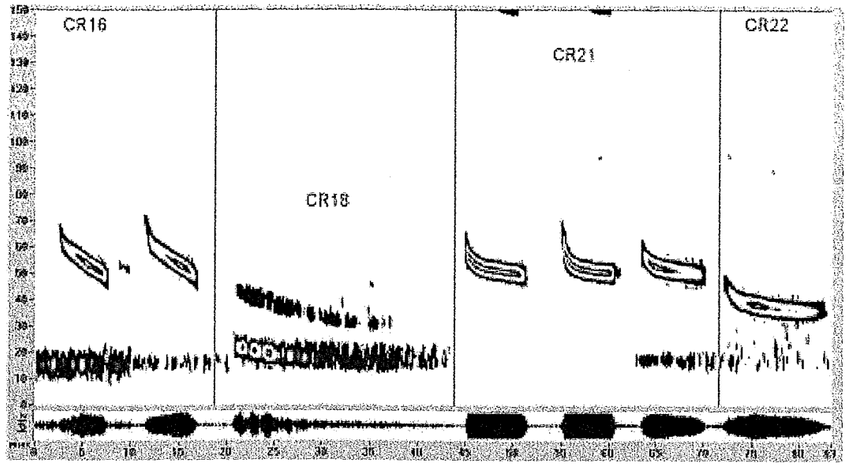

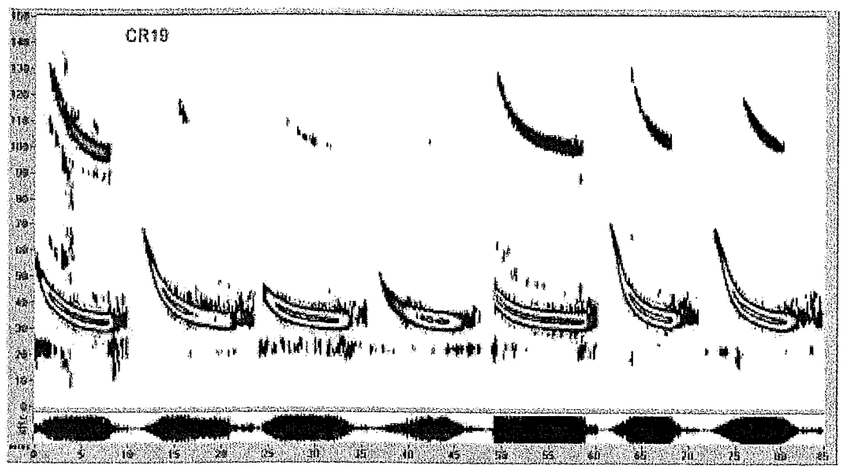

Comparison of Lepidoptera diversity and abundance in forest interior and edge at four sites in Costa Rica

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Abstract: A large percentage of the butterfly species from Central and South America can be found in Costa Rica, and their distribution may be determined by differences in abiotic factors and host plant distribution. We hypothesized that diversity and abundance would vary 1) between forest sites, and 2) between forest edge and interior habitats. We collected butterflies from four different tropical forest sites in Costa Rica: tropical dry forest, Pacific lowland tropical forest, Atlantic lowland tropical forest, and mid-elevation cloud forest. At each site, we recorded butterfly abundance, species richness, geographic distribution and diet breadth (specialist vs. generalist), and whether the butterfly was caught in the edge or interior. Species abundance and diversity increased with decreasing elevation and increasing temperature. Of the 66 species collected, only ten species overlapped between the four sites and only five overlapped between the edge and interior. A greater diversity, but a lower abundance of butterflies was found in the interior than the edge. Our results suggest that continued fragmentation of Central American forests may lead to an increase in butterfly abundance, but a decrease in diversity and a substantial change in Lepidopteran community composition.

Key Words: butterfly, diet, endemic, generalist, human disturbance, range, specialist, species richness

Introduction

Costa Rica is home to 540 butterfly species (DeVries 1987a), a large percentage of all the butterflies known to Central America and the Amazon Basin. Butterfly species are unevenly distributed across the country and this distribution may correspond to differences in forest habitats. Within Costa Rica, forest habitats vary as a result of differences in temperature, rainfall, seasonality and elevation (Janzen 1983).

