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Epiphyll community diversity on *Anthurium* and *Philodendron* (Araceae)

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ABSTRACT

Little is known about epiphyll community diversity. This study compared epiphyll diversity growing on leaves from *Anthurium* and *Philodendron*. I hypothesized that the effect of a collecting vein, present on *Anthurium*, but not on *Philodendron*, would affect microhabitats and epiphyll species diversity. I predicted lower epiphyll abundance on *Anthurium* than on *Philodendron*. Fifteen leaves were collected from each plant species. Morphological species of epiphylls were counted for total percent cover, as well as the total area of the leaves. The Shannon-Weiner Index was used, along with Margalof's index of richness. Analysis was done at metacommunity (all the leaves of *Anthurium* and *Philodendron*) and the local community (individual leaves of *Anthurium* and *Philodendron*) levels. Species richness was significantly greater in both communities, as well as the number of epiphyll occupied boxes for *Philodendron*. Evenness was equal at the metacommunity level ($E_{Philodendron} = 0.62$, $E_{Anthurium} = 0.61$), but at the local community level, *Anthurium* had higher evenness of epiphyll species ($E_{Philodendron} = 0.56$, $E_{Anthurium} = 0.67$, Mann Whitney U' = 163, $p = 0.04$). I hypothesized that the underlying reason is that the collecting vein gives a path for water to leave the leaf, resulting in a drier and more homogenous habitat of the leaf surface. Therefore, no niche-specializing epiphylls can become too abundant. Further studies need to be conducted on collecting veins and homogeneity, coupled with the specialized niches of epiphylls.

RESUMEN

Se sabe muy poco sobre la diversidad de la comunidad de epífilas. Este estudio comparó la diversidad de epífilas creciendo en hojas de *Anthurium* y *Philodendron*. Se predijo que el efecto de la vena de recolección, presente en *Anthurium* pero no en *Philodendron*, afectaría a los microhábitats y a la diversidad de especies de epífilas. También se predijo una abundancia inferior de epífilas en *Anthurium* que en *Philodendron*; se recolectaron quince hojas de cada especie de planta. Se contaron las especies morfológicas de epífilas de acuerdo al porcentaje total de cobertura, así como el área total de las hojas. Se utilizaron los índices de riqueza de Shannon-Weiner y de Margalof. Los análisis se realizaron al nivel de metacomunidad (todas las hojas de *Anthurium* y *Philodendron*) y de comunidad local (hojas individual de *Anthurium* y *Philodendron*). La riqueza de especies fue significativamente mayor en ambas comunidades, así como también lo fue el número de cuadros ocupados por epífilas en *Philodendron*. La uniformidad fue igual al nivel de metacomunidad ($E_{Philodendron} = 0.62$, $E_{Anthurium} = 0.61$) pero, al nivel de la comunidad local, *Anthurium* presentó una uniformidad mayor de especies de epífilas ($E_{Philodendron} = 0.56$, $E_{Anthurium} = 0.67$, Mann Whitney U' = 163, $p = 0.04$). Se hipotetizó que la razón fue que la vena de recolección suministraba una vía de escape de la hoja para el agua, resultando en un hábitat más seco y homogéneo en la superficie de la hoja. Por lo tanto, las epífilas con especializaciones de nicho no pueden volverse más abundantes. Se requieren más estudios sobre las venas de recolección y la homogeneidad acopladas con los nichos especializados de las epífilas.

INTRODUCTION

Epiphylls are mostly bryophytes that live on top of leaves. Bryophytes are nonvascular photosynthetic plants, including liverworts, lichens, and mosses that prefer humid tropical regions (Richards 1954, in Coley et al. 1993). Epiphylls are thought to be non-host specific since epiphylls are very dependent on the abiotic factors of their environment. A majority of bryophytes obtain water and minerals from atmospheric moisture; while a few can obtain these from the substrate they inhabit (Schofield 1985). Therefore, epiphylls increase in abundance with moisture (Drake 2005), decrease with increase fragmentation and sunlight, due to higher rates of evaporation (Hallen 2005), and likewise increase with elevation (Drake 2005).

