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Assessing the importance of vines and trees for Hemiptera (Insecta) in a canopy from Panama

Evaluación de la importancia de arbustos y árboles para Hemiptera (Insecta) en un bosque de Panamá

I. Simón[1*], E. Domínguez[2], R. Collantes[3]

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Abstract
The order Hemiptera is a rich and diverse taxon in habits and species, some of which are considered pests of agricultural crops. Added to this, human activity generates impacts that unbalance the ecosystem, such as the drastic reduction of wild vegetation in favor of urban projects. Parque Natural Metropolitano (PNM) is a protected area located in the city of Panama, Panama; which has several species of trees and vines that can serve as shelter for insects. Therefore, the objective of this study was to evaluate the importance of vines in comparison with trees for the order Hemiptera. As these are sap-sucking insects, they may have preferences for vines, due to certain characteristics such as increased leaf mass production. A random sampling was carried out in the canopy of PNM (8º59’24” N, 79º33’00” W). According to the results, a total of 584 biting-sucking insects (Hemiptera) were collected, belonging to 20 families and 92 species: 53 species in trees and 61 in vines, with 24 species in common. The insect communities in trees were more similar to each other than to the insect communities in vines. Also, although some families of insects, such as Tingidae, may prefer vines, this may be due to a specific relationship of the insect to the plant species, rather than the habit of the plant. In conclusion, vines are important constituents, together with trees, for the establishment of trophic interactions with Hemiptera in the ecosystem, requiring future continuation of this kind of research.

Keywords: Biodiversity, Hemiptera, trophic interactions, trees, vines

Resumen
El orden Hemiptera es un taxón rico y diverso en hábitos alimenticios y especies, de las cuales algunas son consideradas plagas en cultivos agrícolas. Sumado a esto, la actividad humana genera impactos que desequilibran el ecosistema, como la reducción drástica de vegetación silvestre en beneficio de proyectos urbanísticos. El Parque Natural Metropolitano (PNM), corresponde a un área protegida situada en la ciudad de Panamá; la cual cuenta con varias especies de árboles y lianas, que pueden servir como refugio para insectos. Por lo expuesto, el objetivo del presente estudio fue evaluar la importancia de las lianas en comparación con los árboles para el orden Hemiptera. Al tratarse de insectos chupadores de savia, puede haber preferencias por las enredaderas, debido a ciertas características como la mayor producción de masa foliar. Se realizó un muestreo aleatorio en el dosel del PNM (8º59’24” N, 79º33’00” O). De acuerdo con los resultados, se colectó un total de 584 insectos picadores-chupadores (Hemiptera), pertenecientes a 20 familias y 92 especies: 53 especies en árboles y 61 en lianas con 24 especies en común. Las comunidades de insectos en los árboles tenían más similitudes entre ellos que con las comunidades de insectos en las enredaderas. Además, aunque algunas familias de insectos, como Tingidae, pueden preferir las enredaderas, eso puede deberse a una relación específica del insecto con la especie vegetal, más que al hábito de la planta. En conclusión, las lianas son constituyentes importantes, conjuntamente con los árboles, para el establecimiento de interacciones tróficas con Hemiptera en el ecosistema, requiriéndose la continuación a futuro de este tipo de investigaciones.

Palabras clave: Biodiversidad, Hemiptera, interacciones tróficas, árboles, lianas

[1] Escuela de Ciencias Exactas y Naturales, Universidad Estatal a Distancia, Costa Rica.
[2] Laboratorio de Estudios de Plagas Agrícolas, Departamento de Zoología, Universidad de Panamá, Panamá.
[3] Instituto de Innovación Agropecuaria de Panamá, Panamá.
*Autor para correspondencia: isimon@uned.ac.cr

Introduction

The order Hemiptera comprehends several species that are pests in agriculture. Quirós et al. (2009), prepared a catalogue of 71 species of Aphididae and one of Phylloxeridae from Panama, with records of 227 aphid species/host-plant species relationships, that include important crops. Collantes et al. (2021), found that 22% of the arthropods related with ornamental plants in David, Chiriquí, were Hemiptera; and the proximity of gardens to patches of wild vegetation like trees and vines, would contribute to the survival of insects and spiders frequently found in cities.

Studies of herbivory by canopy insects have been realized around the world: from Cameroon (Basset et al., 1992), Australia (Stork & Grimbacher, 2006), Gabon (Basset, 2001), Central America (Wolda, 1979; Barrios, 2003; Basset, 1994, 2001; Ødegaard, 2001, 2006; Charles & Basset, 2005), and French Guyana (Sterck et al., 1992). Some studies have focused on the interactions between insects and their host plants (Basset, 1996; Ødegaard, 2001). These interactions have been more widely studied in beetles and their host plants, but the relation between sap-feeding insects and vines in tropical forests has not been investigated exhaustively.

