Birds' nesting parameters in four forest types in the Pantanal wetland

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Abstract

We tested the heterogeneity/productivity hypothesis with respect to the abundance and richness of birds and the vegetation density hypothesis with respect to birds' nest predation rates, and determined the relative importance of forested vegetation formations for the conservation of birds in the Pantanal. We estimated the apparent nesting success, and the abundance and richness of nesting birds' in four forest types, by monitoring nests during two reproductive seasons in four forested physiognomies (two high productivity/heterogeneity evergreen forests = Cambará and Landi; two low productivity/heterogeneity dry forests = Cordilheira and Carvoeiro) in the Pantanal wetland in Poconé, State of Mato Grosso, Brazil. We found 381 nests of 46 species (35 Passeriformes and 11 non-Passeriformes) in the four forest types. Of these, we monitored 220 active nests belonging to 44 species, 101 during the reproductive season of 2001 and 119 in 2002. We supported the productivity/heterogeneity hypothesis since the two evergreen forests had higher nest abundance and one of them (Cambará) had higher nesting species richness than the dry forests. The number of nests found in each habitat differed with most nests monitored in the Cambará forest (82%), followed by Landi (9%), Cordilheira (6%) and Carvoeiro (3%) forests. The total number of nests monitored was significantly higher in evergreen forests than in dry forests. Also, more species nested in evergreen (37 species) than in dry (16 species) forests. A Correspondence Analysis revealed that only Carvoeiros had a different nesting bird community. The overall apparent nesting success of 220 nests was 26.8%. We did not support the vegetation density hypothesis since nest predation rates were similar between evergreen (73.5%) and dry (70%) forests, and were higher in the Landi (85%) than in the other three forests (69.2 to 72.2%). Our data indicate that Cambará forests seem to be a key nesting habitat for many bird species of the Pantanal. If this local pattern also occurs in other regions of the Pantanal, the use and management of Cambará forests might prove to be important for the conservation of forest birds of this biome. However, conflicting results with other taxonomic groups show that conservation measures for these forests and land use policies should be based on a more complete biodiversity evaluation of the region.

Keywords: nesting success, productivity/heterogeneity hypothesis, vegetation density hypothesis, Pantanal.

Parâmetros reprodutivos de aves em quatro tipos de florestas no Pantanal

Resumo

Testamos a hipótese de heterogeneidade / produtividade com relação à abundância e riqueza de aves e hipótese da densidade de vegetação com relação às taxas de predação de ninhos de pássaros, e determinamos a importância relativa de formações vegetais florestais para a conservação das aves no Pantanal. Estimamos o sucesso de nidificação aparente, a abundância e riqueza de nidificação de aves em quatro tipos de floresta, por monitoramento de ninhos durante duas estações reprodutivas em quatro fisionomias florestais (duas florestas sempre verdes com alta produtividade / heterogeneidade = Cambará e Landi; duas florestas secas com baixa produtividade / heterogeneidade = Cordilheira e Carvoeiro), no Pantanal de Poconé, Estado de Mato Grosso, Brasil. Encontramos 381 ninhos de 46 espécies (35 Passeriformes e 11 não-Passeriformes) nos quatro tipos de floresta. Destes, foram monitorados 220 ninhos ativos pertencentes a 44 espécies, 101 durante na estação reprodutiva de 2001 e 119, em 2002. Apoiamos a hipótese de produtividade/heterogeneidade já que as duas florestas sempre verdes apresentaram maior abundância de ninhos e uma delas (Cambará) apresentou maior riqueza de espécies nidificante do que as florestas secas. O número de ninhos encontrados em cada habitat diferiu da maioria dos ninhos monitorados na floresta Cambará (82%), seguido pelo Landi (9%), Cordilheira (6%) e Carvoeiro (3%). O número total de ninhos monitorados foi significativamente maior nas florestas sempre verdes do que nas florestas secas. Além disso, mais espécies nidificaram nas florestas sempre verdes (37 espécies) do que nas