Although they are non host-specific, epiphylls are associated with certain leaf characteristics. They are more abundant on shorter-lived leaves compared to long-lived leaves (Coley et al. 1993). Drips tips help to decrease water retention and are less overgrown with epiphylls than those without drip tips (Jungner 1891, in Dean and Smith 1978). Substrate also affects epiphyll colonization. Epiphylls more easily colonize smooth surface leaves because they adhere to them better (Morales 2000).

Epiphylls have both positive and negative effects on host plant leaves. Lichens have high levels of terpenoids that deter herbivores (Chopra and Kumra 1988, in Coley et al. 1993), while others help to fix nitrogen for the host plant (Bentley 1987). However, there is evidence of the negative effects of epiphylls on host plant leaves. For instance, the epiphyll *Radula flaccida*, is considered a semi-parasite because it obtains water and nutrients from its host plant, without any reciprocal benefit to it (Berrie and Eze 1974). Another negative effect is that epiphylls can reduce the amount of light an understory tropical plant receives by 55-85%, thus reducing photosynthesis of the host plant by 20% (Coley 1993). Likewise, epiphylls could increase the likelihood of pathogenic infections, because they keep the leaf surface wet (Gregory 1971, in Coley et al. 1993).

Little is known about epiphyll assemblages or community diversity. Plants in the family Araceae (commonly known as aroids) make good study subjects to analyze epiphyll community diversity. Aroids are common in tropical rainforests and are often colonized by epiphylls. Two aroids, *Anthurium* and *Philodendron,* have different leaf morphologies. *Anthurium* has a marginal collecting vein, while *Philodendron* does not. This may make differences in the surface humidity of leaves for the two species. Epiphylls are strongly affected by humidity and leaf surface moisture conditions and thus leaf morphology differences, specifically a marginal collecting vein, may cause differences in diversity. The collecting vein should reduce epiphyll community abundance, in light of its possible role that it reduces water retention on the leaf.

METHODS

This study was conducted April 15th to May 8th, 2006 along the Cerro Chomogo Ridge behind the Estación Biológica Monteverde, Puntarenas, Costa Rica. Leaves were collected from individuals of one species of *Anthurium* and one species of *Philodendron*. A total of fifteen leaves were collected from fifteen individuals of each species, from heights of 1.5 meters and were never the three newest, uppermost leaves of the plant. This minimized possible differences in leaf age. All leaves were north- facing, helping to minimize the affects of different abiotic factors. Direction of the leaf was determined by a compass, from the center of the plant to the tip of the leaf. Once removed, leaves were individually placed into plastic bags, marked as *Anthurium* or *Philodendron***,** numbered sequentially, and kept refrigerated until analysis could be initiated.

To examine the coverage and species of epiphylls on the leaves, they were taken out of the refrigerator and allowed to dry. A transparent 2mm by 2mm grid was placed over the entire leaf and examined under a dissecting scope at 40X magnification. The percent epiphyll coverage was calculated and the kinds of morphological species present were noted. Morphological species of epiphylls were given its own color or pattern, using permanent markers in order to quantify the abundance of each. If more than 50% of the grid was covered by an epiphyll species, the grid cell was counted as "occupied", and marked with the color or pattern designated by which epiphyll was present; if less than 50% of the grid was covered, the cell was considered empty and not marked. In cases where more than one epiphyll was present, the dominant species was said to "occupy" the cell. The number of boxes was counted for each species of epiphyll occupancy and the total number of boxes the leaf occupied. The data were analyzed on metacommunity (all the epiphylls on all the leaves of *Anthurium* and *Philodendron*) and local community (individual leaves of *Anthurium* and *Philodendron*) levels. The metacommunity and local communities were evaluated using the diversity indices S_{marg} (Margalef's index), H' (Shannon-Weiner Diversity Index), S (species richness), E (evenness), and N (the number of boxes occupied by each epiphyll species). The Modified t-test was used to evaluate the significance of H' for the metacommunity and the Mann Whitney test was used to determine if the diversity indices of the local community were significant.

