

Artículo



COMPOSITION AND FREQUENCY OF CAPTURE OF BAT ASSEMBLAGES IN A LANDSCAPE MOSAIC IN NORTHERN PANTANAL, MATO GROSSO, BRAZIL

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ABSTRACT. Influence of landscape patches on species richness and frequency of bats was evaluated in a cattle ranch in northern Pantanal wetland. Besides the lack of information on bats in areas modified by ranching, land use and the seasonal flooding in the Pantanal wetland certainly affects bat fauna composition. Twenty-seven (27) species were captured, distributed in five families. Phyllostomidae predominated with 16 species, followed by Vespertilionidae with five species. Species richness and frequency of captures varied according to the landscape mosaic, presenting positive association to less altered areas. Species more sensitive to environmental disturbances were captured in the most conserved areas, associated to palm forests (acuri palm forest; *Scheelea phalerata*, acuri palm tree) and flooded forest (cambará forest; *Vochysia divergens*). Our data suggest that even vegetation units in extensively deforested areas are valuable for the maintenance of some species of bats, either because they offer many of the resources they need or because they are spatially arranged in order to facilitate the joint use of the landscape patches.

RESUMO. Composição e frequência de captura de assembleias de morcegos em um mosaico da paisagem no Norte do Pantanal, Mato Grosso, Brasil. A influência das manchas da paisagem sobre a riqueza e frequência de captura de quirópteros foi avaliada em uma fazenda de gado no norte do Pantanal. A falta de informações sobre os quirópteros em áreas modificadas pela pecuária, o uso da terra e as inundações estacionais no Pantanal certamente são fatores que limitam o entendimento da composição da quiropterofauna da região. Foram capturadas 27 espécies, distribuídas em cinco famílias. Phyllostomidae predominou com 16 espécies, seguido por Vespertilionidae com cinco espécies. A riqueza de espécies e a frequência das capturas variaram de acordo com o mosaico da paisagem, apresentando associação positiva a áreas menos alteradas. Espécies consideradas mais sensíveis a distúrbios ambientais foram capturadas nas áreas mais conservadas, associadas a florestas de palmeiras (floresta de acuri; *Scheelea phalerata*, palmeira de acuri) e florestas inundadas (floresta de cambará; *Vochysia divergens*). Os dados sugerem que mesmo unidades de vegetação em extensas áreas desflorestadas são valiosas para a manutenção de algumas espécies de quirópteros, seja por oferecerem muitos dos recursos que necessitam ou por estarem espacialmente dispostos de forma a facilitar a utilização conjunta das manchas da paisagem.

Key words: capture frequency, Chiroptera, landscape mosaic, northern Pantanal, similarity in composition.

Palavras-chaves: Chiroptera, freqüência de captura, mosaico da paisagem, norte do Pantanal, similaridade na composição.

INTRODUCTION

The composition of bat faunas varies as a consequence of several factors such as food and shelter availability, habitat integrity, and competition for resources (Fenton et al. 1992; Aguirre 2002; Alho et al. 2011; Bobrowiec et al. 2014; Ávila-Gómez et al. 2015). Habitat loss and fragmentation can affect the composition and the distribution of bat communities (Andren 1994; Fahrig 2003; Castro-Luna et al. 2007). However, more commonly, altered habitats do not inhibit the movement of many species (Bernard & Fenton 2003; 2007; Medina et al. 2007), even though the composition of communities may be influenced by deforested areas, including successional pastures (Bobrowiec & Gribel 2010). Bat communities tend to be less diverse in deforested areas with few dominant and many rare species (Brosset et al. 1996; Fenton et al. 1992). This seems to be more related to the quality of habitats than to the size of the fragments (Ortêncio-Filho et al. 2014).

Bats are important regulators of many ecological processes, such as seed dispersal, pollination and control of insect populations considered as agricultural pests or vectors of diseases (Fleming et al. 1972; Fenton et al. 1992; Kalko et al. 1996; Sazima et al. 1999; Fleming et al. 2009; Munin et al. 2012). The group consequently is useful for evaluating the effects of landscape modification due to human activities, since they differ greatly from a taxonomic and functional perspective (Patterson et al. 2003) easing their use as an indicator of environmental change.

The Brazilian Pantanal, a large and still rather pristine wetland in the center of the South America, is characterized by seasonal flooding. The region is close to Cerrado, Amazonian Forest and Chaco, three of the largest biomes of the continent (Junk et al. 2006). The landscape mosaic is characterized mainly by forests, grasslands and pasture modified by intensive grazing and fire. Probably few areas are still undisturbed (Junk et al. 2006; Oliveira et al. 2013). The fragile balance of ecosystems in the region, defined by the dynamics of periodic flooding, a phenomenon related to higher and lower primary productivity and ecological succession, is threatened by recent economic development trends; deforestation of the adjoining Brazilian central plateau with

enormous areas of agricultural land surrounding the Pantanal and along the headwaters of the main rivers, deforestation within the floodplain itself, and replacement of the original grasslands with exotic grasses (Prance & Schaller 1982; Padovani et al. 2004; Harris et al. 2005; Lourival et al. 2011). The landscape is characterized by a mosaic of dry formations dispersed in various types of marshy areas. This dynamic causes a constant movement of wild animals and cattle in response to the availability of habitats and other resources (Alho 2008).

In the northern Pantanal, the main formations include fields with murundus (wet savanna with forest-islands, locally known as “campo com murundus”), dense forests (cambarazais, forests with dominance of *Wochysia*, *Vochysiaceae*; and acurizais, palm forests with *Attalea phalerata*), open forests (secondary forest physiognomies, for the most part), low-lying grasslands, and physiognomies characterized by the shrubby stratum (Oliveira et al. 2013).

