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Local spatial factors influences birds and fishes communities in the Cerrado biome

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Abstract. In the present study, we tested how spatial and temporal factors influence fish and birds communities in Uru River, Cerrado (Brazilian savannah). Our premise is that birds from gallery forest would respond mainly to seasonal factors (such as dry season) while fishes would be more affected by spatial factor at local scale, given that this community tends to be more spatially constrained. Four seasonal expeditions from August 2008 to June 2009 were conducted (two during rainy season and two during the dry season) in a stretch of 4.2 km of Uru River and its tributary the Brumado stream. Three environments were sampled and the Physical Integrity Index (IIF) was assessed for each one. The icthyofauna was sampled using gillnets (several mesh sizes) and bird community of gallery forest was observed in total sampling effort of 96 hours. We estimated the differences between temporal and spatial factors performing a Non-metric Multidimensional Scaling (NMDS), a Permutational Multivariate Analysis of Variance procedure (PERMANOVA) and an analysis of similarities (ANOSIM). Our results revealed that spatial effects were more influential to bird (85 species) and fish (42 species) communities than the temporal seasonality at Uru River. This result underlines the importance of spatial variability, even in environments connected and close to each other and in spite of the seasonal availability of water and consequently food in Cerrado biome, which is characterized by markedly seasonal variability.

Key-words: gallery forest, temporal variation, small spatial scale, communities structure, Brazilian Savannah

Resumo. Fatores espaciais locais influenciam as comunidades de pássaros e peixes no bioma Cerrado. No presente estudo, nós testamos a influência de fatores espaciais e temporais em comunidades de peixes e de aves no Rio Uru no Cerrado. Nossa premissa é que os pássaros da mata galeria são influenciados pelos fatores temporais, como a estação seca, enquanto peixes seriam mais afetados pelos espaciais em escala local, pois esta comunidade tende a ser mais espacialmente restrita. Foram realizadas quatro amostragens (duas na estação seca e duas na chuvosa) entre Agosto de 2008 e Junho de 2009 num trecho de 4,2 km do rio Uru e seu tributário, o córrego Brumado. Amostramos três ambientes e para cada um deles determinamos o Índice de Integridade Física. A ictiofauna foi amostrada com redes de espera de diversos tamanhos, enquanto que as aves foram amostradas por avistamento num total de 96 horas. Nós estimamos as diferenças entre as influências temporal e espacial através de várias técnicas estatísticas: uma Análise de Escalonamento Multi-Dimensional (NMDS), uma Análise de Variância Multi-variada Permutacional (PERMANOVA) e uma análise de similaridade. Nossos resultados revelaram que os efeitos espaciais foram mais influentes tanto para pássaros (85 espécies) quanto para peixes (42 espécies) que a sazonalidade temporal do Rio Uru. Isto evidencia a importância da variabilidade espacial, ainda que os ambientes estejam próximos e conectados entre si, mais do que a marcante variabilidade sazonal do Bioma Cerrado.

Palavras-chave: mata galeria, variação espaço-temporal, escala especial restrita, estrutura de comunidades, Cerrado

Introduction

The comprehension of biotic and abiotic mechanisms that determine the spatial and temporal distributions of biological communities is essential to understand the structure of communities (Sullivan & Watzin 2008) and provides subsidies for choosing the most suitable areas for the conservation of species (Klink & Machado 2005).

Temporal variation could explain fluctuations and modifications on communities including in fish communities but especially in migratory birds fleeing cooler temperatures (Isaach & Martínez 2002, Batista & Petrere 2007). Natural resources temporal variation could be explained by physical factors (Chifamba 2000) and changes in resource levels could be follow by changes in the community structure (Wiens 1986).

Spatial scale is one fundamental source of variation to both, birds and fishes communities from small to large-scale (Laranjeiras *et al.* 2012, Blamires *et al.* 2008, Barletta *et al.* 2000). Spatial scale influences the heterogeneity of habitats and consequently has effect upon the resources abundance (Hamer *et al.* 1997), affecting mainly fish species diversity in rivers worldwide (Meffe & Sheldon 1988, Súarez & Petrere 2007).

In the present study, we tested how spatial and temporal factors influence fish and birds communities in Uru River, Cerrado (Brazilian savannah). Our premise is that birds from gallery forest would respond mainly to seasonal factors (such as dry season) while fishes would be more affected by spatial factor at local scale, given that this community tends to be more spatially constrained.

Methods

Study area: The Uru River (Tocantins Basin) crosses over areas with plantations of sugar cane or pastures in almost its entire length. The portion used in this study presents preserved riparian vegetation and altered forests and is affected by anthropic pressure through the movement of persons on its banks, particularly sports fishermen and tourists, who come together for leisure activities (grilling, resting).

The total length of a stretch of 4.2 km was studied. Three sampling units were chosen: two on the Uru River (U1 and U2) and the third on its tributary, the Brumado stream (BR) (Figure 1). These sites were chosen for their markedly different physiographic characteristics. The studied area does not contain waterfalls that could act as natural physical barriers to fish species.

