

Species richness, relative abundance, and habitat of reproduction of terrestrial frogs in the Triângulo Mineiro region, Cerrado biome, southeastern Brazil

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ABSTRACT. Based on field observations and pitfall sampling, we determined the species richness, relative abundance, and reproductive habitat of terrestrial frogs in three municipalities in the Triângulo Mineiro region, south Cerrado biome, in southeastern Brazil. We found thirty-two species of terrestrial frogs, belonging to the families Brachycephalidae, Bufonidae, Cycloramphidae, Dendrobatidae, Leiuperidae, Leptodactylidae and Microhylidae. Most of the species were found in open areas and reproduced in human-generated environments, such as artificial lakes (10 species) and ponds (14 species). Dominance was high, with *Physalaemus cuvieri* Fitzinger, 1826 (Leiuperidae) representing 48% of sampled frogs. A larger number of individuals was captured in the wet season, when most of the species were reproducing. Compared to other areas of Cerrado biome, the Triângulo Mineiro sites presented a larger number of species, which may be attributed to the larger sampled area and greater sampling effort, lower altitude and presence of human generated habitats. The richness of terrestrial frogs was also larger than that in some forested localities in southeastern Brazil, indicating that the number of species cannot be explained only by precipitation and type of vegetation cover. The greater abundance of individuals during the wet season may be related to a greater movement of adults to breeding sites and to juvenile recruitment/dispersion. The heterogeneity of environments in the Cerrado biome, including its several isolated highlands, contributes to its high (local and regional) diversity of frogs.

KEYWORDS. Reproductive habitat, relative abundance, richness, *Triângulo Mineiro*, southeastern Brazil.

RESUMO. Riqueza, abundância relativa e hábitat de reprodução de espécies de anuros terrestres na região do Triângulo Mineiro, bioma Cerrado, sudeste do Brasil. Neste estudo foram determinados a riqueza, abundância relativa e hábitat de reprodução de anuros terrestres em três municípios do Triângulo Mineiro, sul do Bioma Cerrado, sudeste do Brasil, baseados em observações de campo e armadilhas de interceptação e queda. Foram encontradas 32 espécies pertencentes às famílias Brachycephalidae, Bufonidae, Cycloramphidae, Dendrobatidae, Leiuperidae, Leptodactylidae e Microhylidae. Muitas dessas espécies foram encontradas em áreas abertas e se reproduziram em ambientes artificiais gerados por ação antrópica, tais como lagos (10 espécies) e poças (14 espécies). *Physalaemus cuvieri* Fitzinger, 1826 (Leiuperidae) foi a espécie dominante, representando 48% do total amostrado. Um grande número de indivíduos de diferentes espécies foi capturado na estação chuvosa, quando muitas das espécies estavam reproduzindo. As áreas amostradas na região do Triângulo Mineiro apresentaram um maior número de espécies quando comparadas com outras áreas do bioma Cerrado, o que pode ser atribuído à maior área amostrada, ao maior esforço de coleta, baixa altitude e presença de habitats gerados por ação antrópica. A riqueza de anuros terrestres também foi maior do que àquela encontrada em localidades florestadas no sudeste do Brasil, indicando que o número de espécies não pode ser explicado somente pela precipitação e tipo de cobertura vegetal da área. A grande abundância de indivíduos durante a estação chuvosa pode estar relacionada ao maior movimento de adultos para habitats de reprodução e ao recrutamento e dispersão de juvenis. A heterogeneidade dos ambientes no bioma Cerrado, incluindo algumas de suas áreas com maiores altitudes, contribui para a alta diversidade (local e regional) de espécies de anuros.

PALAVRAS-CHAVE. Hábitat de reprodução, abundância relativa, riqueza, Triângulo Mineiro, sudeste do Brasil.

