DETERMINATES OF CANOPY EPIPHYTE ABUNDANCE IN A PRIMARY LOWER MONTANE CLOUD FOREST IN CLOUDBRIDGE NATURE RESERVE, COSTA RICA

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ABSTRACT

Epiphytes play an integral role in neotropical rainforest ecosystems. Thus, it is important to understand factors that contribute to the presence or absence of epiphytic growth. The purpose of this study was to determine correlations among height, diameter at breast height (dbh), aspect, slope, and tree species with respect to epiphyte abundance. We sampled 720 trees within a one-hectare study site. All trees were classified into three categories pertaining to significance of epiphyte abundance: 1-none to slight, 2-moderate, and 3-high. Subsequently, we determined or obtained existing data on height, dbh, aspect, slope, and species of sampled trees. Our data shows a positive correlation with height and dbh to epiphyte abundance; as height and dbh increase, epiphyte abundance increases. Our data also may suggest that aspect, slope, and tree species do not correlate with epiphyte abundance. We suggest further studies be conducted on those factors to determine possible correlations.

INTRODUCTION

Epiphytes include vascular and non vascular plants that require mechanical support but not nutrients from other plants. Examples of epiphytes include ferns, bromeliads, orchids, mosses, liverworts, and lichens. Greatest species diversity and abundance of epiphytes are found in neotropical montane rainforests, characterized by high annual rainfall, short dry seasons, and the presence of year-round mist or fog (Nadkarni 1983).

Epiphytes are essential to neotropical rainforest ecosystems. They contribute to nutrient cycles, and they provide food, water, and habitat for a variety of wildlife species including mammals, birds, reptiles, amphibians, and invertebrates. Epiphytes also act as bio-indicators because of their sensitivity to disturbance and environmental changes. Since epiphytes play an integral role in rainforest ecosystems, it is important to understand variables that affect epiphyte abundance (Nadkarni 1992; Gradstein *et al.* 2003).

The objective of this study was to determine positive and/or negative correlations among height, diameter at breast height (dbh), aspect, slope, and tree species with respect to epiphyte abundance within a cloud forest of Costa Rica. Data collected maybe used for a long-term monitoring study to determine potential changes in epiphytic abundance or composition.

METHODS

Description of Study Site

The study site is located in the Cloudbridge Nature Reserve (hereafter, Cloudbridge), which is located on the Pacific slope of the Talamanca mountain range in south-east Costa Rica. It lies approximately 18 kilometers northeast of San Isidro in the San Jose Province of Costa Rica. The site encompasses a one-hectare plot of primary lower montane cloud forest where slopes are moderate to steep, descending in northeast and northwest directions, and elevations range from approximately 1,850 to 1,910 meters.

The study site is part of an ongoing Smithsonian Institute biomonitoring project aimed to better understand regional and global long-term ecological changes (Dallmeier et al.). For the biomonitoring project, the site was divided into 25 20x20 meter quadrats. In each quadrat, all trees (n=720) with a dbh equal to or greater than 10 centimeters were identified, recorded, and tagged. Height and dbh of all tagged trees were estimated, and some tagged trees have been identified to species, genus, and/or family.

General Methods

Field studies were conducted from February 1-18, 2007. First, we determined epiphyte biomass for sample trees. Since we could not assess actual biomass from sample trees without removing epiphytes, representative samples of epiphytes were collected from fallen trees and/or limbs. Next, ocular estimates of the number of samples for each tree were determined using the sample as a standard unit of measurement. The representative samples were then dried by placing them on the roof of the Gavilan Field Station during the day for up to a week; using the conventional, wood burning oven at the field station was problematic because temperature could not be regulated. Finally, the dry sample weight was multiplied by the number of estimated samples to determine total biomass of an individual tree.

To obtain a better vantage point for observing and measuring high canopy epiphytic growth, large, mature trees with suitable architecture were ascended using climbing equipment following Fonteyn *et al.* (1988). Epiphyte biomass in smaller trees was determined from ground observations.

