THE EFFECTS OF HUMAN DISTURBANCE ON TROPICAL BUTTERFLY DIVERSITY

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Abstract - Clearing of tropical rainforests for agriculture or livestock results in decreased plant and animal diversity. We examined the differences in butterfly diversity and abundance between a primary tropical rainforest and neighboring roadside pasture at La Selva biological preserve in Costa Rica. Butterfly species richness was more than twice as high in primary forest than in pasture, and diversity was also higher, even though overall butterfly abundance was nearly 3-fold higher in pasture. The abundance of specialist and generalist species was similar between the two habitats, but there tended to be more endemic and rare species inhabiting primary forest than pasture (7/20 vs. 1/11). Apparently, the loss of primary forest is more likely to result in local extinctions than the loss of pasture and will lead to increased spatial homogeneity of butterfly communities. Few species overlapped between the two habitats, indicating that both primary forest and human-made pastures contribute to overall butterfly diversity, but the same primary forest contributed more species than pasture.

Key Words: La Selva, specialist, generalist, endemic , rare, cosmopolitan, human disturbance, primary forest, conservation

INTRODUCTION

Costa Rica is home to over 540 species of butterflies (DeVries 1987), 204 of which can be found in La Selva Biological Reserve (DeVries 1994). Clear cutting of tropical rainforests for agriculture or livestock often results in decreased plant and animal diversity. We examined the effects of human disturbance on butterflies by comparing diversity and abundance in primary forest and in pastures.

Many butterfly species are specialists, requiring a narrow range of plant species for oviposition sites. A decrease in host-plant diversity as a result of human disturbance could lead to a decrease in butterfly diversity. Conversely, open pasture areas (a frequent result of human disturbance) often have a greater abundance of floral resources for adult butterflies and may even have higher primary productivity. Also, pastures are invariably sunny habitats which butterflies seem to prefer (Jackson 1996). For these reasons, pastures may support larger numbers of butterflies. We hypothesized that butterfly diversity and the proportion of specialist species would be greater in primary forest than in pastures, but that butterfly abundance would be greater in pastures than in primary forest.

To further test the effects of human disturbance on butterflies we looked at differences between each habitat's ability to support endemic vs. cosmopolitan species. Endemic species may be endemic because they have more rigid resource requirements than cosmopolitan species. Disturbance of primary forest habitat decreases spatial complexity and therefore the diversity of habitats and resources. If so, there should be a greater proportion of endemic species in primary forest habitat.

METHODS

We sampled along ten 100 x 10 m transects in both primary rainforest and roadside pasture on 16 - 17 February 1998 at La Selva Biological Reserve, Costa Rica. We recorded species (DeVries 1987a, 1987b) or morphotype for all butterflies seen. Primary forest transects were located along the CCL, CC, SHA, and SSO trails. We restricted our sampling to understory species. Pasture transects were located in fields along the access road to the OTS biological station. We conducted our sampling between 09:00 and 14:00. Weather conditions were sunny for both days.

We classified butterflies as generalists or specialists, and as cosmopolitan, or rare and endemic using data from DeVries (1987a, 1987b). Species that utilized two or fewer genera of plants, or one or fewer families of plants were considered specialists. Butterflies that only occurred in specific habitat types or only in Central America were considered endemic or rare. Cosmopolitan species all occurred in North or South America in addition to Central America.

We calculated the Simpson's Diversity Index for each transect (Begon et al, 1996). We used t-tests to examine the relationship between habitat type and number of species per transect, abundance per transect, and diversity index. We performed a Chi-square test to examine the relationship between habitat type and species richness (under the null hypothesis that equal sampling intensity in the two habitats should reveal an equal total number of species). We used G-tests to examine the relationship between habitat type and proportion of specialist vs. generalist species, and endemic vs. cosmopolitan species.

RESULTS

We recorded a total of 480 butterfly individuals, representing 41 species, in 2 ha over 10 h of sampling in 20 10 x 100 m transects. Total butterfly abundance was almost 3-fold greater in the pasture than the forest (Table 1). However, the pasture butterfly community was dominated by a few very abundant species, so Simpson's Diversity Index was substantially higher in the forest than in the pasture, and butterfly species per transect was virtually identical between habitats (Table 1). Furthermore, each transect in the forest tended to contribute new species, while replicate transects quickly became redundant in the pasture. Consequently, the total species richness was more than twice as high in the forest as in the pasture (Table 1). There was no difference between sites in the proportion of species that were specialists or generalists (t_{18} = 0.00, P = 1.00; Table 1). Our sampling revealed many more endemic species in the forest (7 of 20) than in the pasture (1 of 11) but this difference was not statistically significant.

DISCUSSION

As predicted, butterfly species richness and diversity were greater in primary forest, while abundance was higher in pasture habitats. We observed many butterflies in each pasture transect, but there was a high degree of redundancy in the species that we encountered in each transect. In the primary forest, we were still encountering new species with almost every new transect, so the difference in species richness between habitats would have become increasingly pronounced with additional sampling. Apparently, the loss of host plants and structural complexity in pastures results in the disappearance of many butterfly species and decreased diversity. Sunny open areas, like pastures, facilitate butterfly thermoregulation (Jackson et. al., 1996), contain more floral resources, and could even have higher primary productivity, than the forest understory. The result is a larger number of adult butterflies in a community with low species richness and low diversity.