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florestas secas (16 espécies). Uma análise de correspondência revelou que somente Carvoeiros teveram uma comunidade diferente de aves. O sucesso total de nidificação aparente de 220 ninhos foi de 26,8%. Nós não suportamos a hipótese de densidade de vegetação, pois as taxas de predação foram semelhantes entre florestas sempre verdes (73,5%) e secas (70%), e foram maiores no Landi (85%) do que nas outras três florestas (69,2-72,2%). Nossos dados indicam que as florestas de Cambará parecem ser um habitat de nidificação importante para muitas espécies de aves do Pantanal. Se esse padrão local também ocorre em outras regiões do Pantanal, o uso e manejo de florestas de Cambará pode revelar-se importante para a conservação de aves florestais deste bioma. No entanto, resultados conflitantes com outros grupos taxonômicos mostra que medidas de conservação para estas florestas e as políticas de uso da terra devem ser baseadas em uma avaliação mais completa da biodiversidade da região.

Palavras-chave: sucesso de nidificação, hipótese de produtividade e heterogeneidade, hipótese de densidade de vegetação, Pantanal.

1. Introduction

Locations with a large availability of energy are more qualified to support a greater number of individuals and species (Connell and Orias, 1964). Therefore, organisms should not distribute themselves randomly and some vegetation formations should have higher richness and abundance than others. More complex Amazonian forest had more birds than less structured forest from the same biome (Borges, 2004). Structurally more complex vegetation types decrease the effects of seasonality, resulting in higher stability in resource availability hosting more year-long residents (Hurlbert and Haskell, 2003; Manhães and Dias, 2011).

Some habitats have better food resources, while others offer better protection against extreme climatic variations or offer safer locations for nest construction to decrease predation risk (Wittenberger, 1980). This way, habitat availability and its quality directly act on survival and reproductive success (Martin, 1995). For birds, natural selection should favor individuals that choose habitats and nesting sites that are adequate (ex. high food availability, low abundance of predators) and have life history characteristics that reduce the negative effects of nest predation (Nalwanga et al., 2004; Kristan III, 2007).

Nest predation has a strong influence on birds' reproductive success (Marini et al., 1995; Aguilar et al., 2000; Auer et al., 2007) and for many species it is related to nesting sites characteristics (Martin, 1993; Tieleman et al., 2008). Nest site selection can be influenced by several factors, including nest predation risk, physiological tolerance to abiotic factors and interspecific competition (Martin, 2001; Nalwanga et al., 2004). Nest predation diminishes with an increase in vegetation heterogeneity and foliage density near the nest by reducing the transmission of acoustic, chemical or visual signals (Martin, 1993). This idea is based on the premise that nesting site and vegetation architecture must offer some kind of protection against climate and predation (Nice, 1957). Furthermore, the intensity of rain, the abundance of food resources, photoperiod and latitude are variables related to reproductive success (Young, 1994). However, Young et al. (2008) did not find differences in bird nesting success between seven reproductive sites in Costa Rica.

Birds' habitat use for reproduction and nesting success has been accessed in some neotropical forests (Blake and Loiselle, 2002; Auer et al., 2007) but seldom in the Pantanal wetland of Brazil (Pinho and Nogueira, 2003; Pinho et al., 2006). The Pantanal is a vast sedimentary plain where annual cycles of flooding and dryness are the main force that regulates ecosystem functioning, in accordance with the flooding pulse concept (Junk et al., 1989). For these same authors, the high productivity of the Pantanal plain is dependent on water invasion from rivers that cut the Pantanal plain. The periodic inundations result in drastic environmental changes in the habitats and organisms' life histories.

Overall, this study had three objectives with respect to forest birds from the Pantanal of Poconé, Brazil: A) test the heterogeneity/productivity hypothesis with respect to the abundance and richness of nesting birds (Connell and Orias, 1964); B) test the vegetation density hypothesis with respect to birds' nest predation rates (Martin, 1993); and C) determine the relative importance of forested vegetation formations for the conservation of birds. First, we tested the hypothesis that in more heterogeneous and more productive forest type formations (two types of evergreen forests) nest abundance and nesting species richness should be greater than in less heterogeneous and less productive environments (two types of dry forests). Second, we tested the hypothesis that in forest type formations with higher vegetation density (two types of evergreen forests) nest predation rates should be lower than in forest formations with lower vegetation density (two types of dry forests). Third, we classified the four habitats in relation to their importance for the conservation of forest birds and land use in the studied region.