Even with some inventories the composition of bat fauna is still underestimated, especially when it concerns rare species (Bordignon & França 2009; Alho et al. 2011; Bernard et al. 2011). For the Pantanal, five bat families are represented in the floodplain and seven in the plateaus, the Phyllostomidae family is known as the most common in the region, followed by Molossidae (Alho et al. 2011; Oliveira et al. 2012; Fischer et al. 2018). The most abundant species are usually *Artibeus planirostris* (Spix 1823), *Noctilio albiventris* Desmarest, 1818, *Molossus molossus* (Pallas 1766) and *Carollia perspicillata* (Linnaeus 1758) (Alho 2005; Bordignon & França 2009; Alho et al. 2011; Fischer et al. 2018).

Despite the increase in bat inventories, most studies tend to focus on areas close to large research institutions, or on specific regions. This stresses the importance of more extensive evaluations in several biomes, especially in those less studied, such as the Pantanal (Bernard et al. 2011). The present study evaluates the relationship between bat communities and landscape patches, addressing changes in species richness and frequency of captures including areas in successional stages in the northern Pantanal, Barão de Melgaço region, west of Brazil.

MATERIAL AND METHODS

Study region

The study region is located in northern Pantanal, in the municipality of Barão de Melgaço, State of Mato Grosso, within the Santa Lúcia ranch area ($16^{\circ}53'38.25"S$; $55^{\circ}54'24.98"W$). Altitudes in the plain, excluding isolated mountains or small hills vary between 80 to 200 m. The climate of the region is typical of savanna, "Aw" type, according to the Köppen-Geiger classification (Peel et al. 2007). The average temperatures in the hottest month of the year (January) vary between 26 and 30 °C and in the coldest month (July) between 19 and 20 °C (Hasenack et al. 2003). During winter, a dry climate prevails due to the stability generated mainly by the influence of the subtropical anticyclone of the South Atlantic (Alvares et al. 2013). The rainy season is shorter in the north and the winter drought is more severe. The annual precipitation varies between 1,250 mm in the northern and 1,089 mm in the south (Junk et al. 2006), with precipitation concentrating in the summer months.

The region is composed by a mosaic of open grassland and forest formations with different levels of anthropization due to cattle ranching. Twenty-four sites were sampled, including pastures and forest patches with varied physiognomies. Some were sampled more than others because they were more ample in the study mosaic. Dense forests predominate along rivers (Riparian Forest). Dry forest and palm-tree forests occur in well-drained areas. Seasonally flooded forests occur in lower areas, even though the plain is quite flat. In this context, six (06) sites of herbaceous vegetation associated with cattle raising areas (native and exotic grasses and areas of bare soil) were sampled; three (03) savanna termite sites (physiognomy of grassland with patches of trees and shrubs at termite-associated elevations); and one (01) site near an artificial tank (cattle watering holes) in the transition area between opens grassland and grassland with murundus. Both physiognomies are mainly used for grazing. We sampled five (05) cambará forest sites (seasonally flooded monodominant forest composed mainly by *Vochysia divergens*; *Vochysiaceae*); seven (07) acuri palm forest sites (*Scheelea phalerata*; *Arecaceae*); one (01) pimenteiral (seasonally flooded forest formation with dense and closed canopy, without undergrowth and with medium-sized trees dominated by *Licania parvifolia*, *Chrysobalanaceae*); and one (01) site within gallery forest, not flooded, on the banks of the São Lourenço river (Prance & Schaller 1982; Ponce & Cunha 1993; Oliveira et al. 2013; see Table 1).

These physiognomies have been identified via a generated Land Use Land Cover (LULC) map (Fig. 1), resulting from a non-supervised classification of two satellite images LANDSAT 8 OLI satellite (orbits/points 226/071 and 226/072; dating 26 of August 2014, bands 4, 5, 6 and 7; spatial resolution of 30 meters) and field data. The land cover classes was generated grouping the classes by an isodata non-supervised classification. This phase incorporated landscape descriptions of 200 georeferenced points recorded throughout the study area. Furthermore, as an aid to the image classification, visual analysis was performed on the images available in Google Earth. The identified physiognomies were associated to local names, which were compared to the nomenclature suggested for the Pantanal in literature. The accuracy was tested by a contingency matrix, obtained by overlaying the map

to 174 georeferenced landscape descriptions, aside from the 200 points from the image classification. The image classification accuracy was 93.1%. Geoprocessing tasks were carried out with the aid of software Idrisi Taiga (ClarkLabs) and ArcGis 10.1 (ESRI).

Bat sampling

We conducted field work between the dry and wet seasons (November – December 2014) and at the end of the dry season (October 2015). During thirty-two nights, two areas were simultaneously sampled, totaling 24 sites. Most areas were sampled for one nights, some (Sites 1, 2, 5, 6, 7, 8; Table 1) for two night, the data being then corrected by the capture effort spent. Five to seven mist nets were set up in clearings within vegetation patches, close to rivers, next to bridges, along trails and around man-made watering holes. The nets were open from sunset to midnight and revisions were made at every 15 minutes. Sampling effort was obtained by multiplying the area of each net by the exposure period (six hours), and multiplying by the number of nets (Straube & Bianconi 2002). The frequency of capture of bats species for each sampling site were calculated by dividing the total number of specimens captured by the sampling effort.

The captured bats were kept in cloth bags, and preliminarily identified in the field with keys available (Emmons & Feer 1997; Dos Reis et al. 2007; 2013). Field identification was checked in the laboratory with available literature (Dias & Peracchi 2008; Gardner 2007; Gregorin & Taddei 2002; Moratelli et al. 2013; Velazco et al. 2010). The nomenclature and order of citation of families and species follow Gardner (2007). Voucher specimens were deposited in the Mammals Collection of the Department of Vertebrates at the National Museum, Rio de Janeiro (UFRJ).

