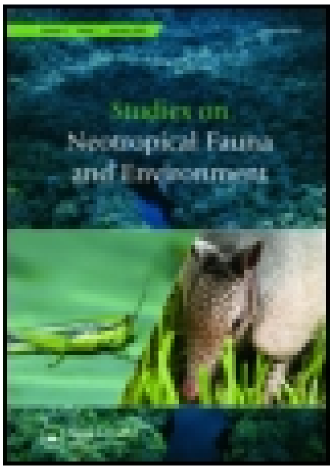

Studies on Neotropical Fauna and Environment
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/nnfe20

Ants, Plants and Butterflies as Diversity Indicators: Comparisons between Strata at six Forest Sites in Venezuela

Frances Osborn , William Goitia , Maira Cabrera & Klaus Jaffé
Published online: 09 Aug 2010.

To cite this article: Frances Osborn , William Goitia , Maira Cabrera & Klaus Jaffé (1999) Ants, Plants and Butterflies as Diversity Indicators: Comparisons between Strata at six Forest Sites in Venezuela, Studies on Neotropical Fauna and Environment, 34:1, 59-64

To link to this article: http://dx.doi.org/10.1076/snfe.34.1.59.8918

Stud Neotrop Fauna & Environm (1999) Vol. 34: 59–64
0165-0521/99/3401-0059$15.00

ANTS, PLANTS AND BUTTERFLIES AS DIVERSITY INDICATORS: COMPARISONS BETWEEN STRATA AT SIX FOREST SITES IN VENEZUELA

Frances Osborn, William Goitia, Maira Cabrera and Klaus Jaffé

Department of Organismic Biology, Simón Bolívar University, Caracas, Venezuela

ABSTRACT

At six different forest sites in Venezuela, we estimated the diversity and abundance of ants and nymphalid butterflies on the ground and in the canopy, and of plants. Statistical analysis using eight different diversity indices for each species group revealed large variations among them. Ground ants appeared to be the most reliable bioindicators, even when only the five most common species are considered. Results showed in addition that ground ant diversity is correlated to that of canopy ants and that vegetational diversity is linked to butterfly diversity but not to that of canopy ants. Ant species diversity in the canopy was always less than that on the ground. We conclude that no simple index or single taxon describes completely complex ecosystems, thus, biodiversity assessments require tools still to be developed.

KEYWORDS: Ants, butterflies, vegetation, bioindicators, ground, understorey, canopy, biodiversity, forest, Venezuela.

INTRODUCTION

A variety of studies have focused on the comparison of species richness and abundance (two components of diversity) of different orders of insects within and between sites with regard to seasonality (Levings, 1983), amount of rainfall (Janzen & Schoener, 1967), altitude and other factors (Janzen, 1973; Janzen et al., 1976). Other studies have looked at the use of indicator species or indicator groups such as ants or butterflies (Brown, 1991) in order to measure the importance of a particular taxon as an indicator of the diversity of a site. Generally, there seems to be a tendency to search for a few taxa and/or indices for biodiversity assessments of given ecosystems.

Ecosystems, however, may be very complex. For example, the relationship between insect and vegetational diversity has not been looked at in great detail, nor has the possible difference between insect communities at ground and canopy level (Nadkarni & Longino, 1990). Here we assess the relative diversity (using eight indices) of bait attracted members of two families of insects, Formicidae (Hymenoptera) and Nymphalidae (Lepidoptera), and compare it with vegetational diversity at six forest sites in Venezuela. We chose different biogeographic ecosystems in order to compare the relative robustness of a given taxon and index to assess biodiversity independent of the site. These comparisons were made with respect to altitude and to two different strata of the ecosystem: the canopy and the ground in the case of the ants, and the canopy and the understorey in the case of the butterflies.