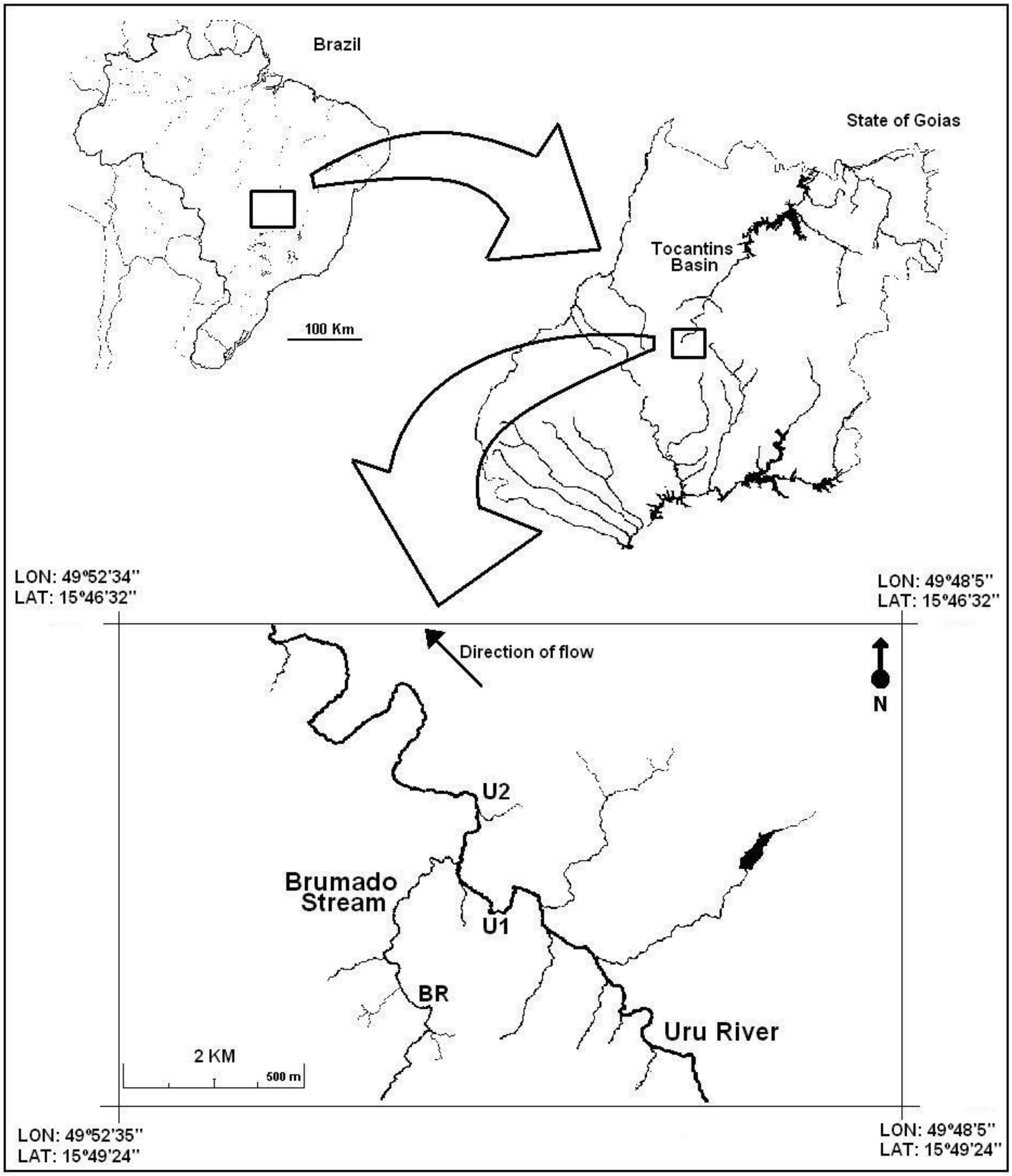

Figure 1. Sampling Local at the Uru River (Goiás State - Brazil). U1: Uru River Sampling Local 1; U2: Uru River Sampling Unit 2 and BR: Brumado Stream Sampling Unit.

The U1 sample unit presents preserved riparian vegetation, dense, and high forest, and displays the presence of native and climax species as *Anadenanthera macrocarpa*, *Tabebuia* sp. *Astronium urundeuva* and *Copaifera* sp.. This portion of the river presents tall ravines, width of almost 40 meters, low-speed waters, and bottom covered by tree trunks (Table I). The U2 sample unit presents degraded riparian forest with sparse trees, absence of ravines, high-speed waters, and substrate formed by rocks. The BR sample unit presents preserved riparian forest and dense with seemingly less anthropic impact than the other two units. The width of the river in this site is smaller than in the other two (Table I) and the bottom features rocks, submerged trees, large boulders, sand in abundance, and deposited organic debris of allochthonous origin.

Data sampling: Two expeditions in the rainy season and two during the dry season (August 2008 to June 2009) were performed. Physiographical data were collected on each sampling unit: depth of the river (m), current speed (m/s), river width (m), and the width of the riparian forest. Also, it was determinate the Physical Integrity Index (IIF), which consists of a protocol containing 12 items with descriptive characteristics of environmental conditions such as land use, conservation status and width of the riparian forest, sediments, and structure of ravines and riverbed (Nessimian *et al*. 2008). The evaluation was performed in three sample units through objective scoring by only one of the authors (Douglas S. Mendonça). Each item has the same weight in the analysis of results and the final index value is the average of the sampled characteristics ranging from 0 (low integrity) to 1 (high integrity).

