ABUNDANCE AND SPECIES RICHNESS OF TREES, BIRDS, BATS, BUTTERFLIES AND DUNG BEETLES in silvopastoral systems in the agricultural landscapes of Cañas, Costa Rica and Rivas, Nicaragua

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Resumen

Examinamos la abundancia, riqueza y diversidad de aves, murciélagos, escarabajos y mariposas en diferentes tipos de cobertura arbórea (bosques, bosques riparios, charrales, cercas vivas y potreros con cobertura arbórea) en dos zonas ganaderas (Rivas, Nicaragua y Cañas, Costa Rica). Con base en esa información, discutimos la importancia de la cobertura arbórea en fincas ganaderas para la conservación de la biodiversidad y recomendamos cómo mantener la biodiversidad en esas zonas.

1. Introduction

Throughout Central America, large areas of land have been deforested and converted into pastures for cattle production, thus creating mosaics of small forest patches interspersed within pastures and crop fields. Within these agricultural landscapes, farmers often retain small-forested areas, which can provide habitats and resources and maintain landscape connectivity for a variety of plants and animals. Yet, little is known about the biodiversity conserved within these agricultural landscapes.

In this study, we examined the importance of different types of on-farm tree cover for the conservation of birds, bats, dung beetles, and butterflies in two pastoral landscapes (Rivas, Nicaragua and Cañas, Costa Rica). Our objectives were: 1) To compare patterns of abundance, species richness and diversity of different taxa within different types of on-farm tree cover (forest patches, riparian forests, secondary growth, live fences, pastures with high tree cover and pastures with low tree cover). 2) To evaluate the importance of these different habitats for biodiversity conservation. 3) To provide recommendations on how to conserve biodiversity within silvopastoral landscapes.

2. Methods

In both Rivas and Cañas, we identified an area of roughly 10 000 ha as the study site. Using aerial photos and satellite images, we identified a total of six types of tree cover (hereafter referred to as 'habitat types'): 1) secondary forests; 2) riparian forests; 3) secondary growth (charral); 4) live fences; 5) pastures with high tree cover (16-25 % tree cover); 6) pastures with low tree cover (0-5% tree cover). High versus low tree cover pastures were selected to determine whether tree density in pastures influences the biodiversity they conserve.

For each habitat type, eight replicas were randomly chosen from the aerial photo (8 plots/habitat/6 habitats = 48 plots total). In each plot, birds were observed and registered during one hour per day (using 4-point counts per site); bats were captured with eight mist nets for a period of six hours each night. Dung beetles were captured using 32 pitfall traps, with the traps being active during 14 hours each day. Butterflies were captured by netting during 1.5 hours per day in 150 m of transects per site. Each of the 48 parcels was sampled for a total of 2 days for birds, bats, small terrestrial mammals, dung beetles, and butterflies, during the study period (April to December 2002). Total sampling effort per plot was 2 hours of observations for birds, 96 mist-net hours for bats, 64 trap-nights for dung beetles and 3 hours of netting for butterflies. In addition, the vegetation within each plot was characterized within a 0.1

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ha area, by recording all trees greater than 10 cm in diameter. Additional details on the sampling methods are available from the first author upon request.

For each taxa (trees, birds, bats, butterflies and dung beetles), we compared the species richness, abundance and diversity (Shannon, Simpson and Equitivity) across the six habitats, using ANOVA (for normally distributed data) or Kruskal Wallis (for non-normally distributed data). For the taxa where guild data were available (trees, birds, bats and butterflies), we also compared differences in the species richness and abundance of different guilds across the six habitats using ANOVA or Kruksal Wallis. For each taxa, we generated species-area curves for each habitat type, in order to compare whether or not the rate of species accumulation differed across habitats. The degree of similarity in species composition among pairs of habitats was calculated using the Jaccard similarity index, and these similarity indices in a Bray-Curtis cluster analysis to determine which habitats had the most similar species composition.

3. Results and discussion

In the Rivas landscape, 22 810 individuals of 342 different species were registered, whereas in Cañas, 32 540 individuals and 408 species were captured (Table 1). In general, the species richness for all groups was higher in the Cañas site than in the Rivas one, suggesting that the Cañas site may be slightly better conserved (both Cañas and Rivas are tropical dry forest ecosystems).

