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A CONTRIBUTION TO THE ECOGEOGRAPHY OF THE BRASILIAN CERRADOS

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ABSTRACT

A survey was made aimed at evaluating the relative importance of gallery forest (on the river levees), backswamp and interfluvial cerrados to the general zoogeography of the domain, especially with regard to conservation problems. The sampling scheme comprised T-shaped arrays of pit-fall traps, the cross-member along the levee (in the gallery forest) and the stem extending across the backswamp. This scheme was used at two localities, on the left bank of the Rio Tocantins across the town of Ipueiras and on the right bank of a tributary, the Rio Manoel Alves Pequeno (or da Natividade), near its mouth. As a control, a grid of traps was set in the interfluvial cerrado between the Tocantins and the Manoel Alves. During a period of 6-8 days 136 frogs (8 species), 55 lizards (7 species) and one snake were collected. Among the lizards, *Tropidurus torquatus* showed preference for the backswamp, while *T. oreadicus* preferred the levee; *Gymnodactylus amarali* clearly preferred interfluvial cerrado. Among the frogs, *Physalaemus cuvieri*, the most abundant species, showed preference for the proximity of the river, *Chiasmocleis centralis* for the backswamp. The gallery forest was not found in this area to harbor a characteristic set of species. The animals sampled in this survey should not suffer from the interruption by flooding of gallery forest, either as residential areas or as faunal corridors. It remains to be seen whether the shores of hydroelectric lakes are ecologically analogous to river backswamps.

INTRODUCTION

The core area of the morphoclimatic domain of the cerrados (Ab'Saber, 1977; Pinto, 1990) is a continuous area of some 1.8 million square kilometers, of highlands of moderate altitude (300 - 900 m), with gentle, rolling topography, with a characteristically hierarchical drainage, covered by a type of vegetation traditionally called "cerrado" in Brasil, to which has frequently been applied , erroneously, I think, the name of "savanna". There is in fact a certain physiognomical resemblance, but the differences are major. Specifically, contrary to, e.g., African savannas, cerrados have no water-saving adaptations, morphological (wax, thorns) or physiological (deciduousness, restriction of transpiration by closure of stomata). The climate (Graphs 1 and 2) is characterized by two contrasting seasons (BRASIL, 1941). Winter temperatures are cool, but equable. The monthly averages vary between 23.2° and 26.6 ° C in summer and between 21.9° and 27.1° in winter. The contrary happens to precipitation. Of a total of 1600 - 1800 mm/year, the 7 summer months contribute from 89 to 97 %, the 5 winter months 3 to 11 %. The very deep (up to 30 meters) soils store enough water to see to the demands of the

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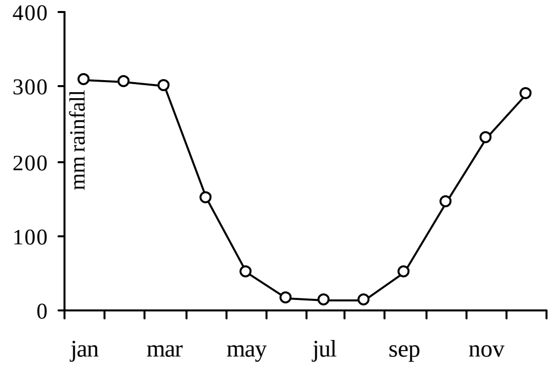

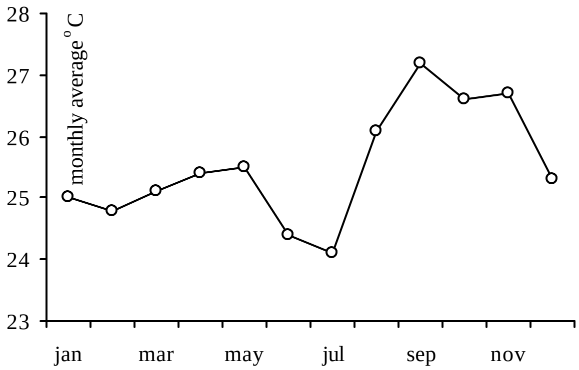

Graphs 1 and 2. Monthly rainfall and average temperature at Porto Nacional, Tocantins (data from BRASIL, 1941).

vegetation, which does not need, as said, water-saving adaptations.