We intended on determining epiphyte biomass for all trees within the study area. However, due to time constraints, it was not possible for us to quantitatively assess every tree. As a result, we decided to qualitatively evaluate sample trees by assigning each tree a value representing significance of epiphyte abundance (Table 1).

Significance of Epiphyte Abundance	Description
1-None to Slight	Little to no epiphytic growth present with the exception of lichens and mosses sporadically located around trunks, crotches, and branches.
2-Moderate	Some epiphytic growth present such as bromeliads and ferns. Epiphytes may appear in few, small, dark masses on branches and in crotches.
3-High	Significant amount of epiphytic growth present throughout canopy. Epiphytes appear as large, dark masses, especially in crotches.

Table 1. Description of significance of epiphyte abundance categories.

After assessing significance of epiphyte abundance, we determined slope and aspect. Height, dbh, and tree species were later obtained from existing data.

RESULTS

Our data have not been statistically analyzed. Thus, the following results reflect observational trends from our raw data; they do not reflect statistically significant analyses. Once the data becomes statistically analyzed, results will be posted on www.cloudbridge.org/researchreports.htm.

We used 6 representative samples (Appendix A: Photographs) to determine epiphyte biomass for 8 sample trees with high significance of epiphyte abundance (Table 2). Since the sample size is insufficient, it is problematic to deduce any correlations among these data; more data would have to be collected to determine correlations regarding quantitative epiphytic biomass.

Tree ID Number	Significance of Epiphyte Abundance (1-3)	Aspect	Slope (°)	DBH (cm)	Height (m)	Species	Total Biomass (kg)
01-09-01	3	NE	35	112.50	40	*Hyeronima alchornioides*	9.16
01-09-30	3	N	20	105.00	35	*Macrohasseltia macroterantha*	41.79
01-10-10	3	NW	30	173.00	35	*Cedrela tonduzii*	28.71
01-10-27	3	NW	30	90.20	40	*Quercus* sp.	27.82
01-15-10	3	NW	35	79.50	40	Unidentified	12.73
01-16-06	3	NW	40	120.10	40	*Sapium* sp.	19.54
01-16-19	3	NW	40	86.40	35	*Quercus* sp.	9.33
01-20-17	3	NNE	30	68.50	40	Unidentified	12.11

Table 2. Aspect, slope, dbh, height, species, and total epiphyte biomass for 8 sample trees classified as having high significance of epiphyte abundance.

We assessed significance of epiphyte abundance on all sample trees within the hectare (n=720). A total of 620 trees were classified as none to slight, 72 trees as moderate, and 28 trees as high (Figure 1; Appendix A: Photographs).

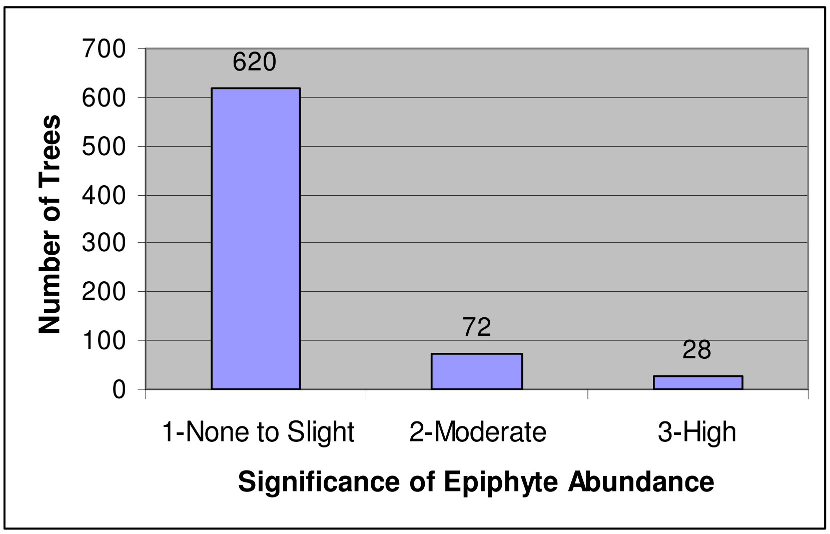

Figure 1. Distribution of sample trees with respect to significance of epiphyte abundance.

