing & Vidal 2002). The interior of the forest experienced another type of disturbance as well: selective logging. Ninety percent of lianas survive tree falls, indicating they could survive selective logging (Schnitzer & Bongers 2002). A few large trees remained standing, and the lianas along with them. Therefore the interior of the forest had more of a habitat of a closed, older growth forest while the edge is more open with abiotic characteristics of a pasture. The influence of forest types within the edge habitat makes it an ecotone. The edge ecotone will show the limited size classes like the disturbed secondary forest, and larger lianas like the primary forest.

The mean liana perimeter in each habitat can indicate forest age. The results show the mean for the secondary was lowest, followed by edge and primary (Figure 2). Recent disturbance will lower the overall age of the habitat. The edge and secondary means were not statistically distinct, presumably due to the high levels of disturbance at both sites. The secondary habitat, which had been clear-cut in the past, showed the lowest age, while the edge had the second highest mean perimeter, probably due to the ecotone qualities of the habitat. Though there was a recent disturbance, the interior of the forest had older sectors. As expected, the primary forest reported the highest mean perimeter since it is the oldest.

I assumed that age within habitats would be uniform; however between plot age comparisons revealed inter-site heterogeneity in the primary site (Figure 3). Plot one showed the highest mean perimeter, indicating the oldest forest. This plot showed significant variation from plots 3 and 4. This shows subtle differences in age within the primary forest mosaic. This is an important contrast to the secondary plot, which all plots had been going through succession on the same temporal scale. In the past, the primary plots probably had limited impact disturbances on a smaller scale, which created this heterogeneity in age.

The data did not show a high abundance of lianas on the edge. This may be explained by the observed presence of other climbers. The edge also shows a proliferation of vines and secondary growth (Laurance *et al.* 1998). Smilax, aroids and other vines were very common and created a tangled, dense understory. I observed an increased percentage of trees with some type of climber. A lower instance of lianas than

expected could be due to the abundance of vines. The vines fill the same niche by responding the same way to disturbances and using the same growth form. This may impede the growth of lianas if their growing substrates are already filled with vines. Furthermore, level of forest disturbance and tree biomass are other predictors of liana abundance, not just distance from edge (Laurance *et al.* 2001). The disturbance within the forest interior or the density of trees could also play a role in the abundance of lianas in each habitat.

In conclusion, variations in liana size class diversity, age and abundance between habitats have wider implications for the composition of the forest. The proliferation of lianas of the same size may cause increased tree damage with succession. Over time, the older secondary forest will probably have a greater instance of larger perimeter lianas. This effect may be worse in the edge disturbance due to the thicker liana sizes in the interior and more small ones caused by the disturbance.

These liana distributions will limit light resources for the regeneration of trees. They may increase the frequency of tree fall disturbances with their added weight. A more heterogeneous distribution of liana sizes, as exhibited by the primary habitat, is probably beneficial for tree productivity because the trees will not be laden with lianas within the same size class. Overall, the disturbances created by edge effects are beneficial to liana species diversity, but they may inhibit species diversity and regeneration of other growth forms.

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TABLE 1. *Richness indices of liana size classes for three forest types. N refers to number of individual lianas in the habitat, and S is the number of size classes recorded.*

Site	N	S	S(marg)	E
Edge	120	11	2.10	0.784
Primary	142	17	3.23	0.746
Secondary	138	6	1.01	0.770