Most Neotropical frogs are only known taxonomically and available information on their ecology is often related to reproduction. In Brazil, frog species check lists are becoming frequent (*e. g.*, BRANDÃO & ARAÚJO, 1998, 2001; BASTOS *et al.*, 2003; TOLEDO *et al.*, 2003; ETEROVICK & SAZIMA, 2004; POMBAL & GORDO, 2004; BRASILEIRO *et al.*, 2005), but information on major ecological parameters, such as abundance, is scarce. Recent decades have been marked by debates on population decline and extinction of frog species around the world. For most species the obvious causes of the decline/extinctions are human related activities, however, the disappearance of species from preserved areas has also been reported (BLAUSTEIN & WAKE, 1990, 1995; PHILLIPS, 1990; LIPS, 1998; GARDNER, 2001; ETEROVICK *et*

al., 2005). Today, the major problem for correctly evaluating the extent of the decline of frog populations is the lack of basic information, especially that necessary to separate natural fluctuations from actual declines (PECHMANN *et al.*, 1991; HEYER *et al.*, 1994; SARKAR, 1996; ALFORD & RICHARDS, 1999; MARSH, 2001).

The anurofauna of South America is the richest of the world (DUELLMAN, 1999; FROST, 2007). At present, around 110 species are known to occur in the Brazilian Cerrado (20% of Brazilian species), from which 32 (28%) are endemic (COLLI *et al.*, 2002). The Cerrado biome, which covers about 1,780,000km², has been designated a biodiversity hotspot, with only 20% of its original area remaining as primary vegetation and only about 6.2% of this corresponding to protected areas (MYERS *et al.*, 2000).

About 56% of the frog species from the Cerrado are terrestrial (COLLI *et al.*, 2002) and can be inventoried for their relative abundance by using methods such as pitfall traps. Herein we present data on richness and relative abundance of terrestrial frogs in the Cerrado of the Triângulo Mineiro, in southeastern Brazil. We also provide information on reproductive habitat of the species. Our data are particularly important because they were obtained from little studied lowland (<800m) Cerrado, which is underrepresented as conservation units and is under greater pressure due to the advance of soy, sugar cane, and cotton plantations and damming.

MATERIAL AND METHODS

The present study was based on data collected from September 1998 to December 2006 in the municipalities of Uberlândia (about 18°55'S, 48°17'W; approx. 750m altitude), Perdizes (about 19°12'S, 47°10'W; 700-1,000m altitude), and Araguari (18°33'S, 48°03'W; 700m altitude). All three localities are within the region of Triângulo Mineiro, in the state of Minas Gerais, southeastern Brazil and are crossed by the Araguari River. Uberlândia lays about 140km west of the sampled area of Perdizes and about 100km south from that of Araguari. The climate of the region has two well-defined seasons, wet/warm from September to March, and dry/mild (with occasional frosts) from April to August (ROSA *et al.*, 1991). Monthly mean temperature ranges from 19 to 30°C. Annual rainfall is about 1,550mm; in drier months the precipitation can be zero (GIARETTA & KOKUBUM, 2004).

At Uberlândia, the original vegetation includes lowland Cerrado environments such as streamside marshes (*Mauritia flexuosa* palm groves, *Palmae*, Veredas) and riverine forests (GOODLAND & FERRI, 1979; SANO & ALMEIDA, 1998). Natural bodies of water include streams, rivers and permanent and seasonal springs; artificial bodies of water include ponds, lakes and drainage channels. In the rural areas, human activities include cattle ranching and mechanized agriculture; large portions of riverine forests have been removed for pastures and, more recently, for the construction of three new hydroelectric power stations (Miranda and Capim Branco I and II, in the Araguari River). Data on richness, reproductive habitat and period were based on weekly field trips since September 1998; data on relative abundance were based on pitfall sampling sets at two sites, Clube de Caça e Pesca and Estação Ecológica do Panga. The "Caça e Pesca" is a 300ha reserve on the outskirts of the city. The local vegetation includes typical secondary growth Cerrado, veredas and patches of exotic grass (*Brachiaria* sp. *Poaceae* and *Melinis minutiflora* *Poaceae*). The Panga is a 410ha private reserve about 35km south at the city; besides the vegetation types described for "Caça e Pesca", it also includes primary cerrado and a small segment of riverine forest (SCHIAVINI & ARAÚJO, 1989; COSTA & ARAÚJO, 2001). Continuous Cerrado environments, pastures and agricultural fields border both localities. Bodies of water include artificial lakes and ponds and veredas along permanent streamlets (about 1m wide; 0.5m deep). The degree of human disturbance is greater at "Caça e Pesca", where in the past 20 years or more some portions of the veredas were drained for agriculture. Fires were also more frequent at this site. See further details on area description and pitfall