Wolda (1979), studied the abundance and diversity of Hemiptera in a Panamanian forest and concluded that vines were more important than the tree *Luehea seemannii* for Hemiptera; he collected more insects of this group when vines were in the top of *L. seemannii*. To a similar conclusion arrived Lowman et at. (1998), they found that, in average, trees with vines in the crown had twice herbivory compared with trees without vines. On the other hand, Sterck et al. (1992), compared herbivory at two neotropical canopies in Freench Guyana; no clear differences were found between vines, trees, and epiphytics, although herbivory levels were similar in both canopies. However, Ødegaard (2003), found that vines are as important as trees for beetle's richness. He estimated in a forest with 300-500 species of vines and trees, 7-10% of phytophagous beetles show species specificity.

Vines have deeper roots and more efficient xylem vessels than trees, which gives the vines a better conduction capacity than trees (Schnitzer and Bongers, 2002). Vines represent less than 5% of tropical forest biomass; however, also presents up to 40% of leaf productivity and respond more strongly than trees to CO2 fertilization (Wright et al., 2004). Most of the fixed carbon is used for the growth of uppermost leaves (Sasek and Strain, 1988), and in consequence, the increment of CO2 in the atmosphere, increments vines biomass and suppresses trees biomass (Phillips et al., 2002; Wright et al., 2004; Phillip and Gentry, 1994; Ingwell et al., 2010). Considering all the arguments exposed, the aim of this study was to compare the community of sap-sucking insects among vines and trees in the canopy of a tropical forest in Panamá.

Methodology

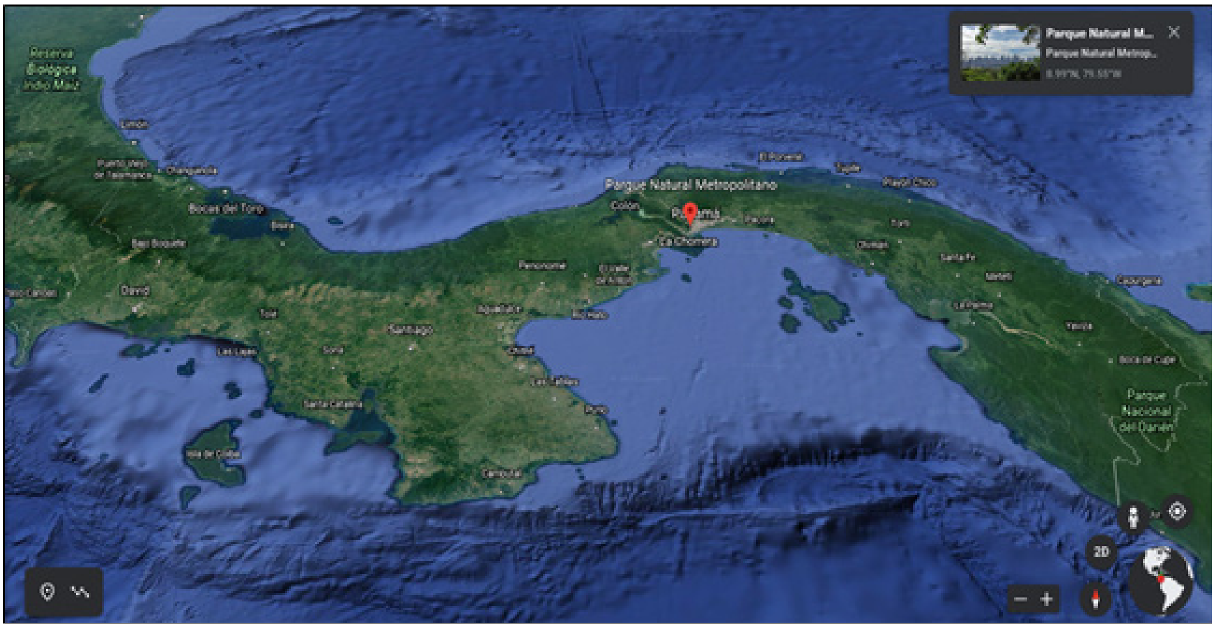
Samples were taken in the Smithsonian Tropical Research Institute´s tower crane located in Parque Natural Metropolitano (PNM), in Panama, near Panama City (8º59'24" N, 79º33'00" W) (Figure 1).