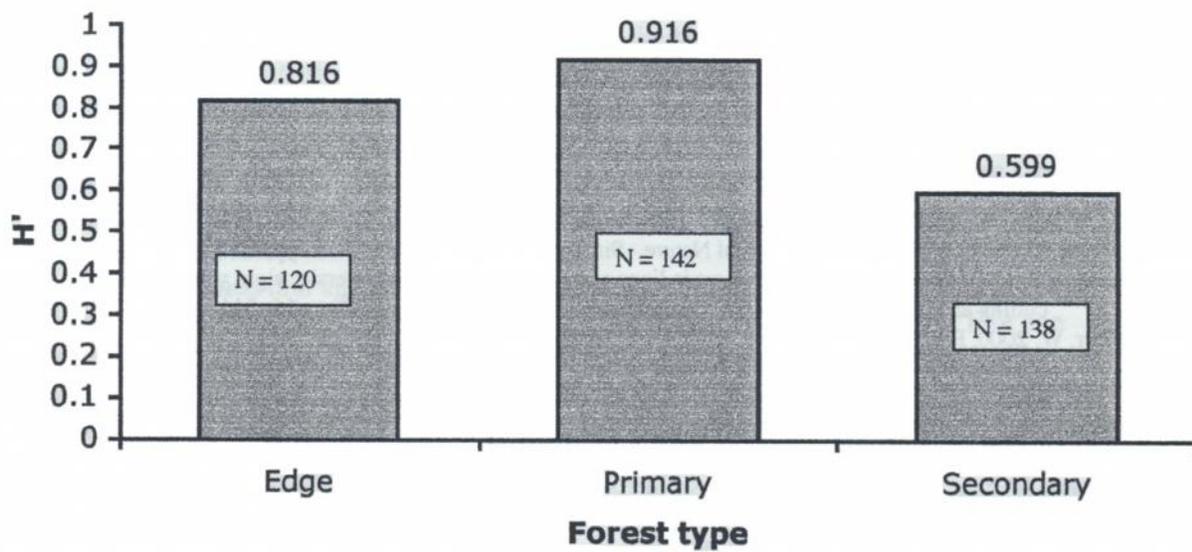


FIGURE 1. Mean diversity indices of liana class sizes for three forest types. Modified t-test showed secondary forest significantly lower from primary and edge ($t = 6.365$, $DF = 244$; $t = 2.326$, $DF = 229$, respectively).

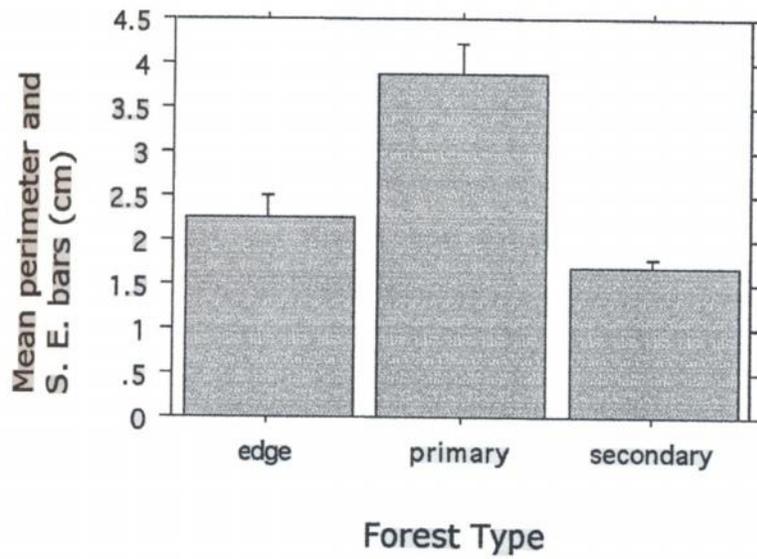


FIGURE 2. Mean liana perimeter for three different forest types. Lianas of primary forest are significantly larger than edge and secondary (One-way ANOVA, $F = 21.047$, $p < 0.0001$, model DF = 398).

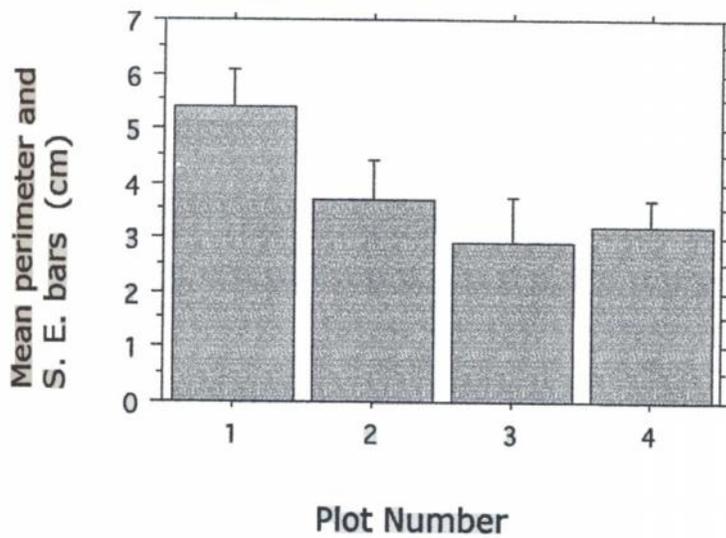


FIGURE 3. Mean liana perimeter of the four plots within the primary site. Plot 1 varied significantly from plots 3 and 4 (One-way ANOVA, $F = 2.851$, $p = 01.097$, model DF = 139).