As of late, butterfly diversity has also been affected by anthropogenic disturbance of forest habitat. A recent study determined that butterfly abundance was greater but diversity was lower in pasture vs. forest interior habitats (Berg et al. 1998). In addition to the conversion of forest to pastureland, fragmentation of forests in Costa Rica also leads to increases in edge habitat. These habitat types differ in light intensity, forest heterogeneity and host-plant diversity. Because many butterflies are specialists that require specific plant species for feeding or ovipostition sites, they may be especially vulnerable to changes in forest structure and composition.

We hypothesized that butterfly diversity and abundance would vary 1) between four distinct Neotropical forest types, and 2) between forest interior and edge habitats. We predicted that in the interior butterfly abundance would be lower but diversity and the proportion of specialist species would be greater. Our results may help in understanding the effects of human disturbance on tropical forests.

Methods

We sampled butterfly populations at four sites in Costa Rica: Palo Verde, Monteverde, Corcovado and La Selva. On 10 January 2002, we sampled on the Pizote trail 0.5 km southwest of the OTS station at Palo Verde National Park, Guanacaste. On 18 January we sampled on the Senderos Principal, Coriblancos, and Jilguero trails and in nearby fields within 400 m of the Estación Biológica Monteverde, Puntarenas. On 1 February, we sampled on the airstrip and the Espevales trail near the Estación Biológica Sirena in

Corcovado National Park, Puntarenas. Finally, on 12 February, we sampled on the trails and open areas near the station at Finca La Selva, south of the Rio Puerto Viejo.

At each site, we captured butterflies with butterfly nets and fruit-baited traps (illustrated in DeVries 1987a) between 08:30 and 11:30. Six people sampled at each site, with effort split equally between the forest interior and edge habitats. For each species identified, we recorded the number and color of individuals captured in each habitat type. We classified butterflies as specialists or generalists depending on whether they utilized one or more than one genus of host plants (DeVries 1987a, 1987b). We grouped species ranges into three categories: Americas (North and South America), Central America (southern United States to Panama) and endemic (Costa Rica, Nicaragua, and Panama).

We used a chi-square test to compare (1) total number of species between sites, (2) total number of individuals between sites, (3) proportions of the number of species in edge versus interior habitats between sights, (4) proportions of the number of individuals in edge versus interior habitats between sites, (5) proportions of species that are generalist versus specialist herbivores between sites, and (6) proportions of species that are generalist versus specialist herbivores between edge and interior habitats. Monteverde was not included in the chi-square analysis of diet breadth (specialist vs. generalist) across sites because of small sample size (n = 9 species). We calculated a Simpson Diversity Index for edge vs. interior and for each of the four sites.

Results

We captured a total of 148 butterflies representing 66 different species. Species richness and abundance varied between sites, and was greatest at Corcovado, intermediate at Palo Verde and La Selva, and lowest at Monteverde (species richness: $\chi^2 = 11.57$, df = 3, $P < 0.01$; Table 1 and abundance: $\chi^2 = 25.15$, df = 3, $P < 0.01$; Table 2). Only 10 of 66 species were found at more than one site (Appendix). Species diversity was greatest at Corcovado and Palo Verde, followed in order by La Selva and Monteverde (Simpson Diversity = 13.7, 11.5, 7.31, 4.31, respectively).

Only 5 species overlapped in edge and interior habitats; however, the proportion of species in edge versus interior was not significantly different between sites ($\chi^2 = 2.57$, df = 3, P = 0.46; Table 1). For Corcovado, La Selva and Monteverde the species richness was greater in the edge than in the interior. However, since species composition was more even in the interior, diversity for all four sites combined was greater in the interior than the edge (Simpson Diversity = 22.75 and 13.23, respectively). Butterfly abundance in edge vs. interior was different between sites ($\chi^2 = 15.1$, df = 3, P = 0.002; Table 2). The abundance was greater in the edge than the interior in all four sites.

