Discussion

Sample sizes were too small for a powerful statistical test, but there was a tendency for increased agonistic behavior of jacanas in the late afternoon. This could be because the cooler temperatures reduce the relative costs of high energy behaviors such as attacking and wing raising. However, it may also be that jacana behavior is not temperature driven, but is instead driven by diurnal changes in food resource availability. Future studies could identify the relative costs and benefits of different activities at different times of day and examine possible patterns in the.availability and use of food resources.

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AVIAN COMMUNITY STRUCTURE IN EDGE AND INTERIOR HABITATS OF TROPICAL DRY FOREST

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Abstract. To examine differences in avian community structure between edge and interior habitats in a tropical dry forest, birds were censused along secondary forest trails and a forest edge in Palo Verde National Park, Costa Rica. Insectivores were more abundant in the interior and granivores were more abundant on the edge. At the structurally complex forest edge, more guilds were represented, and birds were more equitably distributed among guilds. Species richness was greater at the forest edge, but Shannon-Weiner diversity did not differ between habitats. Results support the hypothesis that bird community structure is heavily influenced by habitat structure, which probably affects the availability and diversity of resources.

Key Words: Avifauna, community structure, edge effects, resource guilds, tropical dry forest

Introduction

The factors that determine the structure of ecological communities have been intensively studied for many years. Although the effects of edge creation have been fairly well studied in temperate forests, less is known about the importance of forest edge in tropical systems. Forest edge is comprised of two distinct habitats plus their interface and is often distinguished by increased structural diversity. The assemblage of plants and animals includes species characteristic of the adjoining habitats along with species found exclusively at edges. Thus, the edge should exhibit greater diversity and abundance of resources that can be exploited by bird communities. Structural diversity within forests has been linked to avian diversity in temperate and tropical forests (MacArthur et al, 1966, as cited in Stiles 1983; Terborgh and Weske 1969, as cited in Stiles 1983). To the extent that the structure and availability of resources influence avian community structure, edge bird communities should be more diverse. We evaluated this hypothesis by testing three predictions: 1) species richness and Shannon-Weiner diversity is greater in edge habitats; 2) more guilds are present in edge communities; and 3) birds are distributed more equitably between guilds at the edge.

Methods

Palo Verde National Park falls within Holdridge's tropical dry forest life zone (Janzen 1983), and is host to a rich avifauna and a variety of habitats from marsh to xeric limestone hills. The region was used as a cattle ranch from 1923 until 1982 and is currently undergoing successional changes (Janzen 1983; R.T. Holmes, pers. comm.). We sampled birds along three transects: transect A extended 3 km through tropical dry forest along the Senderos el Pizote, Querque and Cerros Calizos; transect B extended 2.5 km though mesic forest along the Sendero Natural; transect C extended 2.5 km along the edge of park road beginning 300 m east of the Estación Biologica. Transect A represented edge habitat. Transects B and C represented forest habitat. All sites were observed for two consecutive mornings on 9-10 January, 1996, from approximately 0715 until 1030, when bird activity began to subside. Birds within 20 m of each transect were counted and identified to the lowest possible taxonomic level, usually species. Feeding behavior was noted. The maximum number of individuals observed on either day for a species was taken as a minimum estimate of that species' abundance. Birds were assigned to feeding guilds according to their chief food sources as reported by Stiles and Skutch (1989).

We used a chi-square to compare the relative size (number of species) of different guilds at the three sites. The analysis excluded guilds with low abundance (such that no cells had an expected frequency of < 1, and $< 20\%$ had an expected frequency of < 5). To assess the effect of structural diversity on bird community structure, we applied the Shannon-Weiner diversity index to guilds such that guild diversity $H' = -\sum P \ln P$, where P is the proportion of total bird abundance constituted by each guild. Species diversity was calculated according to the standard Shannon-Weiner diversity index (Begon et al. 1990).

Results

Species richness was greatest in the edge transect (n = 26 species, compared to 22 and 17 species on transects B and C in the forest; Table 1). In contrast, Shannon-Weiner diversity was quite similar on all transects (species diversity = 2.69, 2.57, and 2.69 for transects A, B, and C, respectively). Bird species belonging to eleven families and six guilds were found in the edge transect while eight and thirteen families representing four and five guilds respectively were present in the forest transects. More individuals were censused along the edge than in the forest (n = 107 vs 34 and 29 for edge and forest transects respectively; Table 1).