A characteristic feature of the cerrados is the presence of gallery, or ciliary, forests. The competence of rivers, their capacity of carrying materials in suspension, is a function of their velocity (Goudie, 1988). During flood, as the river overflows the banks, the current, by friction, loses speed and thus competence, and the heavier sediments are dropped. In this way is gradually built a longitudinal ridge, a *levee*, of coarse, sandy, well-aerated sediments, backed by a wider or narrower low, seasonally flooded area, the *backswamp* (in Brasil, *varjão*) where the finer silt is deposited, originating compact, poorly aerated soils. The gallery forests start at headwaters along creeks as rows of tall columnar burití palms (*Mauritia*), who like to keep their feet wet, but as soon as a levee appears, the proper gallery forest is established (Rodrigues & Leitão-Filho, 2000). The term "gallery forest" is sometimes loosely applied to any forest in a riparian position, but the proper sense of the term is strictly the forest on the levees of cerrado rivers.

The large Central Brasilian rivers run to the Amazon, and so the gallery forests of the fluvial system form a dendritic pattern converging towards the north. It is easy to understand that, if there is a fauna adapted and limited to ciliary forests (Alho, 1990; Hanski, 1999), the latter will function not only as areas of residence, but also, and very importantly, as faunal corridors, whose interruption may have drastic consequences to the fauna. The same reasoning can be applied to the backswamps. These two formations are unavoidable victims of dam building; it is thus essential that they be considered in any impact assessment. This is the problem I addressed in this work.

Design

In order to test the faunal roles of gallery forest and backswamp, as well as, additionally, the importance of microhabitats and of the interactions between habitats, three areas were sampled: Area A (Fig. 1), on the left bank of the Rio Tocantins, directly across the city of Ipueiras , at approximately 11° 14' S, 48° 28'W. There was good, tall (15 m), dense gallery forest, backed by an extensive backswamp, grading rapidly into poor, battered cerrado.

Area B (Fig. 2), on the right bank of the Rio Manoel Alves Pequeno (or "da Natividade"), a tributary of the Tocantins on its right bank, close to the mouth, some 9 km SSE of Area A, at ca. 1119, 4827. The levee was high, but the ridge narrow and the forest sparse, rapidly passing into rather well-preserved cerrado.

Area C (Fig. 2), control, in a well-preserved patch of interfluvial cerrado between the rivers Tocantins and Manoel Alves. at ca. 1117, 4827, with three strata of vegetation, grass, shrubs and scattered trees.

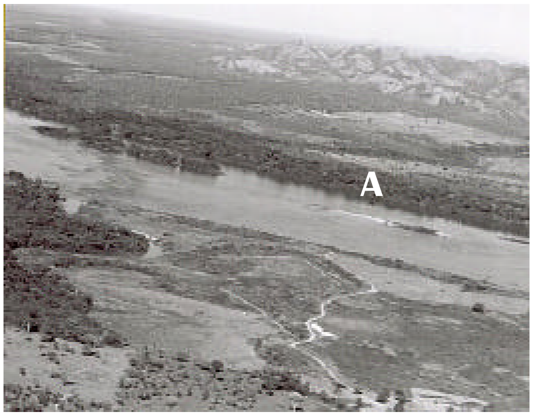

Figure 1. Rio Tocantins, sampling area A.

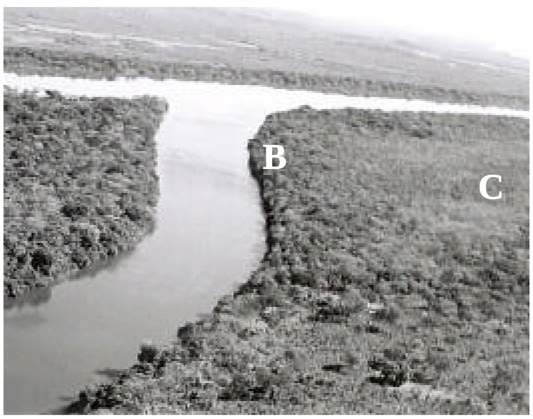

Figure 2. Confluence of Rios Manoel Alves and Tocantins, sampling areas B and C.