The number of generalist versus specialist species was not significantly different between sites ($\chi^2 = 1.37$, df = 2, P = 0.50; Table 3) or between edge and interior habitats ($\chi^2 = 2.21$, df = 1, P = 0.14; Table 4).

TABLE 1. Species richness of butterflies in edge and interior habitats at 4 sites in Costa Rica.

	Corcovado	La Selva	Monteverde	Palo Verde	Total
Edge	20	11	6	9	46
Interior	10	7	3	11	31
Total	30	18	9	20	77

TABLE 2. Number of butterfly individuals in edge and interior habitats at each site.

	Corcovado	La Selva	Monteverde	Palo Verde	Total
Edge	32	26	21	18	97
Interior	24	6	5	16	51
Total	56	32	26	34	148

TABLE 3. Number of generalist and a specialist butterfly species at each site.

	Corcovado	La Selva	Monteverde	Palo Verde	Total
Generalist	9	5	3	5	22
Specialist	9	10	1	12	32
Unknown	12	3	5	3	23
Total	30	18	9	20	77

TABLE 4. Number of generalist and specialist butterfly species in edge and interior habitats totaled over all sites.

	Edge	Interior	Total
Generalist	9	13	22
Specialist	21	11	32
Total	30	24	54

Discussion

Of the 540 butterfly species found in Costa Rica, we captured 66, or about 12%, in the four forest sites. Abundance and species richness varied between sites, and tended to follow an elevation and temperature gradient. Monteverde, a mid-elevation cloud forest, with the highest elevation and coldest climate had the lowest abundance and species richness while Corcovado, a Pacific lowland tropical forest, had the highest. La Selva, an Atlantic lowland tropical forest was intermediate in butterfly abundance and richness. Many butterflies may be restricted to warm, low elevation areas because their flight muscles function poorly at temperatures below 30 °C. This trend could also be influenced by differences in weather during sampling at the four sites. The relatively low butterfly abundance at La Selva may be a consequence of cool, overcast conditions during our sampling at this site.

As predicted, butterfly abundance was greater in edge than interior habitat. If thermoregulatory constraints determine butterfly distribution on a local scale, the greater light intensity of edge habitat should attract more butterflies. We likely overestimated the abundance of butterflies in edge habitat because it was easier to catch butterflies there than in the interior. However, our judgement is that this bias had little effect on the pattern in our data.

Butterfly species diversity was greater in the interior than the edge, but the proportion of specialists did not differ between the edge and interior. Greater structural heterogeneity and diversity of host plants could explain the greater butterfly diversity in the forest interior. We likely overestimated butterfly diversity, especially in the edge, because we focused on catching new species and sometimes did not attempt to catch species that had been caught previously. To better estimate diversity, future studies could record the time of catch to construct species-effort curves.

Surprisingly few species overlapped between the four sites and between the edge and interior habitats, which suggests that there are many butterflies in Costa Rica with very specific habitat requirements, and that we sampled only a small fraction of the species present. Our results suggest that continued fragmentation of forest habitat may increase butterfly abundance, but could potentially decrease diversity and drastically change community composition.

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APPENDIX. List of butterfly species collected at four sites in Costa Rica, 2002. Indicated for each species are the number found in each habitat, distribution (E = endemic, CA = Central America, A = Americas, U = unknown), diet breadth (S = specialist, G = generalist, U = unknown) and color type (L = light, D = dark, A = aposomatic).

Site (Date)	Family	Butterfly species	Abundance		Range	Diet	Color type
			Edge	Interior			
Corcovado (1 Feb)	Hesperiidae	unidentified	3	1	U	U	U
	Nymphalidae	*Adelpha boeotia boeotia*		1	A	G	D
		Aeria eurimida agna		1	A	S	A
		Anartia fatima		12	CA	G	D
		Anartia jatrophae	4		A	G	D
		Anthanassa spp.	2		U	U	U
		Anthanassa tulcis	1		CA	U	D
		Aphrissa boisduvallii	1		A	U	L
		Cissia alcinoe		1	A	G	D
		Cissia hermes	1		A	G	D
		Dryas iulia	3		A	S	A
		Heliconius lybia liboides	1		U	U	A
		Heliconius melpomene rosina	3		A	S	A
		Heliconius sara theudela	5		A	S	A
		Marpesia alcibiades	1		CA	U	D
		Marpesia berania		2	A	U	D
		Morpho peleides limpida		2	A	G	D
		Siproeta stelenes biplagiata		2	A	G	D
	Pieridae	*Aphrissa statira*		1	A	G	L
		Enantia licinia marion	1		A	U	L