The area of collection was restricted to the perimeter of the tower (15 m). PNM is a dry semi-deciduous tropical forest near the Pacific coast; with 279 ha (Wright et al., 1992). That area has an average annual temperature of 28˚C and rainfall of 1740 mm (Charles et al., 2005). The wet season occurs from may to december and the dry season from january to april (Sunshine et al., 2004). (Charles et al., 2005). Some of the common trees in the study area are *Anacardium excelsum*, *Tabebuia rosea*, *Luehea seemannii* and *Bursera simarouba*. There are also some common vines such as *Combretum fruticosum*, *Bonamia trichantha*, *Serjania mexicana*, *Amphilophium paniculatum* and *Tricostigma octandrum*. Insects were collected for this project from seven vine species (*Amphillophium paniculatum*, *Serjania mexicana, Trichostigma octandrum, Combretum fruticosum, Vitis ptiliifolia, Bonamia trichantha, Pithecoctenium crucigerum*) and two tree species (*Anacardium excelsum* and *Luhea seemannii*).

Insects were collected from foliage, with a beating sheet of 0.4 m^2, with a removable plastic bag. After five strokes, the bag was always changed for taking a new sample. One

Figure 1

Location of PNM (red)



Google Earth (2021).

beating sample included insects of only one plant species. A survey consisted of 40 samples (20 from vines and 20 from trees). In total, 39 surveys were conducted in the canopy, from may 2009 through january 2010.

Sampling effort was 624 m^2. Sample unit was the foliar area, each sample had 0.4 m^2, the same area as the beating sheet. One sample had a different number of sheets, depending on the foliar area of the plant species (Table 1). To calculate the number of sheets necessary to complete 0.4 m^2 for each plant species, the average of the foliar area of 15 sheets per specie was measured. To measure the foliar area a LI-3100C brand LI-COR Biosciences was used at the Smithsonian Tropical Research Institute laboratory.

Table 1

Plant species sampled with their foliar areas

Species	Family	Foliar area (cm^2)	Sheets/sample
Luehea seemannii	Malvaceae	67.02	59.68
Anacardium excelsum	Anacardiaceae	116.16	34.43
Bonamia trichantha	Convolvulaceae	60.62	65.98
Combretum fruticosum	Combreataceae	25.99	153.91
Amphillophium paniculatum	Bignoniaceae	92.38	43.30
Pithecoctenium crucigerum	Bignoniaceae	143.83	27.81
Serjania mexicana	Sapindaceae	258.68	15.46
Trichostigma octandrum	Phytolacaceae	25.54	156.62
Vitis tiliifolia	Vitaceae	59.59	67.12

Insects were mounted on pins and sorted to morphospecies based on external morphological characteristics, and after that they were identified to family. Insects were deposited at Programa Centroamericano de Maestría en Entomología, Universidad de Panamá. The analyses were focused on comparing Hemiptera communities between vines and trees. Data did not present normal distributions, according with Lilliefors test of normality (D = 0.4367; $P > 0.05$) and Shapiro-Wilk test (W = 0.3156; $P > 0.05$). The statistical analysis applied was the Wilcoxon test with the R Studio version 0,94,110. To estimate α-diversity, Shannon Wiener and Simpson was used. Similarities in the different communities were calculated with Morisita Horn index (Marrugan, 1988). Morisita Horn similitude index was also used to estimate the similarities between each species of plants. Index diversity was calculated with StimateS (Colwell, 2008).

Results and Discussion

The species accumulation curve did not reach the asymptote neither for vines nor trees (Figure 2). A total of 584 sap-sucking insects (Hemiptera), belonging to 20 families and 92 species were collected: 53 species in trees and 61 on vines, with 24 shared species (Table 2). The percentage of singletons was higher in trees (54%) than in vines (14.8%), and more species were found on vines than in trees. The Shannon Weiner estimator indicates that trees are slightly more diverse than vines. Alpha estimates showed that trees are more rich and diverse than vines. Simpson index indicates that dominance in vine communities is higher than in trees (Table 2).

Figure 2

Species accumulation curves for sap-sucking insects in lianas and trees. The number of samples in lianas and trees was the same.