The abundance of specialist and generalist species was similar between primary forest and pasture habitats. Since man-made pastures contain fewer plant species than primary forest, specialist butterfly species living in these pastures show a great deal of host plant overlap. Pasture specialist species are probably more abundant than forest specialist species because their host plants are more common than host plants in primary forest habitats. *Cissia* spp., the most common butterfly in the pasture, specializes on various types of grass (Poaceae) but most of the *Heliconius* spp. in the primary forest specialize on *Passiflora* spp., which were rare in our transects.

Our data suggest that the forest habitats contain more endemic and rare species than roadside pastures (10 species vs. 1 species). This contrast is probably conservative because many of the forest species were observed only once and could not be reliably classified. Apparently, the loss of primary forest is more likely to result in local extinctions than the loss of pasture and will lead to increased homogeneity of butterfly communities across regions.

Future studies on butterfly diversity and the impact of human disturbance should survey species richness and diversity in the forest canopy. It has been suggested that the canopy may support more species of butterflies than the understory (DeVries, 1987). It would also be interesting to examine butterfly diversity in naturally-occurring meadows and light gaps, which probably have significantly higher plant diversity than human-created open areas. A more complete guide to the butterflies of La Selva and more detailed knowledge of the ranges and biology of rare species would facilitate future surveys of butterfly diversity in this region.

Our data suggest that efforts geared toward butterfly conservation should emphasize the preservation of primary forest. We found little species overlap between the two habitats, indicating that both contribute to overall diversity; however, the relative importance of primary forest for butterfly species diversity is

greater. Several species that were observed in primary forest are very local and rare, including *Memphis aureola* and *Napeogenes peredia hemisticta*. Further clearing of primary rainforest would likely increase the risk of extinction for these and similar species.

LITERATURE CITED

Begon, M., C. R. Harper, and J. C. Townsend. 1996. Ecology: individuals, populations, and communities. Blackwell Science, Boston, MA.

DeVries, P. J., 1987. The butterflies of Costa Rica and their natural history: Papilionidae, Pieridae, Nymphalidae. Princeton University Press, Princeton, New Jersey.

DeVries, P. J., 1997. Vol. II. Princeton University Press, Princeton, New Jersey.

DeVries, P. J., chapter in the La Selva Book.

Jackson, C. D. R. and P. P. C. Shelby. 1996. "The effects of habitat light intensity on lepidoptera communities." Pp. 36-37. *In* A. L. Mannan and D. S. Canny, editors. Dartmouth Studies in Tropical Ecology. Dartmouth College, Hanover, NH. USA.

TABLE 1. Summary of variables measured and test statistics for primary forest and pasture sites.

Variable	Pasture	Forest	Test Statistic
Abundance per Transect	35 ± 2.91	13 ± 1.15	t_{18} = 7.04***
Simpson's Diversity Index (mean ±SE)	4.53 ± 0.49	6.03 ± 0.34	t_{18} = 2.50*
Number of Species per Transect (mean ± SE)	8.1 ± 0.62	8.1 ± 0.46	t_{18} = 0.00
Total Number of Species	14	30	X^2 = 5.82*
Proportion of Specialist Species[a]	7/11	13/17	G = 0.53
Proportion of Endemic Species[b]	1/11	7/20	G = 2.80

* P < 0.05; ** P < 0.01; *** P < 0.001.

[a] Remainder are generalist species. Not all species could be classified.

[b] Remainder are cosmopolitan species. Not all species could be classified.

APPENDIX. List of butterfly species seen at La Selva on 16 and 17 February, 1998. For each species we note the number found in each habitat, diet breadth (S = Specialist, G = Generalist, U = Unknown) and distribution (E = Endemic, C = Cosmopolitan, U = Unknown).

Butterfly species	Abundance: Primary forest	Abundance: Pasture	Diet breadth	Distribution
Antirrhea miltiades	1		S	C
Citharias menander	6		U	C
Dulcedo polita	4		S	E
Euides lybia olympia	2		S	E
Euptychia insolata	3		S	E
Eurema albula	21	2	S	C
Heliconius cydno galanthus	17	2	S	C
Hypothyrus euclea valora	5		S	C
Juditha molpe	1		G	C
Marpesia merops	2		S	C
Mechanitis lysimnia doryssus	5		S	C
Mechanitis polymnia isthmia	3		S	C
Melinaea ethra lilis	1		S	E
Memphis aureola	1		U	E
Morpho peleides limpida	1		G	C
Napeogenes peredia hemisticta	1		U	E
Parides spp.	1		S	C
Perophthalma lasus	1		U	E
Phoebis spp.	21	48	G	C
Pierella helvetia incanescens	4		G	C
Theope spp.	1		S	U
Big black and white spot	1		U	U
Big black	3		U	U
Big orange black-dot	1		U	U
Butter-yellow	3		U	U
Crescent swallowtail	1		U	U
L.B.J.	3		U	U
Red hairstreak	9		U	U
Small orange-yellow	6		U	U
Yellow-headed cloudy 2-dot	1		U	U
Anartia fatima		60	G	C
Anartia jatrophae		9	G	C
Cissia spp.		130	G	C
Dryadula phaetusa		24	S	C
Eurema nise		24	S	C
Heliconius erato petiverana		11	S	C
Heliconius sara fulgidis		1	S	E
Aeria eurimedia agna		2	S	C
Brown long-tail		17	U	U
Brown orange-corner		4	U	U
Orange hairstreak		14	U	U
Heliconius doris†	1		S	C
Nica flavilla cantharа†	1		G	C
Dryas iulia†		1	S	C

† Species observed in study sites, but outside of transects