sampling method in GIARETTA & KOKUBUM (2004) and GIARETTA & MENIN (2004). At "Caça e Pesca", the pitfall traps were maintained continuously from October 1999 to November 2000; the data from Panga traps are from September 2000 to October 2001. In both localities, five arrays of traps were set, each array consisting of three buckets (about 20l; 35cm mouth diameter) in line, two meters apart, linked by a fine meshed nylon net (8m long x 0.6m high, 0.1m buried in the ground). Specimens were recovered from the buckets at least once a week. The traps were set in open formations with shrubs less than one meter tall, and next (3-10m) to water bodies such as veredas streams (n = 4), ponds (n = 4), and lakes (n = 2). The trap arrays were separated from each other by distances of 100 up to 3000m. Diversity of terrestrial frogs at both sites were estimated using Levins' index (B) and its standardized form (B_{sta}) (KREBS, 1989). Micro-spatial variation ("Caça e Pesca" x Panga) in diversity was evaluated by correlating the abundance of the species throughout the Spearman rank correlation coefficient (r_s) (ZAR, 1999).

For Perdizes, species list and habitat information were based on (1) the examination of specimens collected at the Galheiro Reserve (Estação Ecológica de Galheiro; 2,840ha) during a survey performed prior to the construction of Nova Ponte Hydroelectric power station, (2) collections made by the employees of the Companhia Energética de Minas Gerais (CEMIG), and (3) our own data, collected 1-2 nights (2-3 persons) per month between 2002 and 2005. The vegetation at Galheiro Reserve includes several Cerrado physiognomies, including forests and small fractions of rock montane fields (CARDOSO *et al.*, 2002), veredas being rare there. This reserve is surrounded by cattle ranches, agricultural fields and the hydroelectric reservoir of Nova Ponte (Araguari River). We have no data on abundance at this locality.

In Araguari, fieldwork was conducted at a single site (7 days, about 100 hour/man), during December (2005 and 2006). Considering the small sampling period, for Araguari we just present its exclusive species. The sampled environments were the slopes of the Paranaíba River, where narrow strips (up to 30m wide) of forest remain and cover the rocky beds of seasonal streamlets and rain drainage grooves. Cattle are raised between these forest remnants.

Juveniles of two closely related species (*Physalaemus cuvieri* Fitzinger, 1826 and *P. centralis* Bokermann, 1962) were hard to be told apart one each other (often *P. cuvieri* present red coloration on flanks and hidden parts of legs). Because adults of *P. centralis* were rarely heard in field and captured in traps (see results), juveniles that could not be clearly attributed to this species were grouped with *P. cuvieri*.

We searched for a correlation (Spearman r_s) between frog movement (species abundance in the pitfalls) and the length of reproductive season (number of calling months). This analysis was restricted to the "common species", those with at least ten individuals collected in pitfalls during any month (considering the pooled sample of the two sampling sites). Body size is thought to have important ecological implications related to energetic requirements (KNOUFT, 2002) and it is expected to be negatively related with abundance (DINIZ-FILHO *et al.*,

2004); we tested this assumption by rank correlating (ZAR, 1999) our data on abundance with those of size (adult males) of each species.

Voucher specimens were deposited in the frog collection at the Museu de Biodiversidade do Cerrado, at the Universidade Federal de Uberlândia (AAG-UFU): (2155; 2194; 2275; 2289; 2308; 2333; 2338; 2340; 2343; 2400; 2423; 2442; 2445; 2456; 2499; 2500; 2577; 2604; 2622; 2624; 2689; 2691; 2692; 2693; 2856; 2871; 3055; 3096; 3097; 3107; 3848; 4096).