Data analysis

Unweighted Pair Group Method with Arithmetic Mean (UPGMA) was employed based on higher Cophenetic correlation (Van Tongeren 1987; Borcard et al. 2011). Sørensen similarity coefficient and Chord coefficient were used to compare the records of the species and the number of records, respectively. The mean values of the similarity matrices were used as a criterion to the interpretation of the larger groups. A heat map of the matrices was generated, with the intensity of colors representing the similarities of species composition between the sampled sites (Borcard et al. 2011). Data were processed through vegan, gclus and cluster packages using R (version 3.1.3.).

RESULTS

Species Richness and Frequency of capture

With a sampling effort of 26,145 square meters per hour, 659 individuals of 27 species belonging to five families were captured: Emballonuridae (one species), Phyllostomidae (16 species), Noctilionidae (two species), Molossidae (three species) and Vespertilionidae (five species; Table 2). Phyllostomidae was the most species-rich family,

Table 1

Sites sampled in the north of the Pantanal, in the municipality of Barão de Melgaço, MT, within the Santa Lucia ranch area, dominant vegetation and description of each study site.

Sites	Vegetation	Description
1	Cambarazal Closed	Monodominant, heavily forested and seasonally flooded formation dominated by <i>Vochysia</i> .
2	Cambarazal Transition with Murundus	More sparse cambarazal area, adjacent to a savannah with herbaceous matrix and patches of trees at land elevations.
3	Acurizal	Semi-deciduous forest with understory dominated by the acuri palm (<i>S. phalerata</i>).
4	Acurizal	Semi-deciduous forest physiognomy with understory dominated by the acuri palm (<i>S. phalerata</i>).
5	Open field	Intensively grazed area, without trees or shrubs, near a bridge over a nearly dry stream.
6	Open field near a cambarazal	Secondary physiognomy adjacent to a dense cambarazal. The nets were placed near an almost dry stream with little accumulated water.
7	Cambarazal with transition to murundus	Region of abrupt transition between cambarazal forest and savannah, with herbaceous stratum and aggregate trees on land elevations.
8	Degraded, shrubby acurizal nearby road	Mixed physiognomy with acuri palms, novateiros (<i>Triplaris americana</i> , <i>Polygonaceae</i>) and many gravatás (<i>Bromelia balansae</i> , <i>Bromeliaceae</i>).
9	Anthropic open field	Area close to human habitation and with nearby pasture without trees or shrubs.
10	Open field	Open pasture without trees or shrubs.
11	Shrub Pasture	Grazing areas with sparse and low shrubs and patches of open grasslands.
12	Shrubby Pasture	Transition area between pasture and open forests, with sparse trees and without understory.
13	Scattered acurizal palm forest along the bank of the river São Lourenço	Area close to a large fishing camp. Semideciduous forest with little herbaceous or shrub layer.
14	Trail between continuous dense forest, not flooded, along the bank of the São Lourenço river	Area close to a large fishing campo. Emerging forest canopy composed by several species (deciduous and perennial), showing great variation in height and continuity.
15	Field with murundus in transition to young cambarazal	Area with savannah physiognomy with aggregate of small trees at land elevations associated with termite mounds.
16	Field with murundus	Savannah formation with herbaceous matrix and tree elements associated with land elevations (murundus).
17	Dense Acuri palm forest	Semi-deciduous forest physiognomy with understory dominated by the acuri palm.
18	Pimenteiral (<i>Licania parvifolia</i> , <i>Chrysobalanaceae</i>)	Dense, closed-canopy formation with no undergrowth and medium-sized trees.
19	Open acuri palm tree forest	With little undergrowth and near pimenteiral corridor.
20	Young cambarazal forest	Area relatively away from large patches of forests, and in transition to pimenteiral.
21	Area close to an artificial water hole (water for cattle), in transition to savanna and with adjacent termite mounds (murundus)	Tall trees, often branching one-third below the trunk's average position, with a tendency to twisted growth and no obvious stratification.
22	Murundus field adjacent to artificial pond	Tall grass vegetation and tall termite mounds.
23	Acurizal forest	Forest with little herbaceous or shrub layer, and dominated by acuri palm with sparse trees.
24	Cambarazal mixed with sparce novateiro trees (<i>Triplaris americana</i>)	Cambará forest with some terrestrial bromeliads in the understory.

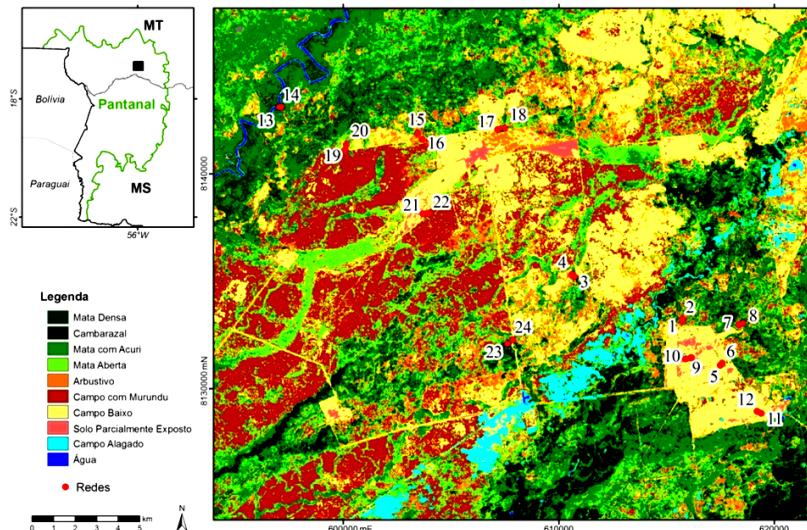


Fig. 1. Thematic map of land use and cover of Santa Lúcia ranch in the northern Pantanal, Barão de Melgaço – MT. Numbers represent the sampling points.

totaling 59.3% of the registered species and up 84.2% of the total captures. *Stenodermatinae* was the most representative, with 399 individuals and eight species captured. The highest percentage of captures was *A. planirostris*, with 211 individuals in 16 sites, representing 32% of the total captures followed by *S. lilium* and *N. albiventris*, with 79 individuals, each accounting for 12% of the captures. The lowest number of catches was of *M. riparius*, with two individuals at one site with 0.3% of the total, *M. molossus* and *N. leporinus*, with one ($n=1$) individual each and 0.15% of the total of captures. Emballonuridae was represented by one species (*R. naso*) and three individuals captured at two sites.

