August 2004

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ABSTRACT

Tank bromeliads (Bromeliaceae, *Vriesea* sp.) harbor diverse faunal communities. A total of 426 arthropods assigned to 62 different morphospecies were collected and identified to taxonomic order. The composition of bromeliad arthropod fauna was investigated in an open pasture to see whether arthropod diversity or richness correlated with distance from the forest edge. Neither arthropod richness nor diversity was found to significantly correlate with distance from the forest edge. These results are discussed in relation to island biogeography theory and the ecological implications of arthropod diversity are considered

RESUMEN

Las bromelias (Bromeliaceae, *Vriesea* sp.) dan refugio a comunidades diversas de artrópodos. Un total de 426 artrópodos asignados a 62 diferentes morfoespecies fueron colectadas e indentificadas a orden taxonómico. La composición de artrópodos en bromelias fue investigada en un potrero abierto para ver si la diversidad de artrópodos o riqueza se correlaciona con la distancia del borde del bosque. Ni la riqueza ni diversidad estuvieron significativamente correlacionadas con la distancia del borde del bosque. Se discuten las observaciones de la diversidad en relación con la teoría de biogeografía de islas y se consideran las impicaciones ecológicas de la diversidad de artrópodos.

INTRODUCTION

Epiphytes in tropical cloud forests provide microhabitats that harbor diverse arthropod communities (Yanoviak et al 2004). Tank bromeliads (Bromeliaceae) are common epiphytes in many tropical forests. Research on the associated fauna found in tank bromeliads suggests that the bromeliad interior may approximate a miniature ecosystem (Janzen 1983). The faunal relationship may be mutuality beneficial. Several studies strongly indicate that faunal associates provide nutrients that are readily available for uptake by the bromeliad host (Janzen 1983). As predators and prey, insects and other arthropods are of prime importance in moving energy through food chains and food webs (Price, 1997). Larger organisms, such as birds also benefit and even partially rely on the food resources bromeliads provide. In a study conducted in the Talamanca mountain range, Costa Rica, the foraging ecology of epiphyte-searching insectivorous birds was quantified (Sillett 1994). The most substrate specific forager was *Pseudocolaptes lawrencii*: 74% of foraging attempts were on bromeliads (Sillett 1994). Insects inhabiting bromeliads may also be integral to pollen dispersal and gene flow for many plant species near the bromeliad host (Howell et al, 1998).

Understanding the dynamics of bromeliad faunal diversity is essential to qualifying human impacts on tropical ecosystems. Bromeliads have often been hypothesized to exhibit characteristics of island ecosystem dynamics (Phaeton1992,

Shaw 1993). A structurally and functionally different habitat surrounds the pasture trees and the bromeliads, creating an island like environment. Since bromeliads naturally occur in the forest, it has been predicted that forest fauna are the major source of colonizers (Phaeton1992). According to the theory of island biogeography, an increase in distance from the forest edge, and thus the pool of potential colonizers, would result in a decrease in immigration and bromeliad faunal richness. This research analyzes bromeliad arthropod diversity in pasture trees to understand the impacts of isolation created by the conversion of forest to pasture.

MATERIALS AND METHODS

The study site was located in an abandoned pasture adjacent to the Estación Biológica, Monteverde, Costa Rica (10º 18´ N, 84º 48´ W), between 23 July and 3 August 2004. The site is located on the Pacific slope at 1530 m, about 300 m below the Continental Divide. The pasture was surrounded on all sides by montane wet forest that extended at least 10 m from the pasture edge. The interior of the pasture exhibited an uneven distribution of small to medium trees, small shrubs, and grasses.

Twenty-two tank bromeliads (Bromeliaceae, *Vriesea* sp.) were selected from tree trunks and logs at varying distances from the forest edge. Bromeliad size and height above the ground were kept relatively constant. Distance from the nearest forest edge, type of substrate, and the presence of nearby bromeliads were documented. The height of the bromeliads was measured from the base of the rosette directly to the ground. Once detached from the substrate bromeliads were immediately contained in a plastic bucket with a sealing lid and transported back to the laboratory where the diameter of the rosette was measured and bromeliads were carefully dissected in the bucket. All arthropods were removed by hand, tweezers, or an aspirator and placed in plastic Ziploc Baggies. Morphospecies were identified and their abundances recorded for each bromeliad.

A Shannon Weiner index was used to calculate diversity for each bromeliad. A simple regression was used to test for a significant correlation between diversity and two separate variables: distance from the forest edge and diameter of the bromeliad rosette. Diversity and distance were compared using Kruskal- Wallis. A Jaccard similarity index was used to determine species overlap between distance intervals (0-10 m, 10-20 m, 20-30 m).