Fish: The icthyofauna was captured using gillnets (15, 20, 30, and 50 mm meshes, 10 meters long). The total sampling effort was of 192 hours of gillnets in the water. The nets were surveyed every two hours. The identifications were made according to Santos *et al.* (2004) and with the help of specialists from the Ichthyology Museum of the Limnology and Aquaculture Research Center at the Maringá State University. The feeding habit of the fish was determined according to the literature (Santos *et al.* 2004, Graça & Pavanelli 2007).

Birds: The methodology used for sampling birds followed Gimenes & Anjos (2004); each of the four sampling expeditions lasted three days with two daily observations between 6 and 11 am and 3 and 6 pm completing a total sampling effort of 96 hours. The observations were divided between four different points with equal time (one hour) and made during walks on trails in the riparian forest or from within a boat on the riverbed. The records from the observed bird species were taken at each point without the establishment of a fixed sighting radius, however, particularly distinguishing the location of contacts among different individuals from the same species, following their displacement; thus, different contacts were not assigned to the same individual. The species, identified both by direct observation or vocalizations, were recorded according to the classification following the Brazilian Committee for Ornithology Registries (CBRO 2009). The trophic guilds were classified according to the literature (Sick 1997, Gimenes *et al.* 2007) and the following types of diet were considered: N – Nectarivorous, F – Frugivorous, O – Omnivorous, P – Piscivorous, I – Insectivorous, C – Carnivorous, and G –Graminivorous.

Statistical Analyses: We performed three statistical analyses in order to contrast the influences of spatial (environments) and temporal (seasonality) variables on the fish and bird communities.

We applied a Non- metric Multidimensional Scaling (NMDS, Legendre & Legendre 1998) to search for spatial and temporal variation patterns in the community of birds and fishes. This analysis summarizes the structure of a biological assemblage contained in a similarity matrix, evaluated in different sample units through multidimensional ordinations. The indexes of Bray-Curtis (with the data previously transformed into logarithms) and Jaccard were used for the data from density and presence/absence of species, respectively.

The Permutational Multivariate Analysis of Variance procedure (PERMANOVA, Anderson 2001) was used to evaluate the effects of the two classification criteria, environments (U1, U2, and BR), and sampling periods (wet and dry seasons) on biological assemblages (bird and fish). PERMANOVA is a multi-factorial ANOVA based on any measured distance using permutation methods (Anderson 2005). The dissimilarity coefficients used were Bray-Curtis (for abundance data, previously transformed into logarithms) and Jaccard (for presence/absence data).

The analysis of similarities (ANOSIM, Clarke 1993) was used to test statistically significant differences between two environmental or sampling periods and groups when the PERMANOVA results suggested differences.

We elected the representative species for each environment using a simple statistical procedure: in this work we consider as typical species those with mean density higher than three and higher than its own respective standard deviation, because high standard deviation (relative to mean) could indicate the occasional use of that environment.

Results

The sampled environments (U1, U2, and BR) presented different environmental characteristics (Table I). U1 was identified as the deepest and with the lowest Physical Integrity Index (IIF); U2 displayed the highest water speed; and BR had the smallest width but the highest IIF value.

Table I. Environmental characteristics of sampled habitats in Uru River (Cerrado, Brazil): U1 and U2 - Uru River; BR – Brumado stream in two seasons (Wet and Dry). IIF = Physical Integrity Index (see text).

Habitat	**Season**	**River**			**Riparian Forest (m)**		**IIF**
		Width (m)	Depth (m)	Water vel. (m/s)	Right Width	Left Width	
U1	Wet 1	35.56	2.62	0.09			
	Wet 2	37.35	2.62	0.3			
	Dry 1	35.39	2.79	0.08	39.31	69.98	0.67
	Dry 2	35.51	3.45	0.12			
U2	Wet 1	24.33	0.64	0.71			
	Wet 2	30.66	1.01	0.63			
	Dry 1	23.33	0.56	0.57	15.27	23.51	0.72
	Dry 2	30.1	0.57	0.91			
BR	Wet 1	8.42	0.94	0.06			
	Wet 2	9.8	1.2	0.14			
	Dry 1	10.3	1.09	0.03	40.71	31.88	0.89
	Dry 2	9.34	1.29	0.1			

Fish Community

Forty-two species of fish were collected, distributed into 4 Orders and 13 Families (Table II). The number of species varied among the sample units: BR presented the greatest richness with 27 species, U1 with 22 species, and U2 with 17 species. The species presented 3 different feeding habits, detritivorous (12 species), omnivorous (15 species), and carnivorous (15 species).

The Loricariidae family was the most represented with 11 species, followed by the families Characidae (9 species), Anostomidae (5 species), Cichlidae (5 species), Pimelodidae (3 species), Erythrinidae (2 species), Hemiodontidae (2 species), Acestrorhynchidae (1 species), Auchenipteridae, (1 species), Curimatidae (1 species), Cynodontidae (1 species), Doradidae (1 species), and Gymnotidae (1 species).

This fish community presented nine new species, not described yet, whose respective testimonial specimens were deposited in specialized collections are waiting for description (Annex 1). None of the collected known species is listed as endangered species.