Address correspondence to: Klaus Jaffe, Departamento de Biologia de Organismos, Universidad Simón Bolívar, Apartado 89000, Caracas 1080A, Venezuela. Fax : +58-2-9063624; E-mail : kjaffe@usb.ve

MATERIALS AND METHODS

Study sites

The study was carried out at six forest sites in different biogeographic areas of Venezuela (classified according to Holdrige, 1967): Cupo, Estado Miranda, 10º17' N, 66º22′ W (Humid tropical forest, 95 m); Sartenejas, Estado Miranda, 10º27′ N, 66º52′ W (Humid premontane forest, 1200 m); Pico Guacamaya, H. Pittier National Park, Estado Aragua, 10º30' N, 67º44' W (Very humid premontane forest, 1660 m); Rio Uracoa, El Merey, Estado Monagas, 8º45′ N, 62º47′ W (Morichal or savanna gallery forest in dry tropical forest, 70 m); San Francisco de Yuraní, Estado Bolivar, 5º3′ N, 60º57′ W (Morichal in humid premontane forest, 980 m); San Ignacio de Yuraní, Estado Bolivar, 5º2′ N, 60º57′ W (Humid premontane forest, 975 m).

Sampling

At each site a 360 m transect was strung through the forest along which collections were made of ants, butterflies from the subfamilies Nymphalinae, Brassolinae, Saturninae, Charaxinae and Morphinae (Papilionoidea: Nymphalidae) and the vegetation, over a period of five days. Ants and vegetation samples were collected only once in the dry season (January to April, 1993), whereas the butterflies were sampled in both the dry and the wet season (July to October, 1993). The ants were captured in pitfall traps (36 × 2 per transect) filled with 50 ml of 3% formaldehyde (Romero & Jaffe, 1989), placed along the transect at 10 m intervals at ground level and in the canopy. These were baited with tuna, minced ham, sweet biscuits and honey. The traps at ground level were covered with a metal grid to protect the contents against predators and a plastic plate to protect them against rain. The traps in the canopy were mounted using a pulley system. One end of a length of nylon was attached to a fishing weight and shot over a high branch using a catapult. This was tied to the other end of the nylon to form a loop. The trap was then tied on and hauled up to the correct height hanging on a rope. Ants attracted to the bait walked down the rope eventually dropping into the trap. Ants were collected the third and the fifth day. The contents of each trap were placed separately in gauze bags and stored in 75% alcohol. The butterflies were collected in hanging net traps 40 × 75 cm, baited with mashed, rotting plantains mixed with a small amount of sugar and rum to improve fermentation (DeVries, 1987). These traps were placed at head height and in the canopy at 20 m intervals along the transect (18 × 2 per transect). The butterflies were collected daily and the individuals from each trap were stored in separate envelopes of tracing paper.

Plant material was sampled by dividing the transect into 36 sections of 10 × 1 m each. In each section one sample of each different morpho-species was collected in a plastic bag, one bag per section. Trees were climbed when necessary.

Data analysis

The relative abundance of genera and species was obtained using frequency of capture in traps rather than number of individuals (see discussion in Romero & Jaffe, 1989). This reduces bias induced by recruitment in the case of the ants and patchy distributions in the case of the vegetation. The frequency of capture of ants and butterflies was obtained by counting the number of traps in which individuals of each species fell. These frequency data were calculated separately for the ground level, the understorey and the canopy. For comparisons of diversity indices, the butterfly data were pooled as they did not differ statistically for understorey and canopy. The frequency of appearance of each morpho-species of plants in the 36 sections of the transect was calculated in the same way. The identification of the ants and butterflies (to species) was undertaken using the collections at the Simón Bolívar University and Entomology Museum of the Faculty of Agronomy, Universidad Central de Venezuela. The plant species diversity was estimated quantifying the diversity of leafs assessed morphologically, as proposed by Vareschi (1992).

Diversity indices

The diversity indices calculated were: sp = species number; R^2 = linear regression coefficient between log(sp) and log (frequency of occurrence of those species); eq = Czekanowski's equitability index (Feisinger et al., 1981); com5 = percentage of traps which captured the five most common species; eq5 = eq calculated using only the five most common species; sw = Shannon Weaver index (Southwood, 1978); dom = Berger-Parker's dominance index (Southwood, 1978); dob = doubling factor or the proportion of species captured in the first 180 m of the transect compared to the total 360 m.

TABLE 1. Values for the various diversity indices for four different species groups at six different sites in Venezuela. AG = ground ants, AC = canopy ants, B = butterflies, V = vegetation. For abbreviations of the diversity indices see Materials and Methods.