RESULTS

Thirty-two species of terrestrial frogs, belonging to Brachycephalidae, Bufonidae, Cycloramphidae, Dendrobatidae, Leiuperidae, Leptodactylidae, and Microhylidae were found in our samplings in the region

of the Triângulo Mineiro (Tab. I) (see AMPHIBIAWEB, 2004, for color pictures of some species).

Most species were from open areas and breed in human generated environments, such as lakes (10 species) and ponds (14 species) (Tab. I); no species could be regarded as strictly forest dweller. Species found in both forests and open areas were *Barycholos ternetzi* (Miranda-Ribeiro, 1937), *Leptodactylus mystaceus* (Spix, 1824), *L. syphax* Bokermann, 1969, and *Odontophrynus cultripes* Reinhardt & Lütken, 1862.

Thirty species were found in Uberlândia (Tab. I); eighteen species were found in Galheiro reserve, with one (*L. cunicularius* Sazima & Bokermann, 1978) being exclusive in relation to Uberlândia. Species from Uberlândia that were not found at Galheiro were *Rhinella granulosa* (Spix, 1824), *L. furnarius* Sazima & Bokermann, 1978, *L. mystaceus*, *L. podicipinus* (Cope, 1862),

Table I. Species and reproductive habitat of terrestrial frogs in Cerrado environments in the Triângulo Mineiro (Minas Gerais, southeastern Brazil). References to reproduction were based on the encounter of at least one egg clutch or two calling males and on the literature. *, Species found in Uberlândia. (1) COSTA *et al.*, 2006; (2) GIARETTA & FACURE, 2006; (3) MENIN & GIARETTA, 2003; (4) GIARETTA & MENIN, 2004; (5) KOKUBUM & GIARETTA, 2005; (6) GIARETTA & KOKUBUM, 2004; (7) SILVA *et al.*, 2005; (8) OLIVEIRA FILHO & GIARETTA, 2006.

Species	Habitat of reproduction
BRACHYCEPHALIDAE	
<i>Barycholos ternetzi</i> *	leaf litter (forest and open areas)
<i>Ischnocnema penaxavantino</i> *	males call from stream-side marshes
BUFONIDAE	
<i>Rhinella granulosa</i> *	lakes/ponds in open areas
<i>R. schneideri</i> *	rivers/lakes
<i>R. cf. veredas</i> *	lakes
CYCLORAMPHIDAE	
<i>Odontophrynus cultripes</i> *	males call from open and forest water courses
<i>Proceratophrys goyana</i> *	forest seasonal water courses
<i>P. aff. goyana</i> *	stream-side marshes
DENDROBATIDAE	
<i>Ameerega flavopicta</i> *	banks along rain drainages (1)
LEIUPERIDAE	
<i>Eupemphix nattereri</i> *	ponds (2)
<i>Physalaemus centralis</i> *	lakes/ponds
<i>P. cuvieri</i> *	lakes/ponds/streamlets (3)
<i>P. marmoratus</i> *	ponds (4)
<i>Pseudopaludicola saltica</i> *	seasonal water flows in open areas
<i>P. ternetzi</i> *	seasonal water flows in open areas
<i>P. mystacalis</i> *	streamlets/ponds/lakes in open areas
<i>P. aff. canga</i> *	streamlets in open areas
LEPTODACTYLIDAE	
<i>Leptodactylus aff. andreae</i> *	natural and artificial grasslands (5)
<i>L. cunicularius</i>	males call from sandstone grasslands
<i>L. furnarius</i> *	stream-side marshes (6)
<i>L. fuscus</i> *	open area ponds/stream-side marshes
<i>L. labyrinthicus</i> *	open area ponds/lakes/stream-side marshes (7)
<i>L. mystaceus</i> *	forest ponds
<i>L. mystacinus</i> *	open area ponds/stream-side marshes
<i>L. ocellatus</i> *	lakes/ponds/stream-side marshes
<i>L. podicipinus</i> *	lakes
<i>L. sertanejo</i> *	open area ponds/ stream-side marshes
<i>L. cf. chaquensis</i>	males call from lakes
<i>L. syphax</i> *	open and forest seasonal water courses
MICROHYLIDAE	
<i>Chiasmocleis albopunctata</i> *	ponds (8)
<i>Dermatonotus muelleri</i> *	ponds
<i>Elachistocleis bicolor</i> *	ponds/lakes