Our data shows a trend between tree height and significance of epiphyte abundance; as height increases, epiphyte abundance increases (Table 3; Figure 2). However, it has not been determined if this trend is statistically significant.

Height (meters)	Significance of epiphyte abundance		
	1-None to Slight	2-Moderate	3-High
Average	18	34	39
Maximum	40	40	40
Minimum	4	18	35

Table 3. Comparison of sample tree heights with respect to significance of epiphyte abundance.

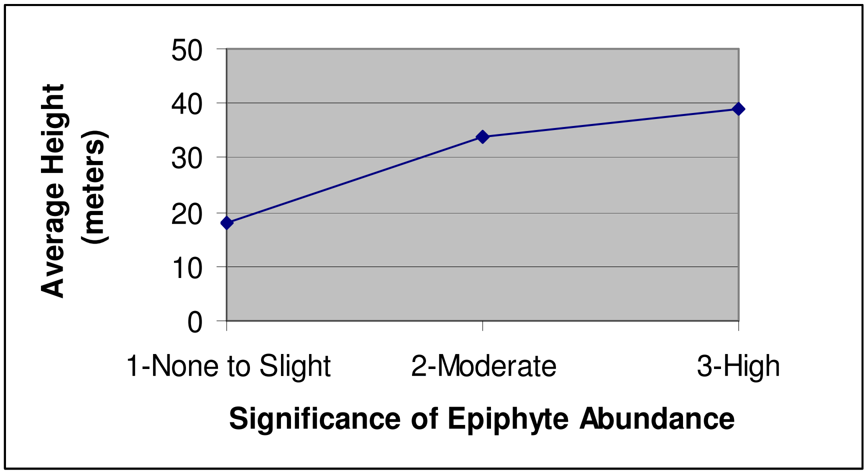

Figure 2. Distribution of average height of sample trees with respect to significance of epiphyte abundance.

Our data also shows a correlation between dbh and significance of epiphyte abundance; as dbh increases, epiphyte abundance increases (Table 4; Figure 3). Again, it has not been determined if this correlation is statistically significant.

DBH (centimeters)	Significance of epiphyte abundance		
	1-None to Slight	**2-Moderate**	**3-High**
Average	19.65	48.47	97.13
Maximum	256.00	126.00	173.00
Minimum	10.00	18.60	49.50

Table 4. Comparison of diameter at breast heights (dbh) of sample trees with respect to significance of epiphyte abundance.

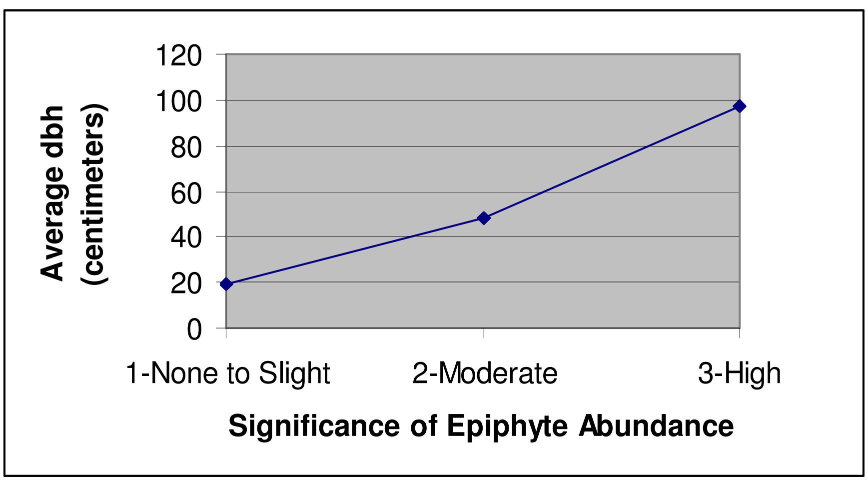

Figure 3. Distribution of average dbh of sample trees with respect to significance of epiphyte abundance.