	Study sites																							
	El Merey				Cupo				Bosque San Ignacio				Morichal San Francisco				Sartenejas				Henri Pittier			
Indices	AG	AC	B	V	AG	AC	B	V	AG	AC	B	V	AG	AC	B	V	AG	AC	B	V	AG	AC	B	V
Sp.	57	28	16	98	39	12	31	133	73	46	51	205	55	30	35	209	26	20	26	144	14	4	20	107
R^2 (log/log)	0.811	0.604	0.951	0.892	0.738	0.375	0.898	0.896	0.748	0.745	0.87	0.872	0.51	0.657	0.8	0.948	0.559	0.532	0.779	0.956	0.494	0.277	0.981	0.923
Eq.	0.578	0.642	0.753	0.606	0.599	0.624	0.766	0.605	0.542	0.666	0.586	0.563	0.561	0.723	0.58	0.598	0.541	0.603	0.669	0.546	0.485	0.75	0.727	0.615
Com5	71.7%	37.1%	31.7%	61.1%	63.9%	27.8%	43.3%	66.7%	65.6%	31.7%	81.1%	82.8%	63.3%	20.6%	94%	55.6%	44.4%	30.6%	32.2%	65%	42.2%	4.4%	34.4%	61.1%
Eq5	0.95	0.84	0.84	0.97	0.94	0.61	0.96	0.88	0.99	0.84	0.93	0.96	0.94	0.87	0.96	0.98	0.86	0.73	0.94	0.96	0.68	0.75	0.84	0.97
Sw	5.971	4.716	3.417	6.09	5.583	4.102	4.389	6.381	6.188	5.121	5.5	6.91	5.794	4.544	5.341	6.596	4.932	4.503	4.167	6.293	4.463	2.322	3.937	6.318
Dom.	0.082	0.172	0.12	0.052	0.109	0.397	0.1	0.057	0.053	0.22	0.078	0.038	0.308	0.129	0.09	0.03	0.16	0.302	0.123	0.051	0.376	0.25	0.133	0.045
Dob	0.754	0.929	0.563	0.724	0.763	0.714	0.968	0.812	0.726	0.804	0.891	0.741	0.909	0.7	0.743	0.837	0.789	0.75	0.731	0.692	0.714	0.75	0.6	0.785

RESULTS

For each site, the values of the various diversity indices (Table 1) and the correlation between the indices (Table 2) were calculated. Few correlations were statistically significant. Comparisons between species groups showed that ground ants and canopy ants are correlated (11 correlations), as are plants and butterflies (10 correlations). No correlation between ground ants and vegetation diversity was found.

As regards comparisons between the insect communities studied at two levels within the forests, canopy and ground (ants) and canopy and understorey (butterflies), it is evident that both assemblages are different, more conspicuously so among ants. Ants captured in both strata represented only 10.4% of all ant species recorded, whereas for butterflies, the captures in both strata represented 32.8% of the total species sampled.

Spearman's correlations between each of the indices and altitude of the sampling site revealed that only the indices R^2 and com5 for ground ants correlated significantly with altitude (rs = –0.886, $p < 0.05$ and rs = –0.943, $p < 0.01$ respectively). All other indices showed statistically non-significant correlations.

DISCUSSION

Diversity indices

The values of the various diversity indices used (Table 1) showed a large variability among indices and among sites. Few correlations between the indices at each site (Table 2) were statistically significant. We may assume that if a sample of species truly reflects the diversity of an ecosystem, most indices should reflect this diversity, and thus high correlation among the indices could be expected. In our study, such a

TABLE 2. Spearman's correlation coefficients between diversity indices of ground ants (GA), canopy ants (CA), butterflies (B) and vegetation (V) among the study sites in Venezuela. For abbreviations of the diversity indices, see Materials and Methods. Values of $r > 0.828$ and > 0.942 are significantly different from random at probabilities of > 95 and > 99 %, respectively.