Artibeus planirostris was the most common species, and numerically dominant at the end of the dry season, captured in acuri and cambará forests in both periods. *Sturnira lilium* was common in both periods, with 94.3% and 72.7% of total captures in the first and second sampling, respectively, and occurring in half of the sampled sites, characterized by acuri palm forest. *Noctilio albiventris* was more frequent between dry and wet seasons, totaling 97% of captures. The records of the species were relatively similar throughout two vegetation zones; 34 individuals (44.2%) captured in cambará forest and 38 (49.4%) in grassland areas (pasture) with sparse trees or shrubs (Table 2).

The richest bat assemblage was in the cambará forest (Site 1; Fig. 1), with 14 species captured (52% of the total species richness). The second richest area was the acuri palm forest (Site 4) and the cambará forest (Site 2) with eight species each. The highest values of captures were in the acuri palm forest (Site 23 with 144 individuals, Site 17 with 70 individuals and Site 4 with 63 individuals).

Grouping the sites considering the class of cover, the forests dominated by cambará showed 19 species, 70.4% of the species richness, and 15.8% of the total number of captures. In the acuri palm forest, 18 species were captured; 66.7% of the species richness and 54% of the total records. In grassland and pastures 13 species were captured; 48.2% of the species richness and 16.8% of the total abundance. In termite savanna eight species were captured; 29.6% of the richness and 4.4% of the total abundance. The sites with the lowest percentage of captures were: seasonally flooded forest (Site 18) dominated by *Licania parviflora* (Chrysobalanaceae), with seven species (25.9% of the species richness and 5% of records); grasslands surrounding a man-made water hole (Site 21), with six species (22% of the richness and 3.5% of the abundance); and a trail in a dense forest (Site 14), with only one species captured (3.7% of richness and 0.15% of records). The similarity in the distribution of species records among sampling sites is shown in Fig. 2.

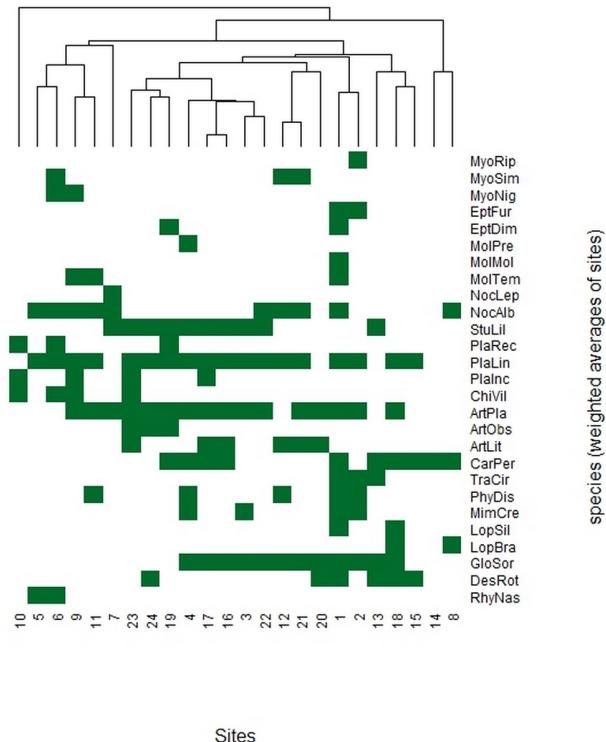


Fig. 2. Diagram obtained through the Sørensen coefficient and the agglomerative method UPGMA showing the records of the species in the sampled sites. The acronyms represent the three initials of the species names (see Table 2).

Landscape patches similarities based on bat assemblages

Bats fauna comparisons were based on the highest value of the cophenetic correlation (UPGMA: composition, $r_{cs} = 0.77$; frequency of captures, $r_{cs} = 0.91$). Based on records five distinct groups of sampled locations (Fig. 4), with subgroups of varying similarities within clusters III and V (Table 3; Fig. 3) were identified.

A cluster composed by two distinct areas, in the same grouping II, with high level of disturbance showed low similarity, and shared one species (*C. perspicillata*). The first one (Site 8) is composed by acuri palms, novateiros (*Triplaris* sp.; Polygonaceae) and understory dominated by terrestrial bromeliad (gravatás). The second one (Site 14) presents a continuous, non-flooding, dense forest, on the banks of the São Lourenço River and is relatively disturbed by human activities (close to a fisherman's camp).