Although the precise patterns of abundance, species richness and diversity varied between the two sites, some general patterns emerged. First, the patterns of species richness abundance across habitat varied among the different groups studied with some groups showing clear patterns across habitats while others did not. For example, in the Rivas landscape, bird species richness was higher in the riparian forests, *charrales*, secondary forests and pastures with high tree cover than in live fences and pastures with low tree cover. In contrast, bat species richness was greater in riparian forests and live fences than in either secondary forests or pastures with low tree cover. Butterfly and dung beetle species richness showed no significant differences among habitats.

Table 1. Number of species and individuals for each taxa sampled in fragmented landscapes of Rivas, Nicaragua and Cañas, Costa Rica

Taxon	No. species		No. individuals	
	Rivas, Nicaragua	Cañas, Costa Rica	Rivas, Nicaragua	Cañas, Costa Rica
Vegetation	146	134	2362	911
Bats	24	42	2299	2,557
Rodents	6	10	71	141
Birds	83	128	1840	1374
Butterflies	50	60	559	544
Dung beetles	33	34	15 679	27 013

In Cañas, on the other hand, the patterns were slightly different from those in Rivas, but like the Nicaraguan site, the patterns of species richness and abundance across habitats varied depending on the group studied (Table 2). These data suggest that different animal groups may respond differently to the same landscape (most likely due to their particular habitat requirements and degree of mobility) and that no one group should be used as a surrogate for other species.

While different groups respond differently to the same landscape, the forested habitats (riparian forests, forest patches and *charral*) appear to hold greater conservation potential for many groups, particularly for species that are dependent on forest cover. In special, riparian forests appear to be very important

Table 2. Total abundance (Ab) and species richness (S) by group and by habitat in Cañas, Costa Rica*

Habitat	Birds		Bats		Butterflies		Dung beetles		Small mammals		Trees	
	S	Ab.	S	Ab.	S	Ab	S	Ab.	S	Ab.	S	Ab.
BS	62	249	21	459	22	77	27	13689	4	54	40	166
BR	60	234	33	714	18	63	25	5803	8	33	58	267
CH	56	217	22	429	20	57	23	2670	3	24	47	347
PAC	53	221	17	255	22	138	25	1752	4	19	20	42
PBC	52	256	14	180	25	111	22	2135	4	7	12	24
CV	56	198	26	520	26	96	24	4436	3	4	34	1141

* Data represent the summary of all 48 plots. Data from live fences are not directly comparable with the other habitats due to differences in the area surveyed.

BS = Secondary forest; BR = Riparian forest; CH = Secondary growth (charral); PAC = pastures with high tree cover; PBC = pastures with low tree cover; CV = Live fence for bird and bat species. These forested habitats also tend to have a greater abundance and species richness of forest-dependent species (which are typically lacking in the less forested landscapes). Thus, whereas the forest habitats do not necessarily always have the highest species richness or abundance of a given group, they usually have a more distinct species composition, consisting of a greater proportion of forest-dependent species.

Live fences appear to be very important for bat and birds, as both of them follow fences as they cross the agricultural landscape. Birds were also often observed perching or feeding in live fences. Additional studies are currently underway to evaluate the role of live fences in facilitating movement across the landscape and to evaluate how the structure, composition and spatial arrangement of live fences in the landscapes affect the fauna that visit them.

The particular characteristics of individual habitats (such as their floristic and structural diversity, or availability of fruit or flowers) are important in determining the species richness and abundance of organisms present as is the landscape context in which the habitat occurs (i.e. how fragmented the landscape is, how much tree cover remains nearby, etc.). For example, the overall higher species richness in the Cañas study site probably reflects, to a larger degree, the fact that this landscape has more remaining forest and larger forest patches than the Rivas site, which is more degraded. Specific landscape analyses are currently under way to determine the exact nature of these relationships.

In summary, the results suggest that a significant portion of the biodiversity still occurs within pastoral landscapes and that on-farm tree cover (particularly forest fragments, riparian forests and *charral*) is critical for conserving biodiversity. Silvopastoral systems (live fences and pastures with trees) are of lesser conservation value than forest patches, but still retain a significant portion of the biodiversity and may play important roles in maintaining landscape connectivity.

The ability of landscapes to maintain biodiversity will depend on the abundance, type and arrangement of tree cover within the landscape as well as the ways in which farmers manage their cattle production systems. Activities that are deemed important for conserving biodiversity within pastoral landscapes include controlling the use of fire, removing cattle from forest patches and riparian forests, reducing application of herbicides in pastures, restricting the logging of trees in pastures, and facilitating natural regeneration in pastures.