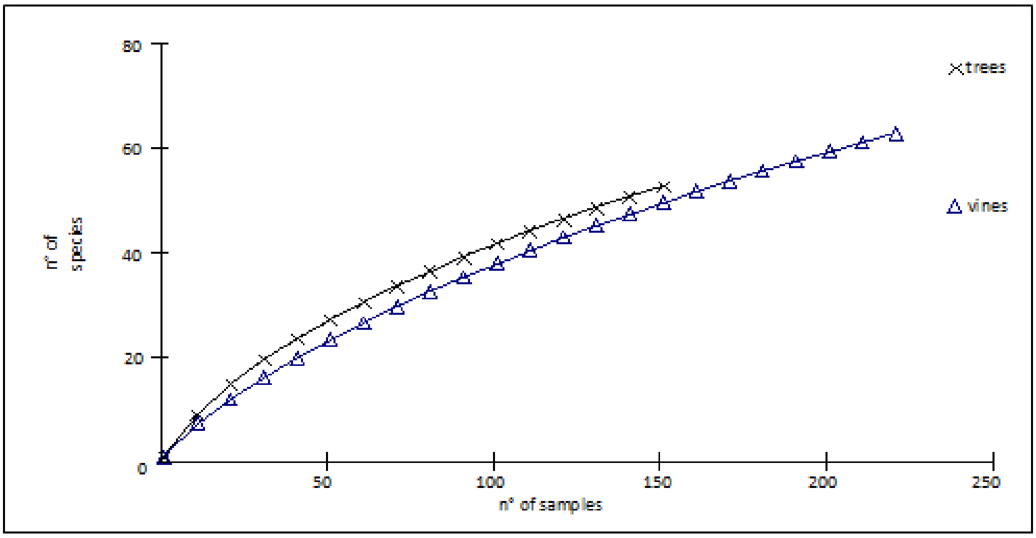


Table 2

Number of species, individuals, singletons, and doubletons in both communities

	Vines	Trees	Total
Individuals	431	153	584
N° of species	63	53	92
Singleton	64	83	147
Doubleton	3	24	27
Shannon±SD	3.9 ± 0.05	4.3 ± 0	-
Alpha	248.6 ± 115.4	115 ± 18.8	-
Simpson±SD	1.4 ± 0.9	0.8 ± 0	-

Similarity between communities of insects was 0,24 (Morisita-Horn Index). According with Wilcoxon, insects on vines were significantly more abundant than in trees (W=24090; *P*<0,05). The highest diversity in the insect community was found on three vines species (Shannon Weiner index). According to Simpson, in any plant species were found dominant insects (Table 3). The Morisita-Horn beta diversity index indicates that the most related communities are *A. paniculatum* and *B. trichantha*, which share nine species. *Anacardium excelsum* and *L. seemannii* were more similar between them than with any other plant species (Table 4).

Table 3

Alpha diversity for the different plant species

Plant species	Shannon Weiner	Simpson
Amphillophium paniculatum	2.54 ± 0.69	-
Anacardium excelsum	3.11 ± 0.5	0.55 ± 0.93
Bonamia trichantha	3.41 ± 0.41	0.38 ± 0.28
Combretum fruticosum	3.6 ± 0.31	0.35 ± 0.19
Luehea seemannii	3.72 ± 0.24	0.35 ± 0.16
Pithecoctenium crucigerum	3.84 ± 0.2	0.36 ± 0.13
**Serjania mexicana*	3.95 ± 0.13	0.38 ± 0.1
**Trichostigma octandrum*	4.01 ± 0.08	0.37 ± 0.06
**Vitis tilifolia*	4.06 ± 0.00	0.37 ± 0.01

* Vine species with the highest diversity.

Table 4

Diversity between communities. β differences between insect's communities in different species[1]

Morisita-Horn

Shared species		*A. paniculatum*	*A. excelsum*	*B. trichantha*	*C. fruticosum*	*L. seemannii*	*P. crucigerum*	*S. mexicana*	*T. octandrum*	*V. ptilifolia*
	A. paniculatum	-	0.33	0.48	0.23	0.30	0.22	0.44	0.20	0.16
	A. excelsum	6	-	0.09	0.01	0.32	0.14	0.25	0.27	0.09
	B. trichantha	9	2	-	0.13	0.18	0.16	0.31	0.10	0.14
	C. fruticosum	2	1	2	-	0.07	0.40	0.13	0.03	0.07
	L. seemannii	9	8	6	2	-	0.11	0.15	0.07	0.10
	P. crucigerum	2	2	2	1	3	-	0.09	0	0.07
	S. mexicana	7	6	7	2	6	2	-	0.46	0.20
	T. octandrum	3	5	2	1	3	0	3	-	0.10
	V. ptilifolia	6	5	7	2	9	2	6	3	-

[1] Upper matrix, Morisita-Horn index; lower matrix, shared species.

Five insect families were significantly different between vines and trees (some families had a very low numbers to be analyzed). Tingidae, Lygaeidae and Membracidae were the most abundant families and presented significative differences (Table 5).