The set of areas in the grouping III, is composed by a combination of physiognomies common to the Pantanal landscape (Cambará Forest; Termite Savanna; Grasslands / Pasture; Pimenteiral; Acuri Palm forest). Seventeen species were captured on these sites (*D. rotundus*, *G. soricina*, *L. silvicolum*; *G.*

crenulatum, *P. discolor*, *T. cirrhosis*, *C. perspicillata*, *A. lituratus*, *A. obscurus*, *A. planirostris*, *P. incarum*, *P. lineatus*, *S. lilium*, *N. albiventris*, *E. diminutus*, *E. furinalis* and *M. simus*), most of which are common to all the sites and composes a cluster. However, pimenteiral forest with sparse acuri palms and transition zones between termite savanna and cambará forest (13(15,18)) are physiognomically quite distinct. Additionally, dense cambará forest, including areas of transition to termite savannas, composed a distinct subgroup (1,2), suggesting an anthropic gradient. Cambará forest when composed mainly by young trees (20), comprises a quite distinct subgroup and far from shrub pasture and grassland surrounding man-made water holes group (12,21).

A larger subgroup within the cluster ((4 (16,17)) (3,22)) is composed of dense forest with acuri palm tree and Termite Savanna and sharing seven species (*G. soricina*, *G. crenulatum*, *C. perspicillata*, *A. lituratus*, *A. planirostris*, *P. lineatus*, and *S. lilium*). A subgroup with areas of physiognomically distinct dense forests (23 (19,24)), show moderate similarity. A common feature is the relatively open understory (cambará forest, forest with acuri palms and transitional zones). These relatively well-conserved

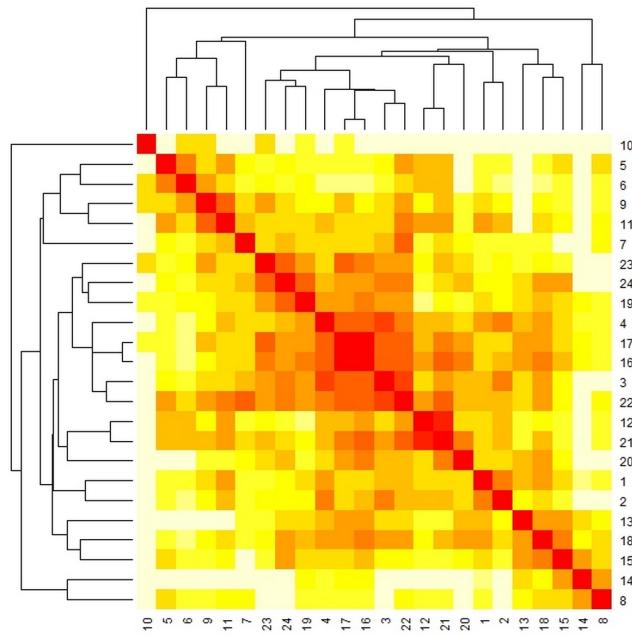


Fig. 3. Heat Map of similarity based on the records of species, obtained through the Sørensen coefficient and the agglomerative method UPGMA.

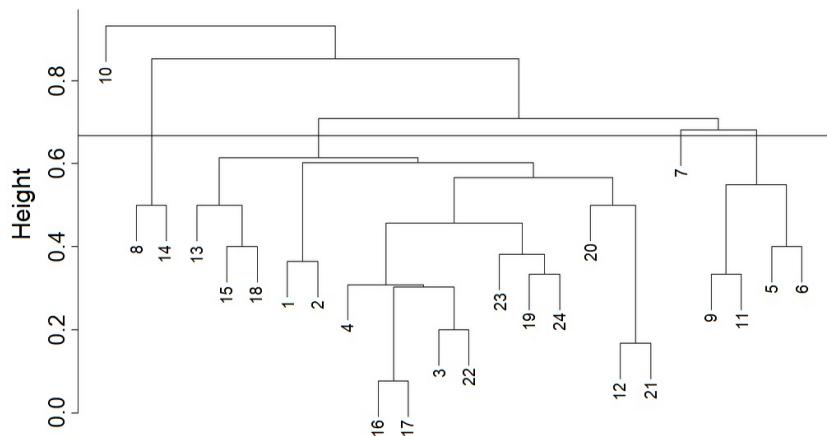


Fig. 4. Dendrogram (UPGMA grouping method and Sørensen coefficient) resulting from the analysis of 24 sampled sites and records of 27 species of bats. The horizontal line demarcates the mean value (0.668) of the similarities, computed through the original matrix values. The cophenetic correlation coefficient (r_{cs}) was 0.77.

and slightly disturbed sites share four species (*A. obscurus*, *A. planirostris*, *P. lineatus* and *S. lilium*).

Groups I and IV, composed of only one area each, respectively, an area of pastures without trees or shrubs (10) presented low species richness (three species caught; *C. villosum*; *P. incarnum*; *P. recifinus*) and one Cambará forest area (Sítio 7), close to the transition to a termite savanna, composes a distinct group with four species (*A. planirostris*, *S. lilium*, *N. albiventris* and *N. leporinus*), both showing low similarity with other areas.

Finally, a group (Group V) consisting only of pasture grasslands, cluster ((9,11) (5,6)), with a relatively similar physiognomy have six species in common (*R. naso*, *A. planirostris*, *C. villosum*, *P. lineatus*, *N. albiventris* and *M. temminckii*) and compose a group with high similarity.

Species frequency of capture, relative to the sampling effort, evidenced four groupings (Table 4; Fig. 6) similar to species richness analysis, but more heterogeneous (Fig. 5).

The pasture area near human settlements compose a distinct group (Group I), quite distant from the others. It presented an extremely low number of captures (four individuals), having low similarity with the other areas, as was observed for species composition reinforcing the low similarity.

Another heterogeneous group (Group II), transition zones, some associated to the proximity of less disturbed natural formations, anthropic areas (cattle-modified forest with acuri), grassland pastures and relatively homogeneous natural grasslands showed moderate similarity. *Noctilio albiventris* (60%) and *P. discolor* (14.8%) showed the highest frequency of captures, being the most frequent species in almost all the sites in this cluster.