Table II. Mean density and standard deviation (SD) of fish species in the habitats (U1, U2 and BR) in all samplings. Feed behavior: D- detritivore; O – omnivore; C – carnivore.

			U1		U2		BR	
Família	**Taxon**	**Food**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Acestrorhynchidae	*Acestrorhynchus falcatus*	C	0.3	0.5	0.5	1.0	1.8	0.5
Anostomidae	*Leporelus vittatus*	O	0.0	0.0	0.3	0.5	0.0	0.0
	Leporinus friderici	O	0.5	1.0	0.0	0.0	0.0	0.0
	Leporinus pachycheilus	O	0.0	0.0	0.5	1.0	2.3	2.1
	Leporinus cf. taeniatus	O	0.0	0.0	1.0	1.2	0.0	0.0
	Leporinus sp.	O	1.8	2.9	0.5	0.6	2.3	4.5
Auchenipteridae	*Auchenipterus nuchalis*	C	0.0	0.0	0.3	0.5	0.0	0.0
Characidae	*Astyanax abramis*	O	0.0	0.0	0.0	0.0	0.3	0.5
	Astyanax elachyleps	O	0.0	0.0	0.0	0.0	2.3	3.3
	Acestrocephalus maculosus	C	0.0	0.0	0.0	0.0	0.5	0.6
	Bryconops caudomaculatus	O	0.0	0.0	0.0	0.0	2.0	2.3
	Galeocharax gulo	C	0.0	0.0	0.3	0.5	1.0	1.2
	Jupiaba sp.	O	0.0	0.0	0.0	0.0	0.3	0.5
	Moenkhausia chrysargyrea	O	0.3	0.5	0.0	0.0	1.3	1.0
	Myleus setiger	O	0.0	0.0	0.5	1.0	0.0	0.0
	Serrassalmus rhombeus	C	1.5	1.7	0.0	0.0	0.0	0.0
Cichlidae	*Cichlasoma sp.*	C	0.0	0.0	0.0	0.0	0.3	0.5
	Crenicichla gr. reticulata	C	0.8	1.0	0.0	0.0	1.3	1.9
	Retroculus lapidifer	C	0.0	0.0	0.0	0.0	1.3	1.9
	Satanoperca acuticeps	O	0.5	0.6	0.3	0.5	0.0	0.0
Curimatidae	*Cyphocharax spilurus*	D	4.5	7.0	0.0	0.0	8.4	8.8
Cynodontidae	*Rhaphiodon vulpinus*	C	0.8	0.5	0.0	0.0	0.0	0.0
Doradidae	*Oxydoras niger*	O	1.3	1.0	0.0	0.0	0.0	0.0
Erythrinidae	*Hoplias aimara*	C	0.3	0.5	0.0	0.0	0.0	0.0
	Hoplias malabaricus	C	1.3	2.5	0.0	0.0	3.1	1.4
Gymnotidae	*Gymnotus sp.*	C	0.0	0.0	0.0	0.0	0.5	0.6
Hemiodontidae	*Hemiodus unimaculatus*	O	1.8	2.2	0.0	0.0	2.3	3.9
	Hemiodus ternetzi	O	0.0	0.0	0.0	0.0	1.3	2.5
Loricariidae	*Ancistrus jataiensis*	D	0.0	0.0	0.0	0.0	1.0	2.0
	Harttia punctata	D	1.0	2.0	1.3	1.0	0.5	0.6
	Hypostomus cf. asperatus	D	0.3	0.5	7.3	7.5	13.8	5.7
	Hypostomus ericae	D	3.2	1.9	0.0	0.0	0.0	0.0
	Hypostomus aff. plecostomus	D	1.8	2.1	1.8	0.5	0.8	1.5
	Hypostomus sp.	D	2.0	2.4	1.0	1.4	2.5	1.7
	Hypostomus sp1	D	0.8	1.0	0.0	0.0	0.5	1.0
	Panaque cf. nigrolineatus	D	0.3	0.5	0.3	0.5	0.0	0.0
	Rineloricaria sp.	D	0.0	0.0	0.0	0.0	3.8	1.7
	Spatuloricaria sp.	D	0.0	0.0	0.3	0.5	0.0	0.0
	Squaliforma cf. emarginata	D	1.3	1.0	0.8	1.0	0.3	0.5
Pimelodidae	*Pimelodus ornatus*	C	0.0	0.0	0.3	0.5	0.0	0.0
	Pimelodus sp1	C	0.5	1.0	0.0	0.0	0.0	0.0
	Rhamdia quelen	C	0.0	0.0	0.0	0.0	0.3	0.5

Bird Community: A total of 85 bird species were observed (Table III). The bird species' richness varied among the environments: U1 presented 44 species, U2 37 species and BR 26 species. The majority was insectivorous (40 species), followed by frugivorous (14 species), and piscivorous (nine species).

Patterns of Diversity: The fish and bird communities presented strong structuring related to the type of environment (U1, U2, and BR), both when considering the density information and the presence/absence of species (Fig. 2, Table IV) showing high beta diversity (elevated difference between environments).