Leptodactylus sertanejo Sazima & Bokermann, 1978, *P. centralis*, all four *Pseudopaludicola* species, and *Dermatonotus muelleri* (Boettger, 1885). One species, *Leptodactylus cf. chaquensis* Cei, 1950, was found only in Araguari.

A total of 2,114 frogs were collected in the pitfalls at both sites in Uberlândia, 1,126 in “Caça e Pesca” and 988 in Panga (Tab. II), the difference in abundance being significant ($\chi^2 = 8.88$, $df = 1$, $p < 0.005$). Twenty pitfall-trapped species were common to both localities; four were exclusively from “Caça e Pesca” (*Leptodactylus sertanejo*, *Pseudopaludicola saltica* (Cope, 1887), *P. mystacalis* (Cope, 1887) and *Rhinella cf. veredas* (Brandão, Maciel & Sebben, 2007)) and two exclusively from Panga (*Ischnocnema penaxavantino* (Giaretta, Toffoli & Oliveira, 2007) and *P. ternetzi* Miranda-Ribeiro, 1937) (Tab. II). Dominance was higher at Panga ($\chi^2 = 65.9$, $df = 1$, $p < 0.001$), with *P. cuvieri* consisting of 57% of the sampled frogs; 40% at “Caça e Pesca”. Based on pitfalls, richness (16-17 spp., Tab. II) and species rank abundances ($r_s = 0.38$, $p = 0.05$, $n = 20$ spp.) were similar at both sites, but species diversity was higher at “Caça e Pesca” (Tab. II). Frog species from Uberlândia not represented in pitfalls were: *B. ternetzi*, *R. schneideri* (Werner, 1894), *Dermatonotus muelleri*, *L. mystaceus*, *L. podicipinus*, *Odontophrynus cultripes*, and *Pseudopaludicola aff. canga* Giaretta & Kokubum, 2003; *R. schneideri*, *O. cultripes*, and *Pseudopaludicola aff. canga* were present at “Caça e Pesca”; *L. mystaceus* just was found at Panga.

Table II. Relative abundance of terrestrial frogs (as estimated by pitfall trapping), in two localities in the municipality of Uberlândia, Cerrado Biome at the Triângulo Mineiro (Minas Gerais, southeastern Brazil). * Known to be present at “Caça e Pesca”.

Species	Number of trapped specimens	
	“Caça e Pesca”	Panga
<i>Physalaemus cuvieri</i>	446	566
<i>Elachistocleis bicolor</i>	106	45
<i>Leptodactylus furnarius</i>	98	21
<i>L. fuscus</i>	97	26
<i>L. aff. andreae</i>	90	24
<i>Eupemphix nattereri</i>	76	59
<i>Physalaemus marmoratus</i>	56	3
<i>Proceratophrys cf. goyana</i>	55	9
<i>L. ocellatus</i>	25	3
<i>L. labyrinthicus</i>	21	4
<i>L. sertanejo</i>	17	0
<i>Rhinella granulosa</i>	11	1
<i>Pseudopaludicola mystacalis</i>	8	0
<i>P. saltica</i>	8	0
<i>P. centralis</i>	5	4
<i>L. mystacinus</i>	4	6
<i>Rhinella cf. veredas</i>	3	0
<i>Ischnocnema penaxavantino</i>	0	164
<i>P. ternetzi</i>	0	2
<i>Chiasmocleis albopunctata</i>	0*	51
Richness	17	16
Diversity (B_{sta})	0.316	0.182
Total number of individuals	1126	988