We used pitfall traps, consisting of 20 liter buckets, diameter at the mouth 30 cm, buried flush with the ground, 4 meters apart, connected by 40 cm tall drift fences of black plastic sheet.

In Area A we placed 25 buckets inside the gallery forest, parallel to the river, and 45 buckets on a perpendicular row crossing the backswamp. They stayed in place for 8 days (April 23 - 30). In Area B we used a similar design, with 25 buckets on the levee and 43 inland. They stayed in place for 7 days (April 24 - 30). In Area C we arranged a grid of 5 x 8 buckets, which stayed in place for 6 days (April 25 - 30).

The traps were visited twice daily, in the morning and in the afternoon. The Appendix lists the materials collected, bucket by bucket and day by day.

Statistics

I used throughout the χ^2 test, which is non-parametric and allows to locate the excesses and deficiencies of frequencies. The notations are:

gl degrees of freedom
ns not significant at the 5% level
* significant at the 5% level
** significant at the 1% level
*** significant at the 0.1% level

Species present

Anura

Leptodactytlidae
Adenomera martinezi (Bokermann, 1956)
Barycholos ternetzi (Miranda-Ribeiro, 1937)
Leptodactylus mystaceus (Spix, 1824)
Leptodactylus podicipinus (Cope, 1862)
Physalaemus cuvieri Fitzinger, 1826
Pseudopaludicola mystacalis (Cope, 1887)

Microhylidae
Chiasmocleis centralis Bokermann, 1952
Elachistocleis ovalis (Schneider, 1799)

Sauria

Gekkonidae
Gymnodactylus amarali Barbour, 1925

Gymnophthalmidae
Colobosaura modesta (Reinhardt & Luetken, 1862)
Micrablepharus maximiliani (Reinhardt & Luetken, 1862)

Polychridae

Anolis chrysolepis brasiliensis Vanzolini & Williams, 1970

Tropiduridae
Tropidurus oreadicus Rodrigues, 1987
Tropidurus torquatus (Wied, 1820)

Amphisbaenia

Amphisbaenidae
Bronia sp in description by Carolina Castro-Mello, 2003

Serpentes

Colubridae
Apostolepis cf. *cearensis* Gomes, 1915

Analysis

Homogeneity of the areas (Table 1)

The three areas sampled, two of them riparian, differing in topography and vegetation, and one inland, differ significantly in the proportion of frogs and lizards (the only species of snake collected was not included in the analysis). As could be expected, the cerrado (Area C) is poorer in amphibians, both in number of species and of individuals (χ^2= 42.930 ***, gl 2). Otherwise they do not differ significantly in the composition of the frog fauna (χ^2= 11.945 ns, gl 14) , but differ regarding the lizards (χ^2= 54.734 ***, gl 14). The difference resides mainly in the preference of *Tropidurus torquatus* for the backswamp and of *Gymnodactylus amarali* for the cerrado.

Table 1 . Herpetofauna of the study areas.

	Area			Sum
	A	B	C	
Anura				
Adenomera martinezi	5	-	-	5
Barycholos ternetzi	14	6	-	20
Leptodactyulus mystaceus	1	-	-	1
Leptodactylus podicipinus	5	4	-	9
Physalaemus cuvieri	48	22	2	72
Pseudopaludicola mystacalis	14	2	-	16
Chiasmocleis centralis	10	-	-	10
Elachistocleis ovalis	2	1	-	3
Sum	99	35	2	136
Sauria				
Gymnodactylus amarali	1	-	4	5
Anolis chrysolepis brasiliensis	1	1	-	2
Tropidurus oreadicus	-	9	3	12
Tropidurus torquatus	14	1	-	15
Micrablepharus maximiliani	-	4	-	4
Ameiva ameiva	11	4	1	16
Cnemidophorus cf. *ocellifer*	-	-	1	1
Sum	27	19	9	55

The gallery forest and the backswamp (Tables 2 and 3)

Areas A and B permit an investigation of the faunistic personality of the segments of the landscape. To do so, we assembled the buckets according to their distance from the top of the levee. In Area A we established 3 groups: buckets 1-25, inside the gallery forest, buckets 26 - 50 in the next 100 meters inland; and buckets 51 - 70 in the backswamp. In Area B we contrasted the forest (buckets 1 - 25) with the adjoining cerrado (buckets 26 - 68). Frogs and lizards were analyzed separately.