RESULTS

Sampling was exhaustive for both plant species (Figure 1). There were 12 species of epiphylls found on *Anthurium*, with four more found on *Philodendron*, for a total of 16 epiphyll species. The percent epiphyll cover of the metacommunity was 24.59% for *Anthurium* and 26.63% for *Philodendron*. The average percent epiphyll cover of the local community was 25.08% for *Anthurium* and 27.06% for *Philodendron*. The indices were compared between local communities of the two plant species (Table 1). There was a significant difference in the averages of S, E, N, and S_{marg} ; there was a higher species richness ($S_{Philodendron} = 8.6 \pm 2.261$, $S_{Anthurium} = 5.6 \pm 1.298$, Mann-Whitney U' = 198.5; $p = 0.0003$, $n = 15$; $S_{margPhilodendron} = 1.217 \pm 0.103$, $S_{margAnthurium} = 0.859 \pm 0.062$, Mann-Whitney U' = 174; $p = 0.0107$, $n = 15$), less evenness ($E_{Philodendron} = 0.559 \pm 0.145$, $E_{Anthurium} = 0.673 \pm 0.152$, Mann-Whitney U' = 163; $p = 0.0362$, $n = 15$), and more boxes covered by epiphylls ($N_{Philodendron} = 766.533 \pm 531.526$, $N_{Anthurium} = 239.333 \pm 135.699$, Mann-Whitney U' = 196; $p = 0.0005$, $n_{Philodendron} = 11457$, $n_{Anthurium} = 3669$) for *Philodendron* than *Anthurium*. *Philodendron* exhibited a higher diversity than Anthurium, but the indices were not significant ($H'_{Philodendron} = 1.206 \pm 0.372$, $H'_{Anthurium} = 1.147 \pm 0.312$, Mann-Whitney U' = 134, $p = 0.3725$, $n = 15$).The indices were also compared between metacommunities of the two plant species (Table 2). *Philodendron*'s epiphyll community was richer ($S_{Philodendron} = 16$, $S_{Anthurium} = 12$; $S_{margPhilodendron} = 1.60$, $S_{margAnthurium} = 1.34$) and was significantly more diverse ($H'_{Philodendron} = 1.72$, $H'_{Anthurium} = 1.51$, Modified t-test, $t = 12.03$, $df = 7372.45$, $p < 0.001$) than *Anthurium*. Philodendron had three times the number of boxes occupied by epiphylls ($N_{Philodendron} = 11457$, $N_{Anthurium} = 3669$), but evenness was equal ($E_{Philodendron} = 0.62$, $E_{Anthurium} = 0.61$). The most abundant epiphyll species for each leaf was noted (Table 3). There were three most abundant epiphyll species in *Anthurium* and five most abundant epiphyll species in *Philodendron*.

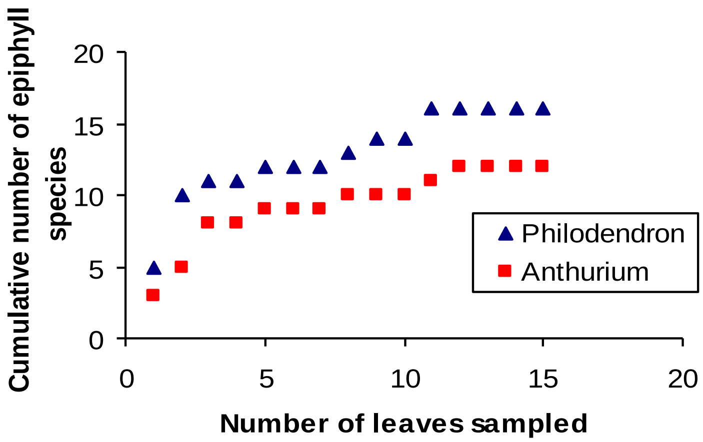

FIGURE 1. The relationship between the number of leaves sampled and the cumulative number of epiphyll species. At n = 11 for *Philodendron* and n = 12 for *Anthurium* epiphyll species richness asymptotes, signifying that a sample size of 15 leaves for *Philodendron* and *Anthurium* was exhaustive of epiphyll species richness.