In both localities, a larger number of individuals were observed in the wet season (Fig. 1) when most of the species were reproducing (Tab. III). Species calling during both dry and wet seasons were *R. schneideri*, *Rhinella cf. veredas*, *L. furnarius* (GIARETTA & KOKUBUM, 2004), *O. cultripes*, *Proceratophrys aff. goyana* (Miranda-Ribeiro, 1937) and *Pseudopaludicola aff. canga*. In both localities, the peaks in frog abundance corresponding to the second rainy season (reproductive season of most species) were of the same magnitude of that of the previous year (Fig. 1). Abundance was not correlated with body size of the species ($r_s = 0.095$, $p > 0.50$, $n = 20$ spp.).

Eleven species can be regarded as common (Tab. III). The months of the beginning (October and November) and final (March) of the wet season presented the greatest overlap (70-100%) of frog movement and reproduction.

DISCUSSION

Climatic factors directly affect the beginning and duration of the reproductive season of frogs (GOTTSBERGER & GRUBER, 2004) and in tropical regions with seasonal climate, most of the frog species reproduce during the rainy season (e. g., AICHINGER, 1987; ROSSA-FERES & JIM, 1994), which holds true for the Cerrado species as well (present work).

Reproductive adaptations to seasonal (xeric) environments, such as breeding activity concentrated in the rainy season (ARZABE, 1999), short reproductive cycle,

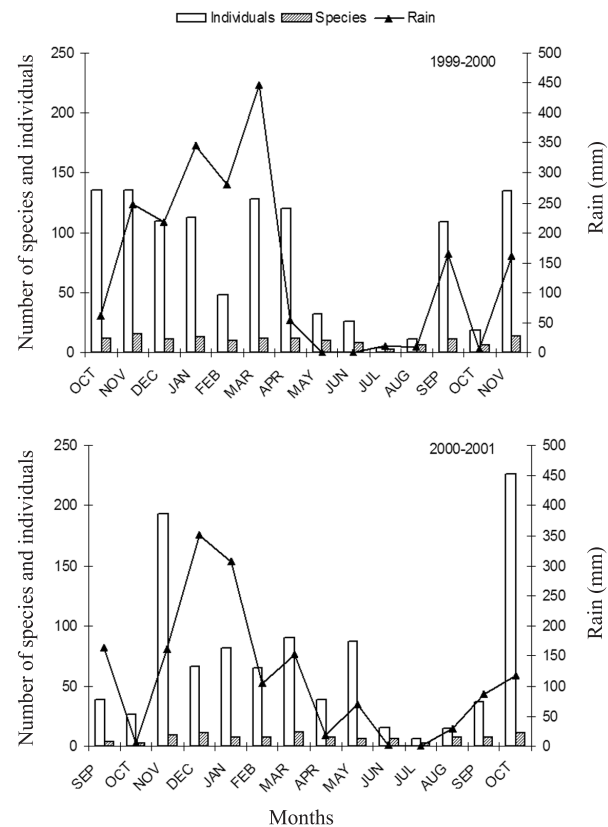


Fig. 1. Precipitation, number of species and number of individuals of frogs captured in pitfall traps at two sites in Uberlândia, southeastern Brazil. Above, “Caça e Pesca”; Below, Panga.

Table III. The eleven most common (abundant) terrestrial frogs of Uberlândia, Cerrado Biome at the Triângulo Mineiro (Minas Gerais, southeastern Brazil) and their calling season. The label "X" represents those months when at least ten frogs were pitfall trapped and "*" represents those months in which males were heard calling. Data from pitfall were combined by joining months of the two different sampling years.