Despite seasonal differences (drought and rainfall in the tropical regions), generally influencing compositional changes of different biological communities, these results indicate that the seasonality was not important in the compositional structure of the community of fish and birds in this region (Table IV).

The differences in species composition among all environments were confirmed by the ANOSIM (Table V) for both types of information (individual density and presence/absence of species) and for fishes and birds communities.

Three species of birds, *Galbula ruficauda*, *Momotus momota* and *Monasa nigrifrons* were dominant in U1 environment. Among fishes, *Hypostomus ericae* was also typically in U1 environment and *Rineloricaria* sp., *Hoplias malabaricus* and *Hypostomus cf. asperatus* were characteristic of BR environment.

Table III. Mean density and standard deviation (SD) of bird species in the habitats (U1, U2 and BR) in all samplings. Feed behavior: D- detritivore; O – omnivore; C – carnivore; N– Nectarivore; F– Frugivorous; P– Piscivore, I– Insectivore, G– Grass feeder.

			U1		U2		BR	
Família	**Taxon**	**Food**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Accipitridae	*Buteogallus urubitinga*	C	0.0	0.0	0.0	0.0	0.3	0.5
	Elanus leucurus	C	0.0	0.0	0.3	0.5	0.0	0.0
	Ictinia plumbea	I	0.3	0.5	0.0	0.0	0.0	0.0
	Rupornis magnirostris	O	0.3	0.5	0.0	0.0	0.0	0.0
Alcedinidae	*Chloroceryle amazona*	P	0.3	0.5	0.3	0.5	0.0	0.0
	Chloroceryle americana	P	1.3	1.3	0.5	1.0	0.8	1.0
	Megaceryle torquata	P	0.3	0.5	2.0	2.8	0.0	0.0
Anatidae	*Amazonetta brasiliensis*	O	0.3	0.5	0.0	0.0	0.0	0.0
	Dendrocygna autumnalis	O	0.3	0.5	0.0	0.0	0.0	0.0
Anhingidae	*Anhinga anhinga*	P	0.3	0.5	0.0	0.0	0.0	0.0
Ardeidae	*Ardea alba*	P	0.0	0.0	0.5	0.6	0.0	0.0
	Ardea cocoi	P	0.0	0.0	0.3	0.5	0.0	0.0
	Egretta thula	I	0.0	0.0	1.5	3.0	0.0	0.0
	Syrigma sibilatrix	I	0.3	0.5	0.0	0.0	0.0	0.0
	Tigrisoma lineatum	P	0.3	0.5	0.0	0.0	0.0	0.0
Bucconidae	*Monasa nigrifrons*	I	7.0	5.1	1.0	2.0	1.3	1.5
Columbidae	*Columbina squammata*	F	0.0	0.0	2.0	4.0	0.0	0.0
	Columbina talpacoti	G	0.0	0.0	1.5	3.0	0.0	0.0
	Leptotila rufaxilla	F	0.0	0.0	0.5	1.0	0.0	0.0
	Patagioenas picazuro	G	0.0	0.0	1.5	3.0	1.0	2.0
Cuculidae	*Crotophaga ani*	I	0.0	0.0	1.0	2.0	0.0	0.0
	Guira guira	I	0.0	0.0	0.0	0.0	1.5	3.0
	Piaya cayana	I	0.0	0.0	0.8	0.5	0.0	0.0
Donacobiidae	*Donacobius atricapilla*	I	0.0	0.0	0.0	0.0	1.0	2.0

Table III. Continuation.