	GAsp	GAr^2	GAeq	GAcom5	GAeq5	GAsw	GAdom
GAcom5	0.886	0.943	–				
GAeq5	0.986	0.841	–	0.928			
GAsw	1.000	–	–	0.886	0.986		
GAdom	–0.829	–0.943	–	–0.886	–0.899	–0.829	
CAsp	0.886	–	–	–	–	0.886	-
CAR^2	0.886	–	–	–	–	0.886	-
CAeq	–	–	–0.943	–	–	–	-
CAcom5	–	0.943	–	0.829	–	–	-0.886
CAsw	0.943	–	–	–	0.899	0.943	-
Bdom	–0.829	–	–	–	–	–0.829	-

	GAsp	GAr^2	CAeq5	CAdom	Vcom5
CAR^2	1.000				
CAsw	0.943	0.943			
CAdom	–	–	–0.986		
Bdom	–0.829	–0.829	–		
Veq5	–	–	–	–0.853	–0.896

	Bsp	Br^2	Beq.	Bcom5	Bsw
Bcom5	0.886	–	–		
Bsw	1.000	–	–	0.886	
Bdom	–0.829	–	–	–	–0.829
Bdob	0.829	–	–	–	0.829
Vsp	0.886	–	–0.829	0.829	0.886
Veq	–	0.943	–	–	–
Veq5	–	–	–	–	–0.896
Vsw	0.943	–	–	0.943	0.943
Vdom	–	–	0.943		

cross-correlation occurred only for ground ant indices (Table 2). Thus, the indices for diversity assessment for ground ants, using our sampling methods, seem to reflect more aspects of the ecosystem than those of the other taxa.

Comparisons between species groups showed that ground ants and canopy ants are correlated, as are plant species diversity and butterfly diversity (Table 2). This suggests that butterflies are tightly associated with the vegetation, serving as food for both larvae (leaves) and adults (flowers, fruit). Although canopy ants may also be associated with the vegetation, this seems to be a much looser arrangement (only one correlation). No correlation between ground ants and vegetation diversity was found.

Many papers on structure and composition of ecosystems base their choice of taxa for biodiversity measurements on specific characteristics and supposed advantages of the selected taxon. Our results show that ecosystem complexity is not easily reflected in simple diversity indices, and sampling different species groups will provide different results. But our results do suggest that sampling of ground ants will give more robust results, using equivalent sampling efforts, compared to the sampling of bait-attracted nymphalid butterflies and/or vegetation.

Correlation between plants and insects

In other studies a positive correlation between vegetation and arthropod diversity was also found for sites in Venezuela, such as that reported by Janzen et al. (1976) along an elevational transect including high moor land (páramo) and evergreen forest, and by Romero (unpublished results) in a study of the ant fauna in savannas. Janzen et al. (1976) postulated that arthropod diversity could be related to net productivity of plants, since higher productivity should sustain more parts (seeds, flowers) with sufficient biomass to support a greater number of host- and part-specific insect herbivore species. However, higher plant productivity has been related to less overall vegetational diversity since more competitive species, in terms of their capacity for rapid growth and reproduction (leading to higher total productivity), tend to dominate in a given area, lowering the vegetational species number (Huston, 1993).

Diversity in the canopy

As regards comparisons between the insects studied at two levels within the forests, canopy and ground (ants), and canopy and understorey (butterflies), it is evident that both insect communities are different, more conspicuously so among ants. Our method captured ants of a lower species number in the canopy than on the ground. Other studies, using fogging techniques for example (Wilson, 1987; Erwin, 1990), claimed the opposite. The use of similar methods to sample the ground and canopy should ensure that meaningful comparisons can be made between the insect communities of these two layers. We think that our approach, although not perfect, samples ants in both strata with a comparable bias, as we measure frequency of capture rather than total number of individuals. In any case, there is a marked separation of the dominant ant genera between the two levels, probably due to the different food and habitat requirements of the two groups.

There was no conspicuous difference between the distributions of butterflies that prefer the understorey and those preferring the canopy, although the less frequent genera tended to be confined to one of the two layers.

Sampling methods

With regard to the collecting efficiency of the three elements, pit fall trapping (in the case of the ants) has often been criticized (Gadagkar et al., 1993) for a tendency toward bias, especially when using baits and for sampling sub-populations. Although both these critiques are valid, the method seems to be the most simple and adequate available at present for comparative studies such as this. It also has the advantage that the insect community remains largely undisturbed, as opposed to the fogging technique which effectively strips the canopy of its arthropod inhabitants. There is a similar bias in the collecting of butterflies using baited traps. Rotting plantains only attract butterflies of some subfamilies from the family Nymphalidae. Furthermore DeVries (1984) estimated that butterflies attracted to these traps only represent about 40% of the diurnal species (excluding Lycaenidae and Riodinidae), thus the method is limited for comparisons of the butterfly community. The vegetation was faster and easier to sample and process than either butterflies or ants, but provided insufficient information (probably because of undersampling), with an equivalent effort, as compared to that for sampling ground ants.