2. Material and Methods

2.1. Study area

This study was conducted in the northern Pantanal (16°15'12''S; 56°22'12''W), Pirizal region, Poconé municipality, state of Mato Grosso, Brazil. Climate of the Pantanal is characterized by a dry season from May to September, and a rainy season from October to April (Nunes da Cunha and Junk, 1998). Mean annual rainfall from 1999 to 2002 was 1,159 mm, with maximum rainfall

in December and minimum in August. Average minimum temperature was 20.9 °C and average maximum was 32.5 °C. Around 47% of the region is represented by flooded grasslands and marshes and 53% by forests. Pirizal has low human density and is difficult to access during the flooding period, what contributes to the relatively conserved state of the landscape (Pinho and Nogueira, 2003).

In the Pantanal, different types of soils and inundation levels are responsible for strong vegetation variations creating a mosaic landscape (Silva et al., 2000; Nunes da Cunha et al., 2006). The diversity of vegetation types in the Pantanal region (Silva et al., 2000; Nunes da Cunha et al., 2006) provides a rare opportunity to test the productivity/heterogeneity and the foliar density hypotheses within the same landscape context. Specifically, two types of dry forests predominate in the region ("Cordilheira" and "Carvoeiro"), with low productivity/heterogeneity (this study define heterogenety/productivity as higher abundance of litter, flowering, fruit and insects and vegetation density). Also, there are two types of evergreen forests ("Cambará" and "Landi") with high productivity/heterogeneity and vegetation density (Marques et al., 2006).

"Cordilheiras" are long and narrow semi-deciduous forests, formed by the deposition of sediments along the border of fossil river beds. They are narrow (~100 m) and long (~kilometers) forests. "Cordilheiras" are composed by cerrado species, with considerably deciduousness during the dry season, what increases the temperature and the exposure to light of the forest interior. Most species flower in August-September, with an increase in arthropod abundance and fruit production in January (Marques et al., 2006; Nunes da Cunha et al., 2007). They are frequently connected to other habitats such as "Landi" forests or "murunduns" (savanna park). The heterogeneous vegetation is not subjected to inundation. It has a dense understory up to 2 m high with an abundance of bromeliads (*Bromelia balansae* Mez, Bromeliaceae) and an arboreal 5-6 m strata with *Petiveria tetrandra* A.B. Gomes (Phytolaccaceae), the abundant *Adelia membranifolia* (Mull. Arg) Pax and K. Hoffm (Euphorbiaceae) and emergent trees up to 30 m high.

"Carvoeiros" (dry forests) are monospecific deciduous open forests, dominated by *Callistene fasciculata* Mart. (Vochysiaceae). They are rarely inundated, have a canopy around 12 m high with the understory dominated by herbs, grasses and patches of bromeliads. Flowering and total deciduousness occur in July-August when temperatures get high. Even though they are located close to rivers and flooded fields, they are dry and the natural grasses of the understory are used by cattle during the dry season and the forest for shelter for large mammals during the flooded season (Nunes da Cunha et al., 2007). They have limited resources (flowers, fruits and arthropods) mostly during the birds' reproductive period (Nunes da Cunha and Junk, 1996).

"Cambarazais" are semi-deciduous seasonally evergreen forests (locally known as "Cambarazais") dominated by *Vochysia divergens* pohl (Vochysiaceae), sometimes forming monospecific stands. They have a canopy around 20 m high with a dense understory dominated by *V. divergens* saplings and other shrubby and herbaceous plants (Melastomataceae and Rubiaceae) which produce fruits year-round. "Cambarazais" occur in areas periodically flooded, and are frequently found within flooded fields and permanent lagoons. They are slightly deciduous, even during the dry period, what keeps the temperature mild in their interior (Nascimento and Nunes da Cunha, 1989). Litter is dense with a rich arthropod biodiversity as in the canopy (Marques et al., 2001, 2006). *Vochysia divergens* is a colonizer of natural flooded grasslands of the region (Nascimento and Nunes da Cunha, 1989).