Most trees were positioned on northwest and northeast aspects (n=339 and n=126, respectively; Table 5), which reflects general aspects of the study area. According to our data, it appears that aspect does not correlate with significance of epiphyte abundance.

Aspect	Number of Trees			
	1-None to Slight	2-Moderate	3-High	Total
NW	285	42	12	**339**
NE	113	9	4	**126**
N	98	7	6	**111**
W	33	2	1	**36**
NNE	22	5	2	**29**
ESE	20	2	0	**22**
SE	15	1	2	**18**
E	10	3	1	**14**
WNW	13	0	0	**13**
S	9	1	0	**10**
SW	2	0	0	**2**
Total	**620**	**72**	**28**	**720**

Table 5. Aspect of sample trees with respect to significance of epiphyte abundance.

There does not appear to be a correlation between slope and significance of epiphyte abundance. Most trees were positioned on a 30 to 40 degree slope, which reflects the overall slope of the study site (Table 6).

Slope (°)	Number of Trees			
	1-None to Slight	2-Moderate	3-High	Total
30	245	29	11	**285**
40	214	28	11	**253**
35	81	8	4	**93**
25	44	4	1	**49**
20	20	3	1	**24**
10	11	0	0	**11**
45	5	0	0	**5**
Total	**620**	**72**	**28**	**720**

Table 6. Slope of sample trees with respect to significance of epiphyte abundance.

According to our data, it appears there is no correlation between tree species and significance of epiphyte abundance (Table 7). However, a total of 608 species have not been identified within the study site and our sample size (n=112) may be insufficient to detect possible correlations.

Species	Number of Trees			
	1-None to Slight	2-Moderate	3-High	Total
Aioueae costaricensis	1	1	0	**2**
Ardisia sp.	1	0	0	**1**
Billia hippocastanum	2	2	0	**4**
Brosimum costaricense	3	0	0	**3**
Brosimum sp.	1	0	0	**1**
Cedrela tonduzii	1	0	1	**2**
Chione sylvicola	1	0	0	**1**

Chrysoclamys sp.	1	0	0	**1**
Cinnamomum triplinerve	1	0	0	**1**
Citronella costaricensis	0	1	0	**1**
Clusia sp.	12	0	0	**12**
Cyathea sp.	2	0	0	**2**
Dendropanax arborens	2	0	0	**2**
Elaeagia auriculata	2	0	0	**2**
Ficus tuerckheimii	1	0	0	**1**
Guarea glabra	2	1	0	**3**
Heliocarpus americanus	1	0	0	**1**
Hyeronima alchornioides	0	0	1	**1**
Hyeronima poasana	0	1	0	**1**
Inga sp.	4	0	0	**4**
Licania sp.	0	0	1	**1**
Macrohasseltia macroterantha	1	0	1	**2**
Meliosma vernicosa	2	0	0	**2**
Miconia sp.	1	0	0	**1**
Mollinedia sp.	6	0	0	**6**
Mortoniodendrum anisophylum	2	0	0	**2**
Myristica fragrans	1	0	0	**1**
Nectandra sp.	5	1	0	**6**
Oreopanax xalopansis	7	1	0	**8**
Panopsis suaveolens	2	0	0	**2**
Persea Americana	1	0	0	**1**
Persea schiedeana	0	1	0	**1**
Posoqueria latifolia	12	0	0	**12**
Posoqueria sp.	1	0	0	**1**
Pouteria sp.	2	1	1	**4**
Prunus annularis	1	1	0	**2**
Pseudolmedia sp.	1	1	0	**2**
Quercus sp.	1	0	2	**3**
Randia sp.	2	0	0	**2**
Rondeletia amoena	1	0	0	**1**
Sabia melliosma	1	0	0	**1**
Sapium glandulosum	0	0	1	**1**
Sapium sp.	0	0	1	**1**
Senecio copeyensis	1	0	0	**1**
Sloanea ampla	1	0	0	**1**
Symphonia globulifera	1	0	0	**1**
Total	**91**	**12**	**9**	**112**

Table 7. Comparison of sample tree species with respect to significance of epiphyte abundance.