Species	Months	J	F	M	A	M	J	J	A	S	O	N	D
<i>Physalaemus cuvieri</i>		X*	X*	X*	X*	X	X		*	X*	X*	X*	X*
<i>Leptodactylus furnarius</i>		X*	X*	X*	*	*	*	*	*	*	*	X*	*
<i>Elachistocleis bicolor</i>		X*	*	X*	X					*	X*	X*	X*
<i>L. fuscus</i>		*	*	X	X				*	*	X*	X*	*
<i>L. ocellatus</i>		*	*				*	*	*	*	*	X*	*
<i>Eupemphix nattereri</i>		*	*			X			*	X*	X*	X*	*
<i>P. marmoratus</i>		*	*	X*	*					*	X*	*	*
<i>Leptodactylus aff. andreae</i>		*	*	X*	X					X*	X*	X*	*
<i>Proceratophrys aff. goyana</i>		*	*	X*	*				X*	*	*	X*	*
<i>Chiasmocleis albopunctata</i>		*	*								X	X*	*
<i>Ischnocnema penaxavantinho</i>		*	*	X*		X	X			*	X*	X*	X*
Total number of species pitfall-trapped		3	2	8	4	3	2	0	1	3	8	10	3
Total number of species calling		11	11	7	4	1	2	2	6	10	10	11	11

and burrowing behavior (DUELLMAN, 1999) are expected for the frogs of Cerrado. In Uberlândia, frogs were more abundant during wet months, which can be attributed to a greater movement rate of adults around breeding sites and juvenile recruitment/dispersion (GIARETTA & KOKUBUM, 2004; GIARETTA & MENIN, 2004).

Although the rank of abundance was relatively similar in our both sampled sites, the "Caça e Pesca" (the most disturbed site) presented a higher species diversity and abundance. This can be attributed to species underrepresented at Panga, such as *R. granulosa* (Spix, 1824), *L. ocellatus* (Linnaeus, 1758), *L. labyrinthicus* (Spix, 1824), and *P. marmoratus* (Reinhardt & Lütken, 1862), which reproduce mainly in human generated bodies of water (e. g. lakes and ponds) (FRANÇA *et al.*, 2004; GIARETTA & MENIN, 2004; SILVA *et al.*, 2005) which are less common there. The even smaller number of species at Galheiro could also be related to the scarcity of adequate breeding areas such as ponds and veredas as well, and to its higher altitude. The small sample effort expended at Araguari precludes more detailed comparisons with the others localities.

High values of dominance, such as those found for *P. cuvieri* at Uberlândia are typical of seasonally stressed environments, as found in other frog species communities (GIARETTA *et al.*, 1997, 1999). Our results did not support the expected inverse correlation between specific abundance and body size (DINIZ-FILHO *et al.*, 2004). For the frog species studied we expect that other factors such as fecundity, capabilities of movement, hydric regulation and predator avoidance may play a role in the determination of the local abundance.

Within the Cerrado Biome, few localities can be regarded as well studied in terms of frog species composition and most of these localities are reserves above 1,000m altitude. There were 14 species of terrestrial frogs at Estação Ecológica de Águas Emendadas (800-1,250m altitude) (BRANDÃO & ARAÚJO, 1998), and 15 at Parque Nacional da Serra da Canastra (900-1,350m) (HADDAD *et al.*, 1988), Floresta Nacional de Silvânia (900m) (DINIZ-FILHO *et al.*, 2004) and Morrinhos (720m) (BORGES & JULIANO, 2007). Restricting comparisons to similar sized sampled areas, Uberlândia presented a richness of

terrestrial frogs similar to that of Brasília (1,170m, 25 spp.) (BRANDÃO & ARAÚJO, 2001), and Serra do Cipó (650-1,800m, 25 spp.) (ETEROVICK & SAZIMA, 2004). Differences among localities may in part also be attributed to the sampling effort, and to the degree of human disturbance, since around human settlements the presence of ponds and lakes may allow greater population densities of those species that otherwise would occur in undetectable densities. The expected decrease in species richness of frogs with increasing altitude (FAUTH *et al.*, 1989; GIARETTA *et al.*, 1999) may also play a role within the Cerrado biome. Keeping in mind the problems regarding taxonomic resolution, the estimated number of shared