Altitudinal effects

Spearman's correlations between each of the indices and altitude of the sampling site revealed that only the indices R^2 and com5 of ground ants correlated significantly with altitude. This result confirms previous reports about the diminishing ant diversity at higher elevations (Janzen et al., 1976), and shows again that ground ant diversity seems to be a robust biodiversity indicator (Brown, 1991), even when only the five most common species are considered. A high biodiversity of the myrmecofauna is meanwhile considered typical for all undisturbed tropical forest habitats, but only by long-term monitoring, the complete spectrum of species can be obtained.

Conclusions

The soil ant species richness seems to be the best bioindicator among those tested in our study. It is interesting to note that the difference between using the five most common ant species in calculating the indices and using all recorded ant species sampled is not large. This kind of simplification may be very useful for biodiversity assessment and should be investigated further. We may conclude that our work showed that no simple solution exists to understand complex systems. The use of single diversity indices using a single taxon for biodiversity assessments should thus be avoided. More research is required to develop new tools for comprehensive biodiversity assessments, specially involving longer periods of investigation and other arthropod groups which are not attracted by baiting.

ACKNOWLEDGMENTS

This project received logistical support from CVG-Proforca, El Merey, technical assistance by Jesus Velasquez, and taxonomic advice from Antonio Nunes Mayhe. Financial support came from project BID-Conicit QF-36.

REFERENCES

Brown Jr KS (1991): Conservation of Neotropical environments: Insects as indicators, p. 349-404. In: Collins NM, Thomas JA, eds., *Conservation of insects and their environments.* Academic Press, London.

DeVries PJ (1987): The Butterflies of Costa Rica and their natural history; Papilionidae, Pieridae, Nymphalidae. Princeton University Press, New Jersey, Oxford. xxii+327 pp.

Erwin TL (1990): Canopy arthropod biodiversity: a chronology of sampling techniques and results. *Revista Peruana de Entomologia 32:* 71–77.

Feisinger P, Spears EE , Poole W (1981) : A simple measure of niche breadth. *Ecology 62:* 27–32.

Gadagkar R, Nair P, Chandrashekara K, Bhat DM (1993): Ant species richness and diversity in some selected localities in Western Ghats, India. *Hexapoda 5:* 79–94.

Holdrige LR (1967): Life Zone Ecology (second de.). Trop. Res. Center, San Jose, Costa Rica. 206 pp.

Huston M (1993): Biological diversity, soils and economics. Science 262: 1676–1679.

Janzen DH (1973): Sweep samples of tropical foliage insects: effects of season, vegetation types, elevation, time of day, and insularity. *Ecology 54:* 687–708.

Janzen DH, Schroeder TW (1967): Differences in insect abundance and diversity between wetter and drier sites during a tropical dry season. *Ecology 49:* 96–110.

Janzen DH, Ataroff M, Fariñas M, Reyes S, Rincon N, Soler A, Soriano P, Vera M (1976): Changes in the arthropod community along an elevational transect in the Venezuelan Andes. *Biotropica 8:* 193–203.

Levings S (1983): Seasonal, annual, and among-site variation in the ground ant community of a deciduous tropical forest: some causes of patchy species distributions. *Ecological Monographs 53:* 435–455.

Nadkarni NM, Longino JT (1990): Invertebrates in canopy and ground organic matter in a Neotropical montane forest, Costa Rica. *Biotropica 22:* 286–289.

Romero HF, Jaffe K (1989): On methods for sampling of Formicidae in savannahs. *Biotropica 21:* 348–352.

Southwood TRE (1978): Ecological Methods, 2nd ed. Chapman and Hall, London. xxiv+524 pp.

Vareschi V (1992): Vegetationsökologie der Tropen. Eugen Ulmer Verlag. Stuttgart, Germany. 306 pp.

Wilson EO (1987): The arboreal ant fauna of Peruvian Amazon forests: A first assessment. *Biotropica 19:* 245–251.

Received: 26 December 1996
Accepted: 30 November 1998