"Landis" are evergreen forests, characterized by the presence of *Mabea* sp. (Euphorbiacea), *Licania parvifolia* Huber (Chrysobalanaceae), *Alchornea discolor* poepp (Euphorbiaceae) and *Calophyllum brasiliensis* Cambess. (Guttiferae). They form dense forest formations periodically flooded with a canopy around 15 m high. A dense understory is dominated by shrubs and a few herbaceous plants. "Landis" are continuous and sinuous geomorphologic depressions located in negative relief (Nunes da Cunha et al., 2007). They function as a drainage line during flooding periods and are not flooded during the dry season. "Landis" are always close to "cambarazais", "cordilheiras" and "murunduns". Litter is thick with a high abundance of arthropods (Marques et al., 2001; Tissiani, 2009).

Nest searching and monitoring were conducted in a 50 ha area in each one of the four forest types, in two consecutive reproductive seasons, between July 2001 and January 2002 and between August 2002 and January 2003. To search for nests we adapted a methodology proposed by Martin and Geupel (1993), utilizing two distinct processes: 1) searching for nests in a meticulous form throughout the entire study area; 2) observing adults carrying nest material and feeding nestlings.

During nest searching and monitoring we were cautious to minimize the impact around the nests, and minimized the attraction of predators to nests by staying as far away and monitoring nests as fast as possible. As soon as the nest was located, identification of the species nesting was conducted via observation at a distance of approximately 15 m with the aid of binoculars or via bird's call. We identified each nest with colored tape placed at least 5 m away to help with their location during the monitoring phase.

We monitored nests at 3-4 days intervals, registering their status (active or inactive) at the time of the visit, until fledging or failure. We considered nests to be active if they contained at least one egg or one fledgling. We considered in the analyses only nests in which the species was identified and contained at least one egg or one fledgling. We considered nesting success when there was at least one fledgling and nest predation when there was damage to its structure or egg(s) was (were) lost or fledgling(s) was (were) not observed before the minimum age allowed for it (them) to leave the nest. We considered nests abandoned when adults were not observed tending the nest for at least 10 days and eggs were cold or when nestlings were found dead without signs of predation. For

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the nesting success analyses we only considered active nests, discarding nests that were abandoned during the construction phase (Table 1). We also did not consider 21 nighthawk (*Nyctidromus albicollis* Gmelin, 1789 and *Nyctiprogne leucopyga* Spix, 1825) nests, since it is nearly impossible to monitor the fledglings after they are born (Table 1). We classified nests as closed when they were constructed in tree holes or as closed structures built with mud, grasses or other materials.

To allow for nest abundance comparison between the four forest types, we utilized the protocol by Martin and Geupel (1993), consisting of the same nest searching effort for all habitats (234 nest search hours in each forest) and the same search area (50 ha, divided in quadrants of 50 × 50 meters). These searches were conducted by three researchers from the beginning of August to the end of January during 2001 and 2002 in each forest type.

2.2. Statistical analyses

We calculated nesting success only by the apparent success method (= proportion of successful nests) due to the objective of calculating general success for the bird communities in each phyto-physiognomy. We did not use other methods such as Mayfield estimate (Mayfield, 1961, 1975) or logistic exposure (Shaffer, 2004) because of small sample sizes for most species in three forest types, and lack or poor data of incubation and/or nestling periods of many species. We tested the hypothesis of random nests distribution between the four forest types with a Chi square test according to Zar (1999). This same test was utilized to examine differences between number of nesting species. We utilized a correspondence analysis (CA) (Gotelli and Ellison, 2004) performed by the program Systat version 12 (2008), to analyze species composition in the habitats.

3. Results

We found 381 nests from 46 bird species (35 Passeriformes and 11 non-Passeriformes) in the four forest types. Of these, 220 nests reached the egg phase and were monitored (Table 1), of which 101 in the reproductive season in 2001 and 119 in 2002. The total nest encounter success was 0.41 nests/search hour. If we only consider only the 220 nests that had eggs or fledglings (useful for the reproductive success analyses), the nest encounter success falls to 0.24 nests/search hour. Considering the four forest types, the nest encounter success was greatest in Cambará (0.77 nests/hour) compared to the other three forests (Landi = 0.08 nests/hour; Cordilheira = 0.06 nests/hour; Carvoeiro = 0.03 nests/hour).