RESULTS

Bromeliad height ranged from 0.85 - 3.75 m above the ground. The diameter of bromeliad rosettes ranged from 0.35-0.53 m. A total of 426 arthropods assigned to 62 different morphospecies were collected. Most morphospecies were identified as members of 14 orders, although 5 morphospecies could not be identified (Table 1). The most species rich order was Coleoptera, which contained 19 morphospecies (Table 1). The second richest order was Araneae, which contained 11 different morphospecies (Table 1). Diversity index (H') ranged from 0.494 to 1.60 (Figure1). A simple regression showed no significant correlation between distance from the forest edge and diversity (R^2 = 0.119, P = 0.1160) (Figure1). Species richness (# of morphospecies bromeliad^{-1}) ranged from 4 to 15 (Table 1). No significant correlation was observed between bromeliad size

and diversity ($R^2 = 0.017$, $P = 0.0790$). No significant difference in species richness or diversity between three distance intervals (0-10 m, 10-20 m, 20-30m) was found. There was a low number of species overlap between distance intervals, with the greatest overlap occurring between 0-10 m and 20-30 m (Jaccard:0.36). Species overlap was very low between 0-10 m and 10-20 m, and between 10-20 m and 20-30 (Jaccard = 0.28: 0.27, respectively)

DISCUSSION

A correlation was not observed between distance from the forest edge and bromeliad arthropod richness or diversity. According to the theory of island biogeography, a negative correlation would be expected between distance from the forest edge and bromeliad faunal richness. This correlation was not observed in previous studies on bromeliad arthropods conducted in the same area (Phaeton 1992, Shaw 1993).

There are several potential explanations for the lack of correlation between diversity and distance from the forest edge. The spatial scale may have not been great enough to observe an existing correlation. Most of the observed species had wings and may have been capable of easily traveling the furthest distance sampled, 30.45 m. Bromeliad environments were not identical: the trees were not evenly spaced, the bromeliads experienced various levels of sunlight availability, surrounding epiphytic flora varied in composition and abundance, and wind conditions may have varied significantly. Although it appears there is little species overlap between distance intervals measured from the forest edge, this may not be significant. There was a very high number of species distributed over a relatively low number of bromeliads with many species occurring only once. It is possible that randomness rather than specialization influenced the apparently low overlap.

Although an attempt was made to hold the size of the bromeliad constant, diameter of the rosette may not have been an accurate measurement of the available habitat space. It was observed that bromeliads with similar rosette diameters had varying numbers of actual leaves and consequently different amounts of available habitat space. Past studies have found a clear correlation between habitat space and diversity (Shaw 1993). Although there was no correlation between rosette diameter and arthropod diversity, the variation in number of leaves could have had an effect on diversity. Another potential source of error in the methodology of the experiment that may have affected the results, was that although samples were contained as quickly as possible, due to difficulty of detachment, prolonged physical disturbance may have allowed some arthropods to escape capture.

The number of morphospecies found was interesting. A recent study examined arthropod diversity in epiphytic mats, primarily bryophytes and mosses (Yanoviak et al, 2004). Of the 1943 arthropods found, only 42 different morphospecies were assigned (Yanoviak et al 2004). Comparatively, bromeliads exhibited a much greater species richness, containing 62 morphospecies out of only 426 arthropods.

Bromeliads provide a habitat for a diverse assemblage of arthropods. It is likely the ecological niche they provide plays an important role in maintaining biodiversity in pastures that contain trees. Due to rapid habitat destruction and fragmentation concern regarding the preservation of insect species has developed rapidly (Price 1997). The arthropods inhabiting bromeliads are a key factor in moving energy through the food

chain and may provide a substantial food source for larger organisms like birds (Price 1997). Arthropods from the order Blattodea are scavengers that break down waste and aid in the cycling of nutrients (Evens 1984). Species of the order Coleoptera occupy many foraging niches as predators, scavengers, and herbivores (Borror and DeLong 1964). Winged arthropods such as those belonging to the order Coleoptera may aid in the pollination systems of local plants. Arthropods are an integral part of ecosystem dynamics. Felling of tropical forests certainly has dramatic an often devastating ecological effects, but the trees and bromeliads that are left will certainly provide many ecological benefits.

ACKNOWLEDGEMENTS

Thanks to the Estación Biológia for the opportunity to conduct research. Thanks to Maria Jost and Oliver Hyman for their expert bromeliad collecting assistance and technical support with statview and excel. Thanks to Carmen Rojas and Carlos Guendon for their help along the way. Thanks to Emily Matheson for listening to me complain.

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Table 1. Numbers of individuals and morphospecies categorized by taxonomic order. An egg sack contained 101 Araneae in a single bromeliad.

Order	#individuals	#species
Araneae	154	11
Blattodea	69	1
Chilopoda	6	4
Coleoptera	38	19
Dermaptera	23	3
Diplopoda	1	1
Diptera	2	1
Hemiptera	6	1
Hymenoptera	9	2
Isopoda	43	2
Lepidoptera	2	1
Orthoptera	25	8
Symphyla*	10	1
Thysanurans	3	1
Unidentified	35	5
Total	426	62

*Was identified to class