DISCUSSION

Initially, our intention was to obtain a quantitative value of biomass for all trees that were assigned a high significance of epiphyte abundance value. However, we realized we would not have enough time to determine quantitative values for each tree considering the length of time it takes to climb one tree. In addition, most trees with high significance of epiphyte abundance were too tall to assess from ground observations, so most sample trees with high significance of epiphyte abundance would have to be climbed.

We also realized that our methodologies for determining a quantitative value for epiphyte biomass were ambiguous, biased, and not replicable. Thus, a researcher assessing a sample tree using an epiphyte sample may collect significantly different data than another researcher assessing the same tree with the same epiphyte sample. Therefore, our quantitative epiphyte biomass methodologies seem impractical resulting in ambiguous and unreliable data. Furthermore, these methodologies would not be viable for a long-term monitoring study regarding the increase or decrease of epiphyte biomass because data would vary drastically, especially if more than one researcher collects data. In addition, the epiphyte samples we collected from the fallen trees may not have been the same species as the epiphytes in sample trees, resulting in inaccurate biomass data. Though many epiphyte species have not been identified, it seems imperative to know the species in order to determine if epiphyte samples are representing all epiphyte species. Our research of relevant studies suggests that there are accepted methods of assessing total epiphyte biomass however these methods are extremely time consuming and laborious.

Our data suggests that as height and dbh increase, the epiphyte abundance increases. However, the maximum dbh value for the none to slight category in Table 3 suggests that large trees may not correlate with epiphyte abundance. However, that sample tree (Tree ID #: 01-10-01) appears to have been heavily gleaned by woodpeckers, which could indicate a decline in the tree's health. Further studies would have to be conducted to determine the reason for the tree's decline (e.g. beetle infestation) and whether or not the reason for the decline correlates to the lack of epiphytic growth. Nevertheless, our data shows that there is a positive correlation between height, dbh, and epiphyte abundance, which is consistent with epiphyte biology; hence, epiphytes are more abundant on trees that can structurally support epiphyte growth and provide sufficient sunlight. Correspondingly, trees that are ideal to support epiphytic growth are likely to be tall and large, as our data suggests.

Our data also suggests that aspect and slope may not correlate with epiphyte abundance. Since our study site had a general aspect and slope, we suggest aspect and slope studies be conducted in different topographic areas. For instance, to conduct an aspect study with respect to epiphyte abundance, four study sites could be identified, each with a general aspect (e.g. one for each cardinal direction). To conduct a study on slope with respect to epiphyte abundance, two study sites could be identified, one with a general slope of less than 25 degrees, and the second with a slope of 26 to 50 degrees.

To determine if tree species correlates with epiphyte abundance, we suggest all trees within the one-hectare study site be identified to species. Subsequently, data can be entered into the excel database we developed, and those data can be analyzed to determine correlations between significance of epiphyte abundance and tree species. In addition, our methodology for classifying trees into significance of epiphyte abundance categories could be used for a long-term monitoring study within the one-hectare study site. All sample trees could be reclassified in the distant future (i.e. 5 to 10 years) to determine possible changes of epiphyte abundance. Those data could then be used to determine possible causes for epiphyte abundance fluctuations. To assist with a long-term monitoring study we have attached a data form and pictures depicting characteristics of each epiphyte abundance category in Appendix A and B of this report, respectively.

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APPENDIX A: PHOTOGRAPHS

APPENDIX B: DATA COLLECTION FORM

Canopy Epiphyte Abundance Data Form • Cloudbridge Nature Reserve, Costa Rica

Date:	Weather Conditions:
Researchers:	Quadrat:

Tree ID #	Significance of epiphyte abundance (1-3)*	Aspect	Slope (°)	Ascended (Y/N)	Sample ID (A-E)	# of Sample Units	Sample Dry Weight (g)	Total Epiphyte Biomass (g)	Comments

*Significance of epiphyte abundance: 1-none to slight, 2-moderate, 3-high.