Insectivores dominated in the forest habitats (Table 2). No one guild dominated the edge habitats, yet seed eaters were more abundant there than along forested transects (Table 2). Guild structures were more diverse along the edge (guild diversity = 1.39) than along the forest transects (guild diversity = 0.94 and 1.24). Furthermore, guilds were more evenly distributed on the forest edge than in forested sites (X^2 = 11.69; $p < .0025$).

Table 2: Guild representation from the edge habitat and the two forested habitats (percent of total individuals observed in each habitat).

Resource Guild	Forest Edge	Forest Site I	Forest Site II
Carrion	3.8	0.0	3.8
Fruit	30.0	33.0	21.0
Insects	39.0	59.0	54.0
Nectar	3.8	5.7	15.0
Seeds	23.0	2.8	5.8
Snakes	1.0	0.0	0.0

Discussion

Both individual species abundance and species richness increased in the edge habitat (Table 1). Similarly, Stiles (1983) found increased species richness in forest edge communities compared to forest interior, forest canopy, and non-forest habitats at six sites in Costa Rica. Twenty-six species were represented in the edge area, but *C. inca* and *A. canicularis* dominated the community, thus decreasing the Shannon-Weiner diversity index. In contrast, the forest species were more evenly abundant and had a higher diversity index. So although richness increased in the edge habitat, because of the species' uneven distribution, the diversity index was very similar to those of the forest habitats.

In our study, guild diversity was greater in the edge community than in the forest because more guilds occurred at the edge, and birds were distributed more equitably among the guilds in the edge community (Table 2). These results supported our hypothesis that increased structural complexity of the forest edge strongly affects guild structure. The interface of forest and open habitats at the edge increases abundance and diversity of resources available to avian communities.

Forest edges and gaps may help maintain avian species and functional diversity. Our results and those of others suggest that structural diversity plays an important role in shaping bird communities. Yet, our data shed little light on the detrimental effects that fragmentation and edge creation may have on more sensitive species. The community changes that result from increased edge habitats might serve to maintain or even increase species richness, but they may also exclude other, more sensitive, species that are restricted to forest habitats.

Table 1: Bird abundances observed in edge habitat (A) and the two forest transects (B and C). Guild membership, defined as major level of food resources taken is also indicated.

Species Name	Family	Feeding Guild	A	B	C
Columbina inca	Columbidae	s	18		
Columbina passerina	Columbidae	s	6		
Leptotila verreauxi	Columbidae	s	1	1	
Amazona albifrons	Psittacidae	f	1		
Amazona auropalliata	Psittacidae	f		2	
Aratinga canicularis	Psittacidae	f	25	1	
unknown	Psittacidae	f		8	3
Coccyzcus minor	Cuculidae	i	1		
Crotophaga sulcirostis	Cuculidae	i,f	5		
Piaya cayanna	Cuculidae	i	1		2
unknown	Cuculidae	i			1
Amazilia rutila	Trochilidae	n	1		
Chlorostilbon canivetii	Trochilidae	n	2		
Hylocharis eliciae	Trochilidae	n	1		
unknown	Trochilidae	n	2	2	4
Trogon melanocephalus	Trogonidae	i,f			1
Trogon violaceus	Trogonidae	i,f			1
unknown	Trogonidae	i,f			1
Bucco macrorhynchus	Bucconidae	i		1	
Melanerpes hoffmannii	Picidae	i,f	1		2
Tityra semifasciata	Tityridae	i,f		1	
Empidonax flaviventris	Tyrannidae	i		1	
Myiarchus crinctus	Tyrannidae	i	1	1	
Myiarchus tyrannulus	Tyrannidae	i		2	
Pitangus sulphuratus	Tyrannidae	i,f	4		
Tyrannus melancholicus	Tyrannidae	i	6	4	2
unknown	Tyrannidae	i	5		1
Campylorrhynchus rafinucha	Troglodytidae	i	4	2	
Thryothorus pleurostictus	Troglodytidae	i		2	
unknown	Troglodytidae	i	1	1	3
Palioptila albiloris	Sylviidae	i		4	
Palioptila plumbea	Sylviidae	i			2
Dendroica petechia	Parulidae	i	2	1	
Vermivora peregrina	Parulidae	i			1
unknown	Parulidae	i			1
Icterus g. galbula	Icteridae	i	5		
Icterus pustulats	Icteridae	i	7		1
Icterus spurius	Icteridae	i	2		
unknown	Emberizidae	s			1

Feeding guild: f = fruit; i = insect; s = seed; c = carrion; n = nectar; sa = small animals

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