We collected six species of Tingidae in vines and three in trees. Species collected in trees were always present in vines surveys. Lygaeidae was poorly represented in trees, but very abundant on vines with *Jadera aleolaas*, dominant species. It was present in big quantities on *Serjania mexicana*. The quantity of Issidae was low, but the differences were significant, and in fact, only one specimen of ten was found on *L. seemannii*, four on vines (including the one on *Luehea*). Membracidae had a preference for trees rather than vines, especially for *L. seemannii*, on which 13 species were collected. *Anobilia nigra* and one morphospecies of *Enchenopa*, were found on vines. The other family better represented on trees was Largidae, and *Fibrenus globicollis* was found 15 times on *L. seemannii* and once on *A. excelsum*.

The cumulative insect species curve suggests that the number of insects might be underestimated, especially those in trees. Although the amount of effort expended between vines and trees was the same. The method used does not allow confirmation as to whether a hemipteran was feeding on a plant, a difficult task in sap-sucking insects, because they do not leave evident signals as do chewing insects.

In some studies, no significant differences have been found between beetles feeding on vines and trees (Ødegaard, 2001), but in others studies the proportion of Chrysomelidae feeding on vines was larger than in trees (Charles et al., 2005). In Hemiptera, Wolda (1979), made some observations and concluded that vines were more important than trees for sap-feeding insects. Analyzing data in general, for vines and trees, we found significant differences (Wilcoxon); however, the communities seem very different (Morisita-Horn Index). Higher diversity (Shannon Weiner), lower dominance (Simpson index), and more singleton and doubletons were found in trees than in vines (Table 2), which might indicate that a larger proportion of sap-feeding insects were visitors to trees.

On the other hand, if we analyze alfa-diversity by plant species, any community has a really dominant insect and diversity is relatively high in all plant species (Table 3), but if we compare the communities, *L. seemannii* and *A. excelsum* are more similar between them than with any other plant species (Table 4). It might be because they have similar habits. However, we find significant differences in only five insect families (Table 5).

Table 5

Contingency table of sap-sucking insects. Abundances of Hemiptera families with significative differences. Other families were collected (Miridae, Pyrrhocoridae, Scutelleridae, Acanalionidae, Achilidae, Cicadidae, Clastopteridae, Derbidae, Flatidae, Issidae, Cicadellidae) but did not present significative differences

Family	Tree	Liana	Total	Wilcoxon test
Issidae	1	9	10	W = 376.5, $P < 0.05$
Largidae	16	1	17	W = 7, $P < 0.05$
Lygaeidae	4	102	106	W = 2537, $P < 0.05$
Membracidae	40	26	66	W = 308.5, $P < 0.05$
Tingidae	15	210	225	W = 4336, $P < 0.05$
Total	76	348	424	

Based on some vine characteristics, such as deep roots, longer, wider and more efficient xylem vessels, higher sap flow and transpiration, which allow vines to maintain conducting capacity longer than trees, we thought that sap-feeding insects might prefer them. In five insect families, we found significant differences between vines and trees. Lygaeidae was poorly represented in trees, but very abundant on vines, with *J. aleola* as the dominant species, but because it was present in large quantities on *S. mexicana*, it probably has a specific relation with this plant. The other family better represented in trees was Largidae, in this case *F. globicollis* was found 15 times in *L. seemannii* and one in *A. excelsum*, so it might be a specific relation. Six species of Tingidae were collected on vines and three in trees, which were always present in vines surveys, so probably it was a visitor in trees. Probably Issidae was as in Tingidae, only a visitor in trees.

With this results, we can say that Hemiptera's preference between vines and trees, could depend more on their inter-specific relations. But in anyway, as vines are increasing in importance in tropical forests (Phillips & Gentry, 1994; Phillips et al., 2002; Wright et al., 2004), by forest fragmentation and edges effect (Laurance et al., 2001; Putz, 1984), it would be valuable to conduct more studies in order to determine how insect communities related to trees or vines change by the pass of time.

Panama represents a continental ecotone, where a convergence of both native and exotic species happens. According to Collantes et al. (2021), patches of wild vegetation near urban areas can contribute to the arthropods species survival. Also, many important crops are developed in the surrounding areas of cities; therefor, further studies about this topic should be developed, to determine how many species of Hemiptera that are present in both trees and vines, are pests.

Conclusions

We can conclude that both vines and trees are important constituents for the establishment of trophic interactions with Hemiptera in the ecosystem, requiring more research of this matter, to identify both pest and beneficial species for strategic crops in Panama.

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