Table 2. Distance from the levee, area A.

	Buckets			Sum
	1-25	26-50	51-70	
Anura				
Adenomera martinezi	-	-	5	5
Barycholos ternetzi	5	5	4	14
Leptodactylus mystaceus	-	-	1	1
Leptodactylus podicipinus	-	2	3	5
Physalaemus cuvieri	22	8	17	47
Pseudopaludicola mystacalis	3	2	10	15
Chiasmocleis centralis	-	8	2	10
Elachistocleis ovalis	1	1	-	2
Sum	31	26	42	99
Sauria				
Gymnodactylus amarali	-	-	1	1
Anolis chrysolepis brasiliensis	-	-	1	1
Tropidurus torquatus	4	2	7	13
Ameiva ameiva	8	-	3	11
Sum	12	2	13	27

The distribution of frogs in Area A is heterogeneous (χ^2= 37.652 ***, gl 14): *Physalaemus cuvieri*, although occurring all over, prefers the proximity of the river; *Chiasmocleis centralis* favors the backswamp. The lizards of Area A showed no preferences (χ^2= 6.948 ns, gl 4).

In Area B the data, ackowledgedly scarce, showed no heterogeneity.

Comments

This study was undertaken at a not particularly favorable time of the year, past the reproductive season of the frogs and well into the dry season; not many specimens were collected,

Table 3. Area B, distance from the levee.

	Buckets		Sum
	1-25	26-68	
Anura			
Barycholos ternetzi	4	2	6
Leptodactylus podicipinus	2	2	4
Physalaemus cuvieri	6	16	22
Pseudopaludicola mystacalis	-	2	2
Elachistocleis ovalis	-	1	1
Sum	12	23	35
Sauria			
Anolis chrysolepis brasiliensis	-	1	1
Tropidurus oreadicus	6	3	9
Tropidurus torquatus	-	1	1
Ameiva ameiva	4	-	4
Sum	10	5	15

notably only one snake. The design, however, permits some conclusions.

As to the major aims of the study, the gallery forest was not found, for the fauna sampled, to harbor a characteristic ensemble. I think this conclusion, at present valid for the time of the year and for the intensity of the sampling effort, will stand with regard to the terricolous element of the fauna: this will suffer no harm from the damming of rivers. On the contrary, even these limited data ascribe to the backswamp an important faunistic role, with corresponding conservation implications. I think it is indispensable to undertake a study similar to the present one on the shores of stabilized reservoirs, to verify whether these shores are the analogues of riverine backswamps.

Besides these conservationist considerations, there are some interesting ecological facts. The diversity in microhabitat preferences among widespread cerrado animals seems very promising. I am thinking especially of the differences between *Tropidurus torquatus* and *T. oreadicus*, two of the commonest cerrado lizards. The decided preference of *Gymnodactylus amarali* for interfluvial cerrado is also noteworthy, as are the fine-grained discrepancies among frog species.

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Appendix. Raw data.