Família	Taxon	Food	U1		U2		BR	
			Mean	SD	Mean	SD	Mean	SD
Falconidae	*Caracara plancus*	O	1.0	2.0	0.0	0.0	0.0	0.0
	Falco sparverius	C	0.0	0.0	0.0	0.0	0.3	0.5
Fringillidae	*Euphonia chlorotica*	I	0.0	0.0	0.0	0.0	0.5	0.6
Furnariidae	*Furnarius rufus*	I	0.0	0.0	0.0	0.0	1.5	1.9
	Synallaxis albescens	I	0.3	0.5	0.0	0.0	0.0	0.0
Galbulidae	*Galbula ruficauda*	I	3.3	1.3	0.0	0.0	0.0	0.0
Hirundinidae	*Atticora tibialis*	I	1.5	3.0	0.0	0.0	0.0	0.0
	Progne tapera	I	1.0	2.0	0.0	0.0	0.0	0.0
	Riparia riparia	I	8.3	8.9	0.0	0.0	1.0	2.0
	Stelgidopteryx ruficollis	I	2.0	4.0	0.0	0.0	0.0	0.0
	Tachycineta albiventer	I	9.0	14.3	0.0	0.0	0.0	0.0
Icteridae	*Cacicus cela*	I	2.0	4.0	3.5	4.1	0.0	0.0
	Cacicus haemorrhous	I	0.0	0.0	0.5	1.0	0.0	0.0
	Gnorimopsar chopi	O	0.0	0.0	0.0	0.0	3.0	3.8
	Icterus cayanensis	F	0.0	0.0	0.5	1.0	0.0	0.0
Jacanidae	*Jacana jacana*	I	0.0	0.0	1.0	2.0	0.0	0.0
Momotidae	*Momotus momota*	I	4.0	0.0	0.0	0.0	0.0	0.0
Parulidae	*Basileuterus culicivorus*	I	0.0	0.0	1.0	2.0	0.0	0.0
	Basileuterus flaveolus	I	0.0	0.0	0.5	1.0	0.0	0.0
	Geothlypis aequinoctialis	F	0.0	0.0	0.0	0.0	0.3	0.5
Phalacrocoracidae	*Phalacrocorax brasilianus*	P	1.0	1.2	1.0	1.2	0.0	0.0
Picidae	*Dryocopus lineatus*	I	0.5	0.6	0.0	0.0	0.5	0.6
	Melanerpes candidus	I	0.0	0.0	0.0	0.0	0.5	1.0
Podicipedidae	*Tachybaptus dominicus*	P	0.3	0.5	0.0	0.0	0.0	0.0
Psittacidae	*Amazona aestiva*	F	0.5	1.0	0.0	0.0	0.0	0.0
	Aratinga aurea	G	1.0	2.0	0.5	1.0	0.0	0.0
	Brotogeris chiriri	F	1.0	2.0	3.0	6.0	0.5	1.0
	Diopsittaca nobilis	G	0.0	0.0	0.5	1.0	0.0	0.0
Rallidae	*Aramides cajanea*	O	0.0	0.0	0.3	0.5	0.0	0.0
	Aramides saracura	O	0.0	0.0	0.0	0.0	0.3	0.5
Thamnophilidae	*Dysithamnus mentalis*	I	0.0	0.0	0.0	0.0	0.3	0.5
	Thamnophilus doliatus	I	2.5	2.9	0.0	0.0	1.0	1.2
Thraupidae	*Dacnis cayana*	F	1.5	1.9	0.0	0.0	0.0	0.0
	Nemosia pileata	F	0.0	0.0	0.0	0.0	0.5	1.0
	Tangara cayana	F	0.5	1.0	0.0	0.0	0.0	0.0
	Thraupis palmarum	F	0.3	0.5	0.0	0.0	0.0	0.0
Threskiornithidae	*Mesembrinibis cayennensis*	O	0.0	0.0	0.0	0.0	0.3	0.5
	Phimosus infuscatus	O	0.3	0.5	0.8	1.0	0.0	0.0
	Theristicus caudatus	O	2.0	2.3	1.0	2.0	0.0	0.0
Tinamidae	*Crypturellus parvirostris*	G	0.3	0.5	0.0	0.0	0.0	0.0
	Nothura maculosa	I	0.3	0.5	0.0	0.0	0.0	0.0

Table III. Continuation.

Família	Taxon	Food	U1		U2		BR	
			Mean	SD	Mean	SD	Mean	SD
Trochilidae	*Amazilia versicolor*	N	0.0	0.0	0.3	0.5	0.0	0.0
	Eupetomena macroura	N	0.0	0.0	0.0	0.0	0.3	0.5
	Phaethornis pretrei	N	0.8	0.5	0.0	0.0	0.0	0.0
	Thalurania furcata	N	0.3	0.5	0.0	0.0	0.0	0.0
	Thalurania glaucopis	N	0.0	0.0	0.0	0.0	0.3	0.5
Turdidae	*Turdus leucomelas*	F	0.5	1.0	0.0	0.0	0.0	0.0
	Turdus rufiventris	F	0.3	0.5	0.0	0.0	0.5	1.0
Tyrannidae	*Casiornis rufus*	I	0.5	0.6	0.0	0.0	0.0	0.0
	Elaenia flavogaster	I	0.0	0.0	0.0	0.0	0.3	0.5
	Gubernetes yetapa	I	0.0	0.0	0.3	0.5	0.0	0.0
	Legatus leucophaius	I	0.5	1.0	0.0	0.0	0.0	0.0
	Megarynchus pitangua	I	0.0	0.0	0.3	0.5	0.0	0.0
	Myiodynastes maculatus	I	0.0	0.0	0.3	0.5	0.0	0.0
	Myiozetetes cayanensis	I	5.8	6.7	6.6	4.5	0.5	1.0
	Pitangus sulphuratus	I	2.8	2.5	0.5	1.0	3.0	3.3
	Pyrocephalus rubinus	I	0.0	0.0	0.3	0.5	0.0	0.0
	Suiriri suiriri	I	1.0	2.0	0.0	0.0	0.0	0.0
	Tyrannus melancholicus	I	0.0	0.0	0.3	0.5	0.0	0.0
	Tyrannus savana	I	0.0	0.0	0.5	0.6	0.0	0.0
Vireonidae	*Cyclarhis gujanensis*	I	0.0	0.0	0.3	0.5	0.0	0.0