Another grouping (Group III), besides those less disturbed, include contrasting physiognomies such as pastures with high anthropic pressure (common physiognomy in ranch areas) to the transition zones. Dense forests with acuri palm (Site 23) presented high similarity of species abundance with termite savanna areas, with or without man-made water holes for the cattle (Sites 21, 22 and 16). Cambará forest, in varied physiognomies (mixed cambará forest, Site 24; transition cambará forest/termite savanna (Site 2), dense cambará forest (Site 1) are arranged in sequence suggesting a structural gradient. This cluster is based on 17 species. Four of them are common to most of sites and with the highest frequency of capture within this group (*Artibeus planirostris* (52%), *P. lineatus* (18.7%), *S. lilium* (7.7%) and *G. soricina* (9%)).

Acuri forest with sparse palm trees, associated to deciduous forests (Sites 13 and 14) and with open understory slightly differs from similar forests, but with higher densities of palm trees and pimenteiral, which are quite open. These areas, Group IV, are quite variable suggesting transition zones. Bats clearly respond to structurally simplified formations such as pimenteiral (Site 18). Termite savannas in their transition to stands of young cambará trees (Site 15) are characterized by a mixture of grassland with sparse trees, and present a distinct assembly of bats. An additional subgroup is formed by dense acuri palm forests (sites 3 and 17) with open understory dominated by the acuri palm and semi-deciduous trees. Among the six shared species, *S. lilium* (30%), *C. perspicillata* (29%), *G. soricina* (11%), *A. planirostris* (8%) and *D. rotundus* (6%) represent the highest frequencies of records.

DISCUSSION

Species Richness and Frequency of capture

The highest species richness and homogeneity in the proportion of captures were recorded in the cambará forest. This is remarkable, since these forests are structurally simplified and composed mainly by the dominant *Vochysia* and with very open understory. Such a variety of groups and trophic structure found suggest a high productivity, which would provide a range of resources for a rich assemblage of bats. Flood pulse may increase the insect populations aside the habitat structural peculiarities (Marques et al. 2001; Denzinger & Schnitzler 2013), but the availability of other resources and even bat shelters in such forests are unknown.

The highest species records in acuri palm forest, may be related to less extreme conditions in that kind of forest, in addition to their internal structural complexity, judging that visually. Abundance of palms which may reach 80-90% of the understory composition may provide high thermal stability (Hofmann et al. 2003) favoring bats, particularly as a result of lower temperatures during daytime, when contrasted to other formations. In northern Pantanal high canopy cover in palm forests decreases the temperature by about 8° C (Hofmann et al. 2003), when contrasted to grasslands or savannas, generally warmer and drier. Within forests higher humidity is due to thermal softening provided by the canopy. Such variations can influence the use of shelters, as well as occurrence and abundance of bats.

Table 2

Species of bats and families captured in Northern Pantanal (MT). Number of individuals (N), percentage of captures in the transition period between drought and flooding period (2014) and drought period (2015), and number (n) of sampling points per vegetation classes. CAM= Cambará forest; ACU= Acuri palm forest; PAS= Pasture; TER= Termite savanna; CDW= Continuous dense forest; PIM= Pimenteiral; ANWH= Area near to man-made water hole.

Family / Species	2014		2015		CAM	ACU	PAS	TER	CDW	PIM	ANAT
	N	%	N	%							
Emballonuridae											
<i>Rhynchoycteris naso</i>	3	1,0	0				2				
Phyllostomidae											
<i>Artibeus lituratus</i>	1	0,3	9	2,6	1	2	1	1			1
<i>Artibeus obscurus</i>	0		4	1,1	1	2					
<i>Artibeus planirostris</i>	44	14,3	167	47,4	5	5	2	2		1	1
<i>Carollia perspicillata</i>	5	1,6	50	14,2	1	5		2	1	1	
<i>Chiroderma villosum</i>	4	1,3	1	0,3		1	3				
<i>Desmodus rotundus</i>	3	1,0	12	3,4	3	1		1		1	
<i>Glossophaga soricina</i>	11	3,6	22	6,3	3	4	1	2		1	1
<i>Lophostoma brasiliense</i>	1	0,3	3	0,9		1					1
<i>Lophostoma silvicolum</i>	1	0,3	2	0,6	1						1
<i>Gardyerteris crenulatum</i>	13	4,2	0		2	2					
<i>Phyllostomus discolor</i>	27	8,8	0		2	1	2				
<i>Platyrrhinus incarum</i>	2	0,7	2	0,6		2	2				
<i>Platyrrhinus lineatus</i>	52	17,0	29	8,2	3	5	5	3		1	1
<i>Platyrrhinus recifinus</i>	2	0,7	2	0,6		1	2				
<i>Sturnira lilium</i>	35	11,4	44	12,5	2	6		2			
<i>Trachops cirrhosus</i>	5	1,6	1	0,3	2	1					
Noctilionidae											
<i>Noctilio albiventris</i>	77	25,1	2	0,6	2	1	5	1		1	
<i>Noctilio leporinus</i>	1	0,3	0		1						
Molossidae											
<i>Molossops temminckii</i>	3	1,0	0		1		2				
<i>Molossus molossus</i>	1	0,3	0		1						
<i>Molossus pretiosus</i>	3	1,0	0			1					
Vespertilionidae											
<i>Eptesicus diminutus</i>	2	0,7	1	0,3	1	1					
<i>Eptesicus furinalis</i>	3	1,0	0		2						
<i>Myotis nigricans</i>	3	1,0	0				2				
<i>Myotis riparius</i>	2	0,7	0		1						
<i>Myotis simus</i>	2	0,7	1	0,3		2					1
Total Individuals	306	100	352	100							

Table 3

Groups of clusters based on the species composition between the sites sampled. The groups of numbers in parentheses represent the associations in the diagram of Fig. 4.