Bucket	Day/hr *	Species	Bucket	Day/hr *	Species
A1	24 M	*Physalaemus cuvieri*	A 20	23 M	*Ameiva ameiva*
A 2	23 T	*Tropidurus torquatus*		25 T	*Tropidurus torquatus*
	24 M	*Physalaemus cuvieri*		26 T	*Ameiva ameiva*
		Barycholos ternetzi	A 21	23 T	*Ameiva ameiva*
A 3	24 M	*Barycholos ternetzii*		24 M	*Physalaemus cuvieri*
	24 T	*Physalaemus cuvieri*		25 M	*Barycholos ternetzii*
	25 M	*Apostolepis* cf. *cearensis*	A 22	23 T	*Ameiva ameiva*
A 4	25 M	*Physalaemus. cuvieri*		24 T	*Ameiva ameiva*
A 5	25 M	*Barycholos savagei*		25 M	*Physalaemus cuvieri*
		Physalaemus cuvieri			*Pseudopaludicola mystacalis*
A 6	24 M	*Physalaemus cuvieri*		28 T	*Ameiva ameiva*
A 7	23 T	*Tropidurus torquatus*	A 23	23 M	*Ameiva ameiva* 2
	25 M	*Physalaemus cuvieri*		25 M	*Physalaemus cuvieri*
		Pseudopaludicola mystacalis			*Barycholos ternetzii*
A 8	24 M	*Physalaemus cuvieri* 3			*Pseudopaludicola mystacalis*
	25 M	*Physalaemus cuvieri*	A 25	24 M	*Physalaemus cuvieri*
A 9	25 M	*Physalaemus cuvieri*	A 26	24 M	*Barycholos ternetzi*
A 10	24 M	*Physalaemus cuvieri*	A 28	24 M	*Physalaemus cuvieri*
A 11	25 M	*Elachistocleis ovalis*	A 29	24 T	*Tropidurus torquatus*
A 12	24 M	*Physalaemus cuvieri*	A 30	24 M	*Chiasmocleis centralis*
	25 M	*Physalaemus cuvieri*		25 M	*Leptodactylus podicipinus*
A 15	24 M	*Physalaemus cuvieri*	A 33	23 M	*Barycholos ternetzii*
	28 T	*Tropidurus torquatus*		24 M	*Pseudopaludicola mystacalis*
A 16	24 M	*Physalaemus cuvieri*	A 35	25 M	*Barycholos ternetzi*
A 18	25 M	*Physalaemus cuvieri*	A 36	25 T	*Tropidurus torquatus*
				29 M	*Leptodactylus podicipinus*
A 38	24 M	*Chiasmocleis centralis* 2	A 56	25 M	*Pseudopaludicola mystacalis*
A 39	24 M	*Chiasmocleis centralis*	A 57	24 M	*Adenomera martinezi*
	25 M	*Physalaemus cuvieri*			*Pseudopaludicola mystacalis*
A 40	24 M	*Chiasmocleis centralis*		25 M	*Physalaemus cuvieri* 2
	25 M	*Barycholos ternetzi*	A 58	26 T	*Anolis chrysolepis brasiliensis*
		Pseudopaludicola mystacalis		28 M	*Colobosaura modesta*
		Physalaemus cuvieri	A 59	24 M	*Ameiva ameiva*

Continued

Bucket	Day/hr *	Species	Bucket	Day/hr *	Species
A 43	24 M	*Physalaemus cuvieri* 2		25 M	*Chiasmocleis centralis*
		Barycholos ternetzi		26 M	*Leptodactylus podicipinus*
	25 M	*Physalaemus cuvieri*	A 60	23 T	*Tropidurus torquatus*
A 44	24 M	*Elachistocleis ovalis*		24 M	*Physalaemus cuvieri*
		Chiasmocleis centralis		27 M	*Leptodactylus podicipinus*
A 45	24 M	*Chiasmocleis centralis*	A 61	24 M	*Physalaemus cuvieri*
A 47	24 M	*Chiasmocleis centralis*		24 T	*Physalaemus cuvieri*
A 50	24 M	*Physalaemus cuvieri*			*Ameiva ameiva*
	25 M	*Physalaemus cuvieri*		25 M	*Physalaemus cuvieri* 2
A 51	27 M	*Leptodactylus mystaceus*		27 M	*Pseudopaludicola mystacalis*
A 55	24 M	*Physalaemus cuvieri*	A 62	24 M	*Adenomera martinezi*
	25 M	*Physalaemus cuvieri* 2		25 M	*Adenomera martinezi*
		Adenomera martinezi			*Barycholos ternetzei*
	26 T	*Tropidurus torquatus*	A 63	24 M	*Physalaemus cuvieri*
A 56	24 M	*Physalaemus cuvieri*		24 T	*Tropidurus torquatus*
	25 M	*Physalaemus cuvieri* 2	A 64	24 T	*Tropidurus torquatus*
A 64	25 M	*Physalaemus cuvieri*	B 5	25 M	*Physalaemus cuvieri*
		Barycholos ternetzi		25 T	*Ameiva ameiva*
		Tropidurus torquatus	B 6	25 M	*Physalaemus cuvieri*
A 65	24 M	*Physalaemus cuvieri*			*Barycholos ternetzi*
	27 M	*Pseudopaludicola mystacalis* 2	B 7	25 M	*Physalaemus cuvieri*
	29 M	*Gymnodactylus amarali*			*Barycholos ternetzi*
A 66	23 T	*Tropidurus torquatus*	B 8	26 M	*Physalaemus cuvieri*
	25 M	*Barycholos ternetzi*	B 10	25 M	*Tropidurus oreadicus*
	26 M	*Leptodactylus podicipinus*	B 13	26 T	*Ameiva ameiva*
	27 M	*Adenomera martinezi*	B 14	26 T	*Tropidurus oreadicus*
		Pseudopaludicola mystacalis 2	B 15	26 M	*Barycholos ternetzi*
A 67	25 M	*Physalaemus cuvieri*	B 21	27 M	*Leptodactylus podicipinus*
		Pseudopaludicola mystacalis		30 M	*Tropidurus oreadicus*
A 68	24 T	*Tropidurus torquatus*	B 22	25 T	*Tropidurus oreadicus*
	25 M	*Barycholos ternetzi*	B 23	27 M	*Micrablepharus maximiliani* 2
	25 T	*Ameiva ameiva*	B 24	30 M	*Ameiva ameiva*