3.1. Productivity/heterogeneity hypothesis: nest abundance and nesting species richness

There was considerable support for the productivity/heterogeneity hypothesis, since one of the evergreen forests (Cambará) had most nests and high richness, and the other forest (Landi) had higher number of nests than the dry forests. The number of nests monitored in the Cambará forest was significantly higher than the other

three forests (x^2 = 380.3 d.f. = 3; p < 0.001) (Table 1). Considering all encountered nests (381) (including the abandoned nests during the construction phase), the nest distribution between the four forest types was not random (Figure 1), with most of the nests (~ 80%) occurring in Cambará and Landi (~ 12%). We encountered less than 8% of the nests in the two dry forests combined. There is a higher number of bird species attempting to reproduce in evergreen forests (totaling 37 species), 36 species in Cambará and 14 in Landi, compared to the dry forests (totaling 16 species), 15 species in Cordilheira and eight in Carvoeiro (Table 1). Ten bird species nested in both the evergreen and dry forests and 29 species nested exclusively in the evergreen forests.

The Correspondence Analysis (CA) indicated that nesting bird species are similar between Cambará, Landi and Cordilheira, and different from Carvoeiro (Figure 1). This differentiation is evident for species with open nests (Axis 1 from Figure 1) as well as closed nests (Axis 2 from Figure 1). Species that nest in closed nests chose vegetation types with greater richness of arboreal species, since these have higher availability of holes to nest than evergreen forests.

3.2. Foliage density hypothesis: nesting success

There was no support for the nest density hypothesis, since one of the evergreen forests (Cambará) had nest predation rate similar to the two dry forests, and the other evergreen forest (Landi) had the highest nest predation rate. The overall apparent nesting success was 26.8% for all nests throughout the two reproductive seasons. We did not observe nest loss due to bad weather, thus all loss was attributed to predation. The apparent success of nests was 27.8% in Cambará, 15.0% in Landi, 30.8% in Cordilheira and 28.6% in Carvoeiro. Predation rate was 72.2% in Cambará, 85.0% in Landi, 69.2% in Cordilheira and 71.4% in Carvoeiro (Tables 1 and 2).

Due to the larger number of active nests encountered in Cambará compared to the other forest types, it was possible to test statistically the reproductive success only between evergreen (Cambará and Landi combined; n = 200 nests) and dry (Cordilheira and Carvoeiro combined; n = 20 nests) forests (Tables 1 and 2). For this comparison we used open and closed nests jointly, since the number of nests in the dry forests is very small and the open nests reproductive success (26.5%) did not differ (X^2 = 0.220; d.f.= 1; p > 0.50) from the closed nests (29.3%) (Table 1). The data did not provide evidence to reject the null hypothesis that reproductive success is the same between dry and evergreen forests, since the proportion of predated and successful nests did not differ (x^2 = 0.115, d.f. = 1, P > 0.50) between them.

4. Discussion

The productivity/heterogeneity hypothesis had good support, since the two evergreen forests had higher nest abundance and one of them (Cambará) had higher nesting species richness. When combining similar forest types, the number of nests and species reproducing was higher

Table 1. Distribution of open and closed nests in the forest types (Cambará, Cordilheira, Landi and Carvoeiro), their fates (success, predated and abandoned during the construction phase) in the region of Pirizal, Pantanal of Poconé, state of Mato Grosso, Brazil. In parenthesis are only the active nests, excluding abandoned nests.