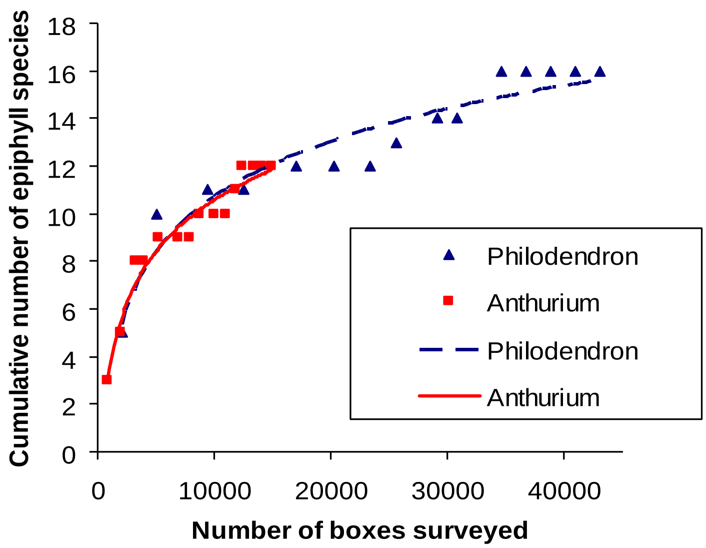

FIGURE 2. The relationship between the number of boxes surveyed and the cumulative number of epiphyll species. The number of boxes is a proxy for the amount of area. Higher *Philodendron* epiphyll species richness ($S_{Philodendron}$ = 16, $S_{Anthurium}$ = 12) is a strong consequence of the greater area surveyed. According to the highly similar trend lines ($R^2_{\mathrm{Philodendron}}$ = 0.9149, $R^2_{\mathrm{Anthurium}}$ = 0.9539), as more area is surveyed, similar species richness would be found in *Anthurium*.

TABLE 1. Average diversity indices of the local communities of *Anthurium* and *Philodendron*. *Philodendron* had a greater average area covered by epiphylls. The epiphylls were significantly more abundant (N, the number of epiphyll occupied boxes, Mann-Whitney U' = 196; $p = 0.0005$, $n_{Philodendron} = 11457$, $n_{Anthurium} = 3669$) and had higher species richness (S, species richness, Mann-Whitney U' = 198.5; $p = 0.0003$, $n = 15$; S_{marg}, Margalef's index, Mann-Whitney U' = 174; $p = 0.0107$, $n = 15$) on *Philodendron*. There was significantly higher evenness of epiphylls on *Anthurium* compared to *Philodendron* (Mann-Whitney U' = 163; $p = 0.0362$, $n = 15$). There was not a significant difference in species diversity (H', Shannon-Weiner Diversity Index, Mann-Whitney U' = 134, $p = 0.65$, $n = 15$).

	Anthurium	*Philodendron*	Significance	p-value
Smarg	0.86 ± 0.06	1.22 ± 0.10	Yes	0.01
H'	1.15 ± 0.31	1.21 ± 0.37	No	0.37
S	5.60 ± 1.30	8.60 ± 2.26	Yes	<0.01
E	0.67 ± 0.15	0.56 ± 0.15	Yes	0.04
N	239.33 ± 135.70	766.53 ± 531.53	Yes	<0.01
Average Percent Covered	25.08%	27.06%		

TABLE 2. Diversity indices of the Metacommunities of *Anthurium* and *Philodendron*. *Philodendron* had a greater average area covered by epiphylls. The epiphylls were more abundant (N, the number of epiphyll occupied boxes), had higher species richness (S, species richness; S_{marg}, Margalef's index), and in consequence were significantly more diverse (Modified t-test, $t = 12.03$, $df = 7372.45$, $p < 0.01$) on *Philodendron* than *Anthurium*. The evenness of epiphylls was equal for the two plant species.