Groups	SITES
I	(10)
II	(8 – 14)
III	(13(15,18))(1,2)(4(16,17)(3,22))(23(19,24))(20(12,21))
IV	(7)
V	((9,11)(5,6))

Fig. 5. Heat Map of the similarity matrix (Chord coefficient) regarding the captures of bats, obtained through the agglomerative method UPGMA.

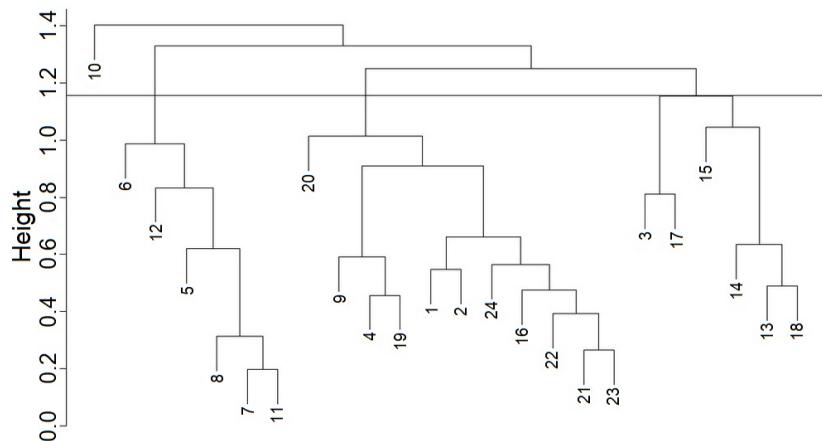
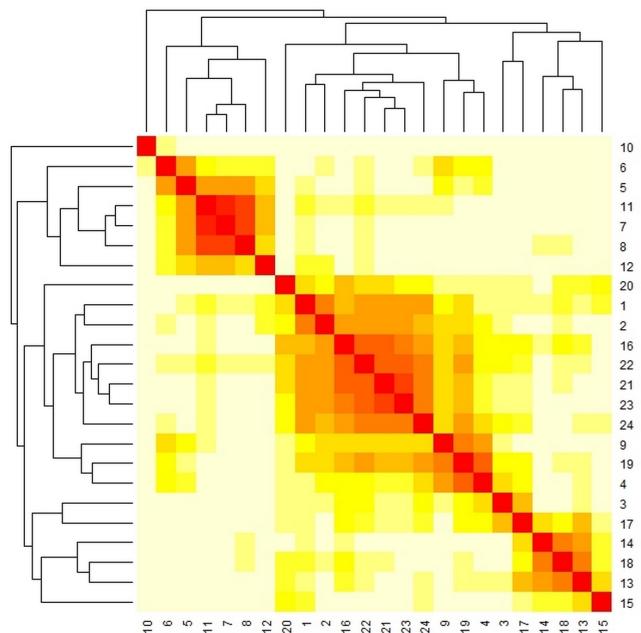


Fig. 6. Dendrogram (UPGMA grouping method and Chord coefficient) resulting from the analysis of 24 sites, based on captures of 27 species of bats. The horizontal line demarcates the mean similarity value (1.155) based on the original matrix. Cophenetic correlation coefficient (r_{cs}) was 0.91.

Table 4

Groups of clusters based on the abundance of captures of bats by sampled sites. The groups of numbers in parentheses represent the associations in the diagram of Fig. 6.

Groups	SITES
I	(10)
II	(6(12(5(8(7,11))))))
III	(20(9(4,19)))((1,2)(24(16(22(21,23))))))
IV	((3,17)(15(14(13,18))))

A new record for the floodplains, *Eptesicus diminutus*, until now known for the dry areas within the plain (Fischer et al. 2018), was got in the beginning of the wet season and in the dry season. *Artibeus planirostris* and *N. albiventris* presented high capture rates similar to other studies in Pantanal (Alho 2008; Oliveira et al. 2011; 2012). The three *M. pretiosus* specimens, a DD (Data Deficient, ICMBIO 2014), were captured only in the forests with the acuri palm (Site 4). *Lophostoma brasiliense*, *L. silvicolum*, *T. cirrhosus* and *G. crenulatum*, species recognized as normally associated to structurally intact forests and less disturbed areas (Fenton et al. 1992; Medellín et al. 2000), reinforces the association of Phyllostominae with these habitat types in the Pantanal (acuri, cambará forest and pimenteiral).

Although available data does not allow major generalizations regarding the bat fauna in the Pantanal, 27 species recorded locally represent a relatively high number considering other inventories. Similar or lower species richness was recorded in other regions of the Pantanal, even with greater sampling effort (Oliveira et al. 2011; 2012; Sousa et al. 2013; Oliveira et al. 2013). The species richness in the study region comprises about 30% of the species registered for the Pantanal biome (Dos Reis et al. 2013; Oliveira et al. 2013; Fischer et al. 2018). However, this number may be higher, due the complexity of the landscape mosaic and the less accessible areas not surveyed.

The capture of Phyllostomidae may be partly related to the method used (mist nets set at near ground level), which provides reasonable information on the diversity and abundance of bat fauna (Fleming 1986; Simmons & Voss 1998), especially frugivores (Carollinae and Stenodermatinae). On the other hand this group is recognized as the more diverse in Pantanal (Alho 2008; Oliveira et al. 2011). Another possible reason for high richness and abundance of the group in the region is that most species eat

fruits and flowers of plants of successional stages as secondary forest (Willig et al. 2007; Heer et al. 2015). Some families are probably underrepresented due to the capture method used.