Site (Date)	Family	Butterfly species	Abundance		Range	Diet	Color type
			Edge	Interior			
Corcovado (1 Feb)	Pieridae	*Eurema boisduvaliara*		1	CA	U	L
		Eurema dairaa	1		A	G	L
		Eurema nise	1		A	S	L
		Phoebis argante		1	A	S	L
		Phoebis philea philea	1		A	S	L
		Phoebis sennae	1		A	S	L
		Phoebis trite	1		A	S	L
La Selva (12 Feb)	Heliconidae	*Philaethria dido*	1		A	S	A
	Hesperiidae	Unidentified	1		U	U	U
	Nymphalidae	*Anartia fatima*	2		CA	G	D
		Caligo atreus dionysos		1	A	G	D
		Caligo eurilochus		1	A	G	D
		Caligo illioneus oberon		1	A	G	D
		Cissia alcinoe	10		A	G	D
		Cissia hesione	1		CA	S	D
		Cissia libye	1		A	S	D
		Eueides lybia olympia	5		A	S	A
		Godyris zygia		1	E	S	A
		Heliconius cydno galanthus	1		A	S	A
		Hyposcada virginiana evanides		1	A	S	A
		Megeuptychia antonoe	2		A	S	D
		Oleria paula		1	A	S	A
	Pieridae	*Dismorphia amphiona praxinoe*	2		A	S	A
		Dismorphia theucharila fortunata	1		A	U	A
	Riodinidae	*Emesis lucinda*	1		A	S	D
MonteVerde (18 Jan)	Hesperiidae	*Pyrgus* spp.	2		U	U	U
	Nymphalidae	*Anartia fatima*	9		CA	G	D
		Cissia hermes	7		A	G	D
		Heliconius clysanymus montanus		2	CA	S	A

Site (Date)	Family	Butterfly species	Abundance		Range	Diet	Color type
			Edge	Interior			
MonteVerde (18 Jan)	Nymphalidae	*Heterosais edessa nephele*		2	A	U	A
		Manataria maculata		50	A	G	D
		Pteronymia fumida	1		A	U	A
	Pieridae	*Eurema* spp.	1		U	U	U
	Riodinidae	*Theope* spp.	1		U	U	U
Palo Verde (10 Jan)	Hesperiidae	unidentified		4	U	U	U
	Nymphalidae	*Adelpha basiloides*		1	CA	G	D
		Anartia jatrophe	1		A	G	D
		Ascia josephina josepha	2	3	A	S	L
		Ascia monuste		1	A	G	L
		Danaus gilippus	10		CA	G	A
		Danaus plexippus	1		A	S	A
		Dione juno	1		A	S	A
		Dryadula phaetusa	1		A	S	A
		Hamadryas feronia farinulenta		1	A	S	D
		Megeuptychia antonoe	1	1	A	S	D
		Memphis proserpina		1	CA	U	D
		Siproeta stelenes biplagiata		2	A	G	D
		Taygetis andromeda	1	3	A	G	D
	Papilionidae	*Battus polydamas polydamas*	1		A	S	D
		Eurytides branchus	1		CA	S	D
		Papilio thoas nealces		1	A	S	A
	Pieridae	*Appias Drusilla*	1	1	A	G	L
		Eurema daira	1	3	A	G	L
		Eurema nise		1	A	S	L
		Eurema proterpia	1		A	S	A
		Itaballia demophile centralis		3	A	S	L
		Phoebis philea philea	1		A	S	L
		Phoebis trite		1	A	S	L