Species	Phyto-physiognomies					Fate		
	Cambará	Landi	Cordilheira	Carvoal	Total	Success	Predated	Abandoned
Open nests								
Crypturellus undulatus (Temminck,1815)	0	0	1 (1)	1 (1)	2 (2)	1	1	0
Ortalis canicollis (Wagler, 1830)	2 (2)	1 (1)	0	0	3 (3)	0	3	0
Patagioenas cayennensis (Bonnaterre, 1792)	13 (9)	0	1 (1)	0	14 (10)	3	7	4
Leptotila verreauxi Bonaparte, 1855	15 (12)	1 (1)	2 (3)	0	18 (16)	3	13	2
Nyctidromus albicollis (Gmelin, 1789)	12	5	3	0	20	-	-	-
Nyctiprogne leucopyga (Spix, 1825)	1	0	0	0	1	-	-	-
Cercomacra melanaria (Ménétriès, 1835)	29 (22)	1 (0)	0	0	30 (22)	7	15	8
Formicivora rufa (Wied, 1831)	0	0	0	1 (1)	1 (1)	0	1	0
Taraba major (Vieillot, 1816)	14 (13)	4 (2)	1 (0)	0	19 (15)	4	11	4
Thamnophilus doliatus (Linnaeus, 1764)	14 (8)	0	0	0	14 (8)	6	2	6
Thamnophilus pelzelni Hellmayr, 1924	1 (1)	0	0	0	1 (1)	0	1	0
Cnemotriccus fuscatus (Wied, 1831)	2 (2)	0	0	0	2 (2)	0	2	0
Cyanocorax cyanomelas (Vieillot, 1818)	0	0	2 (2)	0	2 (2)	0	2	0
Turdus rufiventris Vieillot, 1818	1 (1)	0	1 (1)	0	2 (2)	1	1	0
Mimus saturninus (Lichtenstein, 1823)	2 (2)	0	1 (1)	0	3 (3)	2	1	0
Polioptila dumicola (Vieillot, 1817)	2 (1)	0	0	1 (1)	3 (2)	2	0	1
Ramphocelus carbo (Pallas, 1764)	24 (21)	12 (6)	0	0	36 (27)	2	25	9
Paroaria capitata (d'Orbigny & Lafresnaye, 1837)	3 (3)	0	0	0	3 (3)	0	3	0
Saltator coerulescens Vieillot, 1817	3 (1)	0	1 (1)	0	4 (2)	1	1	2
Sub-total	138 (98)	24 (10)	13 (10)	3 (3)	178 (121)	32	89	36
Closed nests								
Megascops choliba (Vieillot, 1817)	0	0	0	1 (1)	1 (1)	0	1	0
Galbula ruficauda Cuvier, 1816	8 (5)	2 (2)	0	0	10 (7)	5	2	3
Celeus flavus (Statius Muller, 1776)	0	1 (1)	0	0	1 (1)	0	1	0
Celeus lugubris (Malherbe, 1851)	0	3 (3)	0	1 (1)	4 (4)	1	3	0
Colaptes campestris (Vieillot, 1818)	2 (2)	0	0	0	2 (2)	2	0	0
Pyriglena leuconota (Spix, 1824)	0	1 (1)	0	0	1 (1)	1	0	0
Cranioleuca vulpina (Pelzeln, 1856)	18 (10)	3 (0)	0	0	21 (10)	3	7	11
Furnarius leucopus Swainson, 1838	11 (4)	0	1 (0)	0	12 (4)	0	4	8
Furnarius rufus (Gmelin, 1788)	3 (2)	0	0	0	3 (2)	0	2	1

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Table 1. Continued...