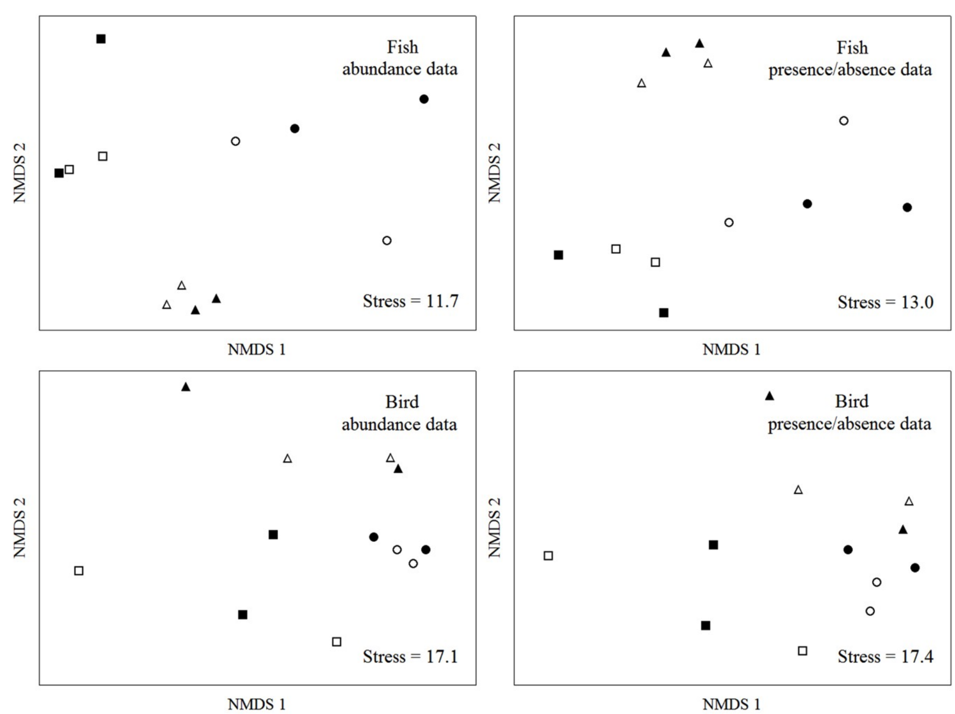

Figure 2. NMDS ordination scores for abundance and presence/absence of fishes and birds assemblages in Uru River (Cerrado, Brazil). Habitats: Circles = U1; Squares = U2; Triangles = BR. Seasons: White symbols = Dry seasons; Black symbols = Wet seasons.

Table IV. PERMANOVA (Permutational Multivariate Analysis of Variance, F value) for Fish and Bird assemblages. d.f. = degrees of freedom; P = significance based on 10,000 randomizations

Biological assemblages and factors	d.f.	Abundance		Presence/ Absence	
		F	P	F	P
FISH					
(1) Environments	2	**3.70**	0.001	**2.90**	0.001
(2) Season (Wet and Dry)	1	0.41	0.905	0.53	0.931
Interaction (1) × (2)	2	0.60	0.859	0.56	0.965
BIRD					
(1) Environments	2	**1.75**	0.004	**1.50**	0.001
(2) Season (Wet and Dry)	1	0.67	0.897	0.79	0.896
Interaction (1) × (2)	2	0.49	1.000	0.76	0.979

Table V. ANOSIM (Analysis of Similarities, R value) for Fish and Bird assemblages. *P* = significance based on 1,000 randomizations.

Environments	Fishes		Birds	
	R	*P*	*R*	*P*
Abundance				
U1 x U2	**0.71**	0.028	**0.39**	0.028
U1 x BR	**0.68**	0.038	**0.53**	0.025
U2 x BR	**0.66**	0.020	**0.46**	0.025
Presence/Absence				
U1 x U2	**0.78**	0.026	**0.54**	0.029
U1 x BR	**0.79**	0.028	**0.48**	0.030
U2 x BR	**0.94**	0.031	**0.51**	0.030

Discussion

Even though our sampling represented four seasonal samples (two in the dry and two rainy seasons) in three environments relatively close to each other, our results revealed that environmental influences were more influential to bird and fish communities than the temporal seasonality in the gallery forest at Uru River. This result underlines the importance of spatial variability, even in environments connected and close to each other and in spite of the seasonal availability of water and consequently food in Cerrado biome, which is characterized by markedly seasonal variability.

Furthermore higher integrity in the environments did not imply in higher species richness. However, the heterogeneity of environments resulted in species composition distinct by environment, increasing the total richness of birds and fishes communities. Consequently, species richness in this study was higher when compared to other studies in Cerrado (*e.g*. Aloisio *et al.* 2005, Laranjeiras *et al.* 2012).

Frequently the connection between communities is evaluated by performing analyses of concordance (Dolph *et al.* 2011) and/or coherence (Thomaz *et al.* 2007). However our sampling size and number of replicates hampered such an evaluation. Nevertheless fish and birds communities of Uru River showed the same pattern influenced by small spatial scale (different environments), and this investigation should have turned into a redundant analysis.

The remaining fragments in the landscape are distinct environments in terms of area, degree of anthropic activity, quality and, in the case of aquatic environments, sediment type, width, depth, and even water speed. These spatial differences significantly influenced and differentiated the composition and abundance of species of fish and birds in the three studied environments.

It is worth to consider that the fragmentation of the Cerrado biome occurs especially as the result of agricultural activities modifying the landscape reaching water bodies and the gallery forest. This causes the Cerrado to be one of the most threatened biomes on the planet with many of its species becoming nationally or globally endangered (Klink & Machado 2005).

