HABITAT AND LANDSCAPE FEATURES AFFECTING BIRD DISTRIBUTION IN A BULRUSH PATCH SYSTEM ALONG THE SÃO GONÇALO FLOODPLAIN, SOUTHERNMOST BRAZIL

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INTRODUCTION

Ecologists have long recognized that species do not occur homogeneously over space, but rather that abundances are patchy (Bowers & Matter 1997). One approach often used to investigate patterns of animal distribution involves the concept of the ecological niche and the idea that each species has a unique set of requirement that must be provided by the habitat, in order for the species to persist (MacKenzie *et al.*, 2006). Habitat structure plays a key role in structuring faunal diversity (e.g., MacArthur *et al.*, 966, Wiens 1974, Guadagnin & Maltchick 2007), as habitat affects wildlife directly through mechanical effects (e.g., providing cover for breeding, nesting, foraging activities, etc.) and indirectly (e.g., through microclimate changes) (Harrell & Fuhelendorf 2002). Nonetheless, this relationship is of one the most poorly understood ecological mechanisms. Therefore, quantifying the relationship between habitat structure and wildlife is a crucial task for ecologists and conservation biologists.

Although the effect of forest fragmentation on terrestrial birds has been extensively studied, the role of natural or anthropogenic fragmentation on waterbirds has not received as much attention (Guadagnin & Maltchick 2007). The floodplain of the Canal São Gonçalo, in southernmost Brazil, is an ideal scenario to evaluate the relationship of waterbird assemblages and patchy habitats, for it is characterized by discrete patches of tall, emergent waterplants, distributed among a matrix of shorter vegetation.

OBJECTIVES

Based on this context, our study aims to: i) describe the structure of bird assemblage inhabiting bulrush patches along the Canal São Gonçalo; ii) comprehend the influence of habitat and landscape features on the composition and abundance of this bird assemblage.

MATERIAL AND METHODS

Study site: Our study was conducted in habitat patches formed by the bulrush *Schoenoplectus californicus* in the floodplain of the Canal São Gonçalo ($31^0$49'37,57"S, $52^0$18'42,61"W), Rio Grande do Sul, southern Brazil. This natural canal is the only connection between the Lagoa dos Patos and the Lagoa Mirim, and it is characterized by a diverse and unique wetland system, forming one of the largest extensions of continuous marshlands in the state. Along the canal, *S. californicus* forms nearly monospecific stands that vary in shape and size amidst a matrix of flooded fields used for livestock production. Livestock, most likely, is the main source of disturbance, inducing changes in vegetation structure and influencing directly habitat and resource availability for birds.

Data collection: We used a Geographical Information System to quantify landscape and habitat metrics and to select habitat patches along the floodplain. We identified 211 patches and three large "source" fragments. We used random - stratified sampling to define our sampling unities. We allocated patches in three size classes (116 - 2,000 m ^{2}, 2,001 - 10,000 m ^{2} and $\geq$10,001 m ^{2}) and randomly drew ten patches. Other 12 patches were selected in loco. Twelve environmental landscape and habitat attributes were quantified as predictor variables: area, microhabitat diversity (defined as the Shannon - Wiener function based on the area occupied by different classes of vegetation cover), distance to the "source" fragment, distance to the nearest large patch, distance to the nearest patch, distance to roads, distance to dry fields, distance to the nearest water body (i.e., ponds and the São Gonçalo canal), water depth within the patch, mean vegetation height, mean vegetation density,

and vegetation structural heterogeneity (calculated according to Wiens 1974).

We counted all birds found in the 42 patches. Censuses were conducted in November 2008 by two observers equipped with binoculars during early morning hours. We used direct count technique as our quantification method. We also employed a systematized sampling procedure of play - back calls to detect secretive birds, such as rallid species.

Data analyses: Diversity patterns were investigated using scatter plots, where x - axis represents species richness and y - axis represents evenness (Melo 2008). We computed Smith & Wilson's (1996) index as the measure of evenness, due its properties (independence of species richness and sensitiveness to both rare and abundant species).

Pooled data from all patches were used to fit one of the four commonly used abundance models (i.e., Broken - stick, Geometric series, Log - normal and Log - series) to the data (Margurran 1988).

We used Canonical Correspondence Analysis (CCA) (ter Braak 1986) to explore the relationship between environmental variables and bird assemblage structure. CCA is a method of direct gradient analysis, which focuses on generating a unimodal axis with respect to the response variable and a linear axis with respect to the predictor variable (ter Braak 1986, Gotteli & Ellison 2004). Significance of canonical ordination axes was evaluated through Monte - Carlo statistics (9,999 permutations under reduced model), using all environmental variables. In order to perform the CCA, environmental variables were normalized and bird counts were square root transformed [X'ij = V (Xij+0.5)]. CCA was carried out using CANOCO 4.5 (ter Braak & Smilauer 2002).

We employed separate linear regression models to test species richness - area relationship (SAR). SAR fit was compared across three alternative statistical models (i.e., logarithmic power function, exponential and the linear regression on untransformed data), as advocated by Connor & McCoy (1979). In order to determine which model fits the data best, we inspected a series of diagnostic plots of residuals and Cook's distance plot (Gotteli & Ellison 2004), searching for the model that best linearized the relationship and reduced the deviation of points around the regression line (Connor & McCoy 1979). Regressions were carried out in the statistical package R (R Development Core Team 2009).

Significance level adopted in all analysis was $\alpha = 0.05$. Results are shown as mean ± 1 SD.

RESULTS AND DISCUSSION

We recorded 1,173 birds belonging to 34 species and 13 families. Relative abundance fitted the log - normal model ($x^2 = 2.31$, $p = 0.54$). Species richness among patches ranged from 1 - 18 species. In 8.4% of all patches only one species was recorded. Patches showed high evenness patterns (mean = 0.61 ± 0.3).

Mean patch size was 7,294.75 ± 13,593.99 m ^{2} (max. = 70,647.8 m ^{2}; min. = 116.6 m ^{2}). The logarithmic power function presented the best fit for SAR. There was a significant positive relationship between log - area and log - species richness ($F_{1,40} = 46.11$; $p = 0.0001$). Log - area accounted for 53.55% of the variance in log - species richness ($r^2 = 0.53$).

The four canonical axes accounted for 37.8 % of the variation of species data and for 82.1% of species - environment relationship. The four canonical axes displayed high species - environment correlations (r = 0.88, 0.65, 0.64 and 0.69, respectively). The global test of significance showed that the canonical relationship between both matrices was highly significant ($p = 0.0006$). Area presented the highest correlation value with the first axis (r = 0.73), followed by vegetation density (r = 0.44). Measures of vegetation structure (i.e., vegetation heterogeneity and height) presented the highest correlations with the second axis (r = 0.41 for both variables). Microhabitat diversity was poorly correlated with the first two axes.

CONCLUSION

Positive and highly significant relationship was found between log - area and log - species richness. Structural bulrush complexity seems to play a more important role than microhabitat (i.e., vegetation cover) diversity in structuring the bird assemblage inhabiting bulrush patches along the São Gonçalo floodplain. This hypothesis, however, requires further testing. Other factors, such as chance, inter - especific competition and the small size of some patches in relation to minimal territory size requirements of some species may also limit the presence of birds in small patches and deserve further investigation.

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