Species	Phyto-physiognomies					Fate		
	Cambará	Landi	Cordilheira	Carvoal	Total	Success	Predated	Abandoned
Synallaxis albilora Pelzeln, 1856	27 (13)	0	0	0	27 (13)	2	11	14
Lepidocolaptes angustirostris	0	0	1 (1)	0	1 (1)	0	1	0
Xiphocolaptes major (Vieillot, 1818)	0	0	0	1 (1)	1 (1)	0	1	0
Xiphorhynchus picus (Gmelin, 1788)	0	0	1 (0)	1 (1)	2 (1)	1	1	0
Camptostoma obsoletum (Temminck, 1824)	5 (2)	1 (0)	0	0	6 (2)	1	1	4
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	3 (2)	0	0	0	3 (2)	0	1	2
Myiarchus ferox (Gmelin, 1789)	1 (1)	0	0	0	1 (1)	1	0	0
Myiodynastes maculatus (Statius Muller, 1776)	1 (1)	0	1 (1)	2 (0)	4 (2)	2	0	2
Myiozetetes cayanensis (Linnaeus, 1766)	3 (2)	0	1 (1)	0	4 (3)	1	2	1
Pitangus sulphuratus (Linnaeus, 1766)	8 (8)	0	2 (0)	0	10 (8)	1	7	2
Todirostrum cinereum (Linnaeus, 1766)	12 (9)	0	0	0	12 (9)	3	6	3
Tolmomyias sulphurescens (Spix, 1825)	1 (1)	0	0	0	1 (1)	0	1	0
Tyrannus melancholicus Vieillot, 1819	1 (1)	0	0	0	1 (1)	0	1	0
Pheugopedius genibarbis Swainson, 1838	8 (3)	2 (0)	0	0	10 (3)	2	1	7
Cantorchilus leucotis Lafresnaye, 1845	52 (12)	9 (3)	0	0	61 (15)	2	13	46
Basileuterus flaveolus (Baird, 1865)	1 (1)	0	0	0	1 (1)	1	0	0
Eucometis penicillata (Spix, 1825)	1 (1)	0	0	0	1 (1)	0	1	0
Procacicus solitarius (Vieillot, 1816)	2 (2)	0	0	0	2 (2)	0	2	0
Sub-total	168 (82)	22 (10)	7 (3)	6 (4)	203 (99)	29	70	104
Total	306 (180)	46 (20)	20 (13)	9 (7)	381 (220)	61	159	140
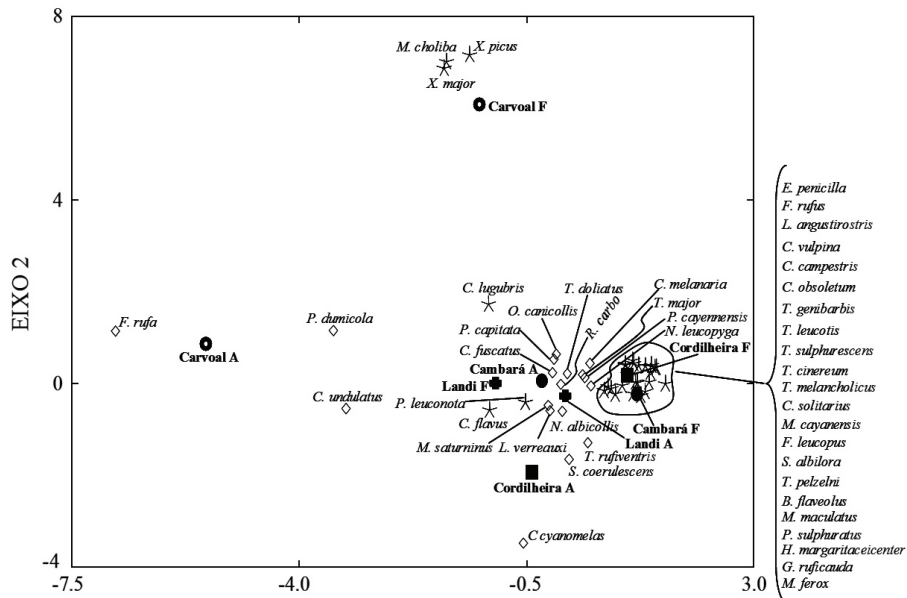
Figure 1. Graphic representation of the Correspondence Analysis for the distribution of nest types in the four forest types in forested habitats in the region of Pirizal, Pantanal of Poconé – MT. Legend: (● = Cambará (A = open nests, F = closed); ■ = Cordilheira (A = open nests, F = closed); O = Carvoal (A = open nests, F = closed); ✚ = Landi (A = open nests, F = closed). ◊ = bird species that reproduce in open nests and ★ = bird species that reproduce in closed nests. For open nest distribution in the habitats, total inertia was 1.101. Axes I and II capture 89.2% of the open nest species distribution. For closed nests, total inertia was 2.321. Axes I and II capture 74.4% of the closed nest species distribution.

Table 2. Number of successful and predated nests in the evergreen (Cambará and Landi) and dry (Cordilheira and Carvoeiro) forests in the region of Pirizal, Pantanal of Poconé, MT, Brazil.