Similarities between Sites based on species assemblages

The species record shows some consonance with the vegetation zones, with variations or discontinuities in some cases. Disturbed areas do not seem to inhibit the movement of some species, suggesting a flow between vegetation zones (Bernard & Fenton 2003; 2007; Medina et al. 2007) including those with intensive livestock, but less abundant or rare species may be more likely to decline due to land use (Davies et al. 2000). The occurrence of four species of the subfamily Phyllostominae may indicate relatively low disturbance (Fenton et al. 1992; Medellín et al. 2000) in acuri palm forest, cambará forest and pimenteiral.

Clusters are heterogeneous, but the similarities were relatively high within some subgroups as (13(15,18)), (4(16,17)(3,22)) and (16(22(21,23))) (Figs. 4 and 6), even if they presented contrasting physiognomy. Open physiognomies favor certain forms of flight and habitat use, but to a large extent represent the original mosaic. Groups of sites mainly composed by pastures or large corridors between forest zones are used by species for foraging and moving between patches (Heer et al. 2015).

Cambará and acuri palm forests contrasted sharply with more open areas where the species richness was lower. The composition may be related to the high mobility of the group (Medina et al. 2007), suggesting that the discontinuity in the landscape mosaic does not necessarily mean species habitat packing, but that they use the mosaic in a varied way. Two large groups of species use the landscape mosaic differently. The first one is composed by frugivores, associated mainly to dense forests, particularly with acuri palm forest, or areas near to more closed formations, suggesting association with availability. Frugivore Stenodermatinae bats are mainly consumers of pioneer plant species, common in clearings or trails (Gomes et al. 2014). The ability of these bats to explore modified habitats and to perform long-distance flights are key features that influence the persistence of the group in sites with different levels of degradation (Fleming 1988; Bernard & Fenton 2003; Medina et al. 2007). The second group is composed by insectivore species more associated to sparse vegetation or grasslands. They are more frequent in areas closer to water

bodies such as rivers, using bridges as shelters and areas with relatively similar physiognomies (cambará forest with their varied structures) suggesting common factors that should be further explored.

On the other hand, well-preserved areas presented higher species richness and higher frequency of bats when contrasted with those most disturbed. This suggests that for effective conservation of bats in human modified landscapes, areas with original vegetation should be maintained to increase the chances survival of species that are sensitive to deforestation (Castro-Luna et al. 2007). Patch of habitats can provide refuge, especially with respect to rare and more specialized species in a landscape dominated by pastures (Heer et al. 2015).

Studies that relate the occurrence and activity of organisms with disturbed landscapes but with preserved patches (Bernard & Fenton 2003; 2007; Bobrowiec & Gribel 2010) generate valuable information for managing livestock areas to protect wildlife. Despite the loss of habitat in the region, the most conserved areas showed a richer bat fauna. However, this integrity may be affected by the proportions of extensive grazing areas, where the composition was not always diverse, but composed by groups of species more vulnerable to the degradation process. The effect of fragmentation and habitat loss may be positive in some cases, whereas habitat loss has extensive negative effects on populations (Fahrig 2003; Castro-Luna et al. 2007).

Data on bat faunas collected in northern Pantanal, in cattle ranches, may reinforce the importance of the maintenance of natural vegetation within extensive livestock areas for the conservation of biodiversity, as has already been stressed for the group (Castro-Luna et al. 2007; Heer et al. 2015). Bat assemblages, recognized through cluster analysis, showed reasonable patterns of spatial arrangement, grouping vegetation areas with relatively similar compositions. In some cases, physiognomically quite distinct groups suggest use of the mosaic instead of isolated patches, presenting a very similar composition of bat fauna. Some clusters containing distinct vegetation physiognomies suggests that bats may be responding to mosaic variability, potentially using some areas as shelter and others for foraging in an integrated way in the mosaic.

CONCLUSION

The Brazilian Pantanal has fauna inventories still underdeveloped, particularly on the composition of bat fauna. The relationship between species richness and frequency of capture of bats with the mosaic of

the landscape were evident, suggesting a very wide habitat use, even though vegetation zones present remarkable peculiarities related to its structure. Some formations are monodominant or even open fields or savannas. The richest bat assemblage was in the monodominant cambará forest, followed by the acuri palm forest. The highest percentage of captures was of Phyllostomid bats confirming a general pattern of Pantanal bat fauna. Vespertilionids were less representatives (e.g. *M. riparius*; 0.3% of the total). Some species (*L. brasiliense*, *L. silvicolum*, *T. cirrhosus* and *G. crenulatum*) are associated to undisturbed areas, suggesting common factors to systems slightly apart from anthropic pressure.

The highest records of species were in the acuri palm forests, structurally more complex, suggesting that the conservation of forests in the Pantanal, even though the region is composed of a mosaic where forests are less expressive, can be a way to maximize the conservation of biodiversity. For effective conservation of bats in human modified landscapes, areas with original vegetation should be maintained to increase the chances of survival of sensitive species. As the Pantanal region is mostly composed of private areas (cattle ranches, Seidl et al. 2001), their management can be a way to maximize biodiversity conservation. Strengthening conservation plans and the importance of natural vegetation within extensive livestock areas can be a way to adequately integrate land use with conservation plans. Although a high biodiversity coexists with the most common form of land use, there is a significant deforestation or modification of open areas changing the physiognomy of the landscape with the addition of extensive areas with exotic pastures (Seidl et al. 2001; Harris et al. 2005) or simply regional elimination of certain categories of vegetation (Oliveira et al. 2013), which reduces the availability of habitats for certain groups of bats such as philostomids (this work, and Silveira et al. 2018). The maintenance of a varied mosaic can favor diversity by reconciling it with the form of land use.

It is evident that large-scale sampling efforts should change the scenario of knowledge about the bat fauna in the region, considering that vast areas have not been sampled so far and that even limited sampling has already shown an expressive richness higher than that known for other regions of the Pantanal.

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