The BR environment, for example, it is the most preserved because it is the least exposed to anthropic activity. The BR presented three fish species: *H. malabaricus*, generalist predator (Nunes 2009); *H. cf. asperatus*, the most abundant detritivorous that takes advantage of allochthonous material, and *Rineloricaria sp*., also detritivorous with preference for bottom environments with rocks, logs, and sand (Ghazzi 2008). The fish species *H. ericae*, scrapper detritivorous, is more typically of the U1 environment taking advantage of its slower speed current that allows greater deposition of allochthonous material in this deeper environment.

The U1 environment with high richness of birds had as typically species: *G. ruficauda, M. Momota,* and *M. nigrifrons*, which are insectivorous, resistant to anthropic impact, and widely distributed in South America. These three species prefer to nest in ravines, which were only observed in U1; the first two species excavate their own nest and the latest takes advantage of holes excavated by other species (Sick 1997).

The U2 environment is less preserved than BR and more impacted than U1 and no representative species was identified in this environment, which is probably related to its intermediate environmental characteristics that favor species occurring in other environments as well.

Environments with their unique characteristics were fundamental in the composition and density of these assemblages. Therefore, even being environments with small distances in between, in which similar species compositions would be expected (Dormann *et al.* 2007), physical differences of the gallery forest, and conservation status, cause the compositions of these assemblages to be specific for each environment. Thus, small patches should not be underestimated when considering species conservation in the Cerrado biome because fragmented landscapes might stand out as promising sites for the investment of resources in management and conservation funds.

Conclusion

The Cerrado is characterized by two different seasonal periods (wet and dry), which do not seem to alter the structure of communities of fish and birds in the Uru River region. These communities are influenced, in terms of composition and abundance, by differences between the environments, even if they are close and intertwined with each other. Moreover, each environment is unique and relevant to the conservation of the pool of species.

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ANNEX I from: Local spatial factors influences birds and fishes communities in the Cerrado biome

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SILURIFORMES. Loricariidae: *Ancistrus jataiensis* (Müller, Silva e Bertaco, 2005) – NUP 9261; *Harttia punctata* (Rapp Py-Daniel e Oliveira, 2001) – NUP 9263, NUP 9270; *Hypostomus cf. asperatus* (Castelnau, 1855) – NUP 9253, NUP 9258; *Hypostomus ericae* (Carvalho e Weber, 2004) – CILPEEC 1268; *Hypostomus aff. plecostomus* (Linnaeus, 1758) – NUP 9255; *Hypostomus* sp. – NUP 9254, NUP 9259; *Hypostomus* sp.1 – NUP 9271; *Panaque cf. nigrolineatus* (Peters, 1877) – NUP 9256; *Rineloricaria* sp. – NUP 9260; *Spatuloricaria* sp. – NUP 9269; *Squaliforma cf. emarginata* (Valenciennes, 1840) – NUP 9257. Doradidae: *Oxydoras niger* (Valenciennes, 1821) – CILPEEC 1257. Auchenipteridae: *Auchenipterus nuchalis* (Spix e Agassiz, 1829) – NUP 9265. Pimelodidae: *Pimelodus ornatus* (Kner, 1858) – NUP 9247; *Pimelodus* sp.1 – NUP 9250; *Rhamdia quelen* (Quoy e Gaimard, 1824) – NUP 9239. CHARACIFORMES. Acestrorhynchidae: *Acestrorhynchus falcatus* (Bloch, 1794) – NUP 9242. Anostomidae: *Leporelus vittatus* (Valenciennes, 1850) – NUP 9244; *Leporinus friderici* (Bloch, 1794) – NUP 9237; *Leporinus pachycheilus* (Britski, 1976) – NUP 9268; *Leporinus taeniatus* (Lütken, 1875) – NUP 9243; *Leporinus* sp. – NUP 9251. Characidae: *Astinax abramis* (Jenyns, 1842) – NUP 9272; *Astinax elachylepis* (Bertaco e Lucinda, 2005) – NUP 9280 *Acestrocephalus maculosus* (Menezes, 2006) – NUP 9274; *Bryconops caudomaculatus* (Günther, 1864) – NUP 9252; *Galeocharax gulo* (Cope, 1870) – NUP 9275; *Jupiaba* sp. – NUP 9278; *Moenkhausia chrysargyrea* (Günther, 1864) – NUP 9273; *Myleus setiger* (Müller e Troschel, 1844) – NUP 9266; *Serrasalmus rhombeus* (Linnaeus,

1766) – NUP 9267. Curimatidae: *Cyphocharax spilurus* (Günther, 1864) – NUP 9277. Cynodontidae: *Rhaphiodon vulpinus* (Spix e Agassiz, 1829) – NUP 9248. Erythrinidae: *Hoplias aimara* (Valenciennes, 1847) – NUP 9264; *Hoplias malabaricus* (Bloch, 1794) – NUP 9249. Hemiodontidae: *Hemiodus unimaculatus* (Bloch, 1794) – NUP 9241; *Hemiodus ternetzi* (Myers, 1927) – NUP 9240. GYMNOTIFORMES. Gymnotidae: *Gymnotus* sp. – NUP 9276. PERCIFORMES. Cichlidae: *Cichlasoma* sp. – NUP 9281. *Crenicichla gr. reticulata* (Heckel, 1840) – NUP 9279; *Retroculus lapidifer* (Castelnau, 1855) – NUP 9245; *Satanoperca acuticeps* (Heckel, 1840) – NUP 9246.