Habitat	Fate		Total
	Success	Predated	
Evergreen forests	53 (26.5%)	147 (73.5%)	200
Cambará	50 (27.8%)	130 (72.2%)	180
Landi	3 (15.0%)	17 (85.0%)	20
Dry forests	6 (30.0%)	14 (70.0%)	20
Cordilheira	4 (30.8%)	9 (69.2%)	13
Carvoeiro	2 (28.6%)	5 (71.4%)	7
Total	59	161	220

in evergreen forests compared to dry forests. However, the two evergreen forests differed considerably from each other, since Cambará forest had the largest number of nests encountered, suggesting that this is the habitat which attracts the largest number of individuals to reproduce. Similarly to the nest abundance results, point counts and mist net samples showed that the evergreen forests, especially cambarazais, have higher bird richness than the dry forests (Pinho and Marini, 2012). This can be related to the proximity to water bodies, foliage density, vegetation structure, food resources and microclimate. Cambarazais are semi-deciduous seasonally evergreen forests, keeping most of their canopy cover during the dry season (Nascimento and Nunes da Cunha, 1989), keeping the climate more favorable and providing more protection against increased temperatures and predators.

Landi forests, despite the canopy foliar retention during the dry season, are characterized by a small number of tree species with a thin sub canopy, which may offer a limited number of nesting sites. Nevertheless, the Landi forest had about twice as many nests than the dry forests. Other authors have also registered a larger number of nests in more structured habitats, with favorable climate, trees with a greater structure and foliar density (Best and Stauffer, 1980; Nalwanga et al., 2004). There was a lower number of bird species and a smaller number of nests in dry forests (Cordilheira and Carvoeiro), which can be related to the fact they are deciduous forests. They also have simpler vegetation stratification, completely losing their vegetation cover during the dry period, thus, offering reduced food availability and little protection against increased temperatures and predation during the dry period

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(Nunes da Cunha and Junk, 1996). The two nighthawks, which do not depend on nesting sites above the ground, for they construct nests with little structure directly on the ground, provide a different kind of evidence that contradicts the hypothesis of limited nesting sites in the dry forests. We found 18 nighthawk nests in the evergreen forests and only three in the dry forests (Table 1).

Our results demonstrate that nesting success was similar between evergreen and dry forests not corroborating the hypothesis that there is more predation in habitats with decreased foliar density. Furthermore, the success rate in Cambará was similar to that of Cordilheira and Carvoeiro. The success rate in Landi, however, was about half of the other three forests. One potential explanation for this high predation rate in the Landi is that the richness and abundance of marsupials, potential nest predators, was much higher in Landis than in Cambarás (Aragona and Marinho-Filho, 2009). But Cordilheiras had similar marsupial abundance, but lower richness, than Cambarás. However, protection against nest predators may not be the principal factor influencing habitat selection for nesting. Other factors, such as the availability of locations for nest construction, shelter against extreme climatic variations or food resources may also affect nesting habitat selection.

The results of this study indicate that the Cambará forest is an important nesting habitat for a diverse number of forest bird species, being the main forest where various species nest in the region and where the nesting success is similar among most of the studied forest habitats. The two least important forests for forest nesting birds are Landi and Carvoeiro. Landi forests had the highest predation rate and Carvoeiro had the fewer number of species and nest abundance. Despite our data being preliminary, for we only studied one spatial replicate of each forest during two reproductive seasons, future studies should explore better this evidence of the importance of Cambarás for forest bird reproduction in the Pantanal. Conflicting results with other taxonomic groups, such as marsupials (Aragona and Marinho-Filho, 2009), show that conservation measures and land use policies should be based on a more complete biodiversity evaluation. This and other studies can assist in the formulation of management and conservation decisions for Pantanal reserves which are strongly pressured by deforestation and transformation into pasture lands (Harris et al., 2005).

In summary, we provided support for the productivity/heterogeneity but not for the vegetation density hypothesis. We encountered a larger number of nests and species nesting in the Cambará forests than in the other three forests, but one dry forest (Carvoeiro) was especially poor. Predation pressure did not differ between the two forest types, despite the difference in species abundance and number of species reproducing; and nesting success was similar between forests, but lower in one evergreen forest (Landi). However, the small number of nests monitored in three of the four studied forests, despite similar sampling efforts, makes the results preliminary. Apparently, specific characteristics of Cambarás and Landis, such as higher

vegetation heterogeneity and higher productivity can explain some of the differences found between these forests.

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