	Anthurium	*Philodendron*
S_{marg}	1.34	1.61
H'	1.51	1.72
S	12	16
E	0.61	0.62
N	3669	11457
Average Perce Covered	24.59%	26.63%

TABLE 3. The most abundant epiphyll species for each leaf of *Anthurium* and *Philodendron*. *Anthurium* had three most common species. *Philodendron* had five most common species.

	Anthurium		Philodendron	
Leaf Number	Most Abundant Species	Percent Area of Epiphyll Cover	Most Abundant Species	Percent Area of Epiphyll Cover
1	2(maroon)	16.089%	4(red)	41.156%
2	8(light green)	7.657%	3(brown)	12.798%
3	2(maroon)	5.361%	1(purple)	3.948%
4	8(light green)	14.659%	1(purple)	37.547%
5	2(maroon)	16.126%	2(maroon)	10.758%
6	8(light green)	12.411%	2(maroon)	12.266%
7	1(purple)	5.463%	1(purple)	46.492%
8	1(purple)	19.251%	1(purple)	15.118%
9	8(light green)	15.234%	1(purple)	3.953%
10	8(light green)	5.464%	15(dg w/brown)	5.287%
11	1(purple)	16.808%	3(brown)	6.934%
12	1(purple)	6.367%	2(maroon)	11.210%
13	2(maroon)	8.691%	1(purple)	19.466%
14	1(purple)	17.066%	1(purple)	8.265%
15	2(maroon)	16.533%	2(maroon)	8.804%

DISCUSSION

The results for the local communities showed average community richness is greater on *Philodendron* than on *Anthurium* (Table 1). This is due in part to *Philodendron* having larger leaves and higher epiphyll coverage (Figure 2; Table 1). However, when the differences in coverage and area are accounted for, species richness on *Philodendron* is still greater. This will be discussed further below.

Despite having higher richness, epiphyll communities on *Philodendron* are, on average, equally diverse (H') as those on *Anthurium* (Table 1). This is due to the fact that the average evenness of epiphyll communities on *Philodendron* is lower than *Anthurium*'s epiphyll communities (Table 1). This result suggests that individual *Philodendron* leaves are dominated by few species, whereas *Anthurium* epiphyll communities are not. The unevenness in *Philodendron*'s epiphyll communities might reflect different competitive abilities of epiphylls. Because less evenness means, the identity of the common species changes from leaf to leaf (Table 3), it seems more likely that chance and colonization are involved.

The results for the metacommunities did not exactly mirror local communities. Species richness was again greater on *Philodendron* than on *Anthurium* (Table 2). However, this time there was a significant difference in diversity and no difference in evenness (Table 2). The evenness of *Philodendron*'s epiphyll community for the metacommunity is higher than that for local communities. The increase in evenness means that on a per-leaf basis epiphyll communities are dominated, but overall the dominant species changes from leaf to leaf.

The higher diversity of *Philodendron*'s epiphyll community is a simple consequence of higher richness across the metacommunity. The per-leaf richness is also higher; suggesting that there is something about the individual leaf that allows many species to co-exist.

The presence or absence of a collecting vein may influence how many species co-exist by influencing leaf surface moisture. A vein, as present in *Anthurium*, may homogenize the surface moisture, making conditions uniform and drier. A uniform and drier habitat would lessen the advantage of being competitive in more moist, heterogeneous conditions. The lack of a vein may result in such conditions, favoring different species with different microhabitat requirements. The differences in habitat, allows for niche specialization and greater species richness.

Additional experimentation is needed to understand the role of a collecting vein in light of leaf surface conditions, and to determine if epiphylls have distinct niche specializations. Aroids and epiphylls are regularly interacting with each other, especially in the humid tropics. Therefore further knowledge is essential to understanding epiphyll intraspecific interactions, and host plant – epiphyll relations.

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