Continued

Bucket	Day/hr *	Species	Bucket	Day/hr *	Species
A 69	24 T	*Physalaemus cuvieri*	B 25	26 M	*Barycholos ternetzi*
	26 T	*Tropidurus torquatus*		26 T	*Tropidurus oreadicus*
A 70	24 M	*Chiasmocleis centralis*	B 34	25 M	*Physalaemus cuvieri*
		Pseudopaludicola mystacalis	B 36	26 T	*Micrablepharus maximiliani*
			B 37	27 M	*Elachistocleis ovalis*
B 1	25 T	*Tropidurus oreadicus*		28 T	*Tropidurus oreadicus*
B 2	25 M	*Physalaemus cuvieri* 2	B 40	25 M	*Pseudopaludicola mystacalis*
B 3	27 M	*Leptodactylus podicipinus*	B 43	25 M	*Barycholos ternetzi*
B 4	25 T	*Ameiva ameiva*	B 44	25 M	*Physalaemus cuvieri*
B 48	25 M	*Physalemus cuvieri*	B 66	25 T	*Physalemus cuvieri*
	25 T	*Pseudopaludicola sp.*		26 M	*Physalemus cuvieri*
B 50	25 M	*Barycholos ternetzi*	B 67	26 M	*Physalemus cuvieri*
	27 M	*Leptodactylus podicipinus*		28 T	*Tropidurus oreadicus*
B 52	26 T	*Tropidurus oreadicus*			*Micranblepharus maximiliani*
B 54	25 M	*Physalemus cuvieri*			
B 55	25 M	*Physalemus cuvieri*	C 12	26 T	*Tropidurus oreadicus*
B 56	26 T	*Physalemus cuvieri*	C 19	26 M	*Physalemus cuvieri*
B 57	25 M	*Physalemus cuvieri*	C 20	26 M	*Gymnodactylus amarali* 2
B 58	25 M	*Physalemus cuvieri* 2	C 21	26 M	*Ameiva ameiva*
	26 M	*Physalemus cuvieri*	C 23	26 M	*Physalemus cuvieri*
B 59	26 M	*Physalemus cuvieri* 2		27 M	*Tropidurus oreadicus*
B 62	28 T	*Anolis chrysolepis brasiliensis*	C 25	29 M	*Tropidurus oreadicus*
B 63	26 M	*Physalemus cuvieri*	C 27	26 M	*Gymnodactylus amarali*
		Leptodactylus podicipinus	C 31	30 M	*Cnemidophorus* cf. *ocellifer*
B 64	30 M	*Tropidurus torquatus*	C 36	29 M	*Gymnodactylus amarali*

* - Days of April, 2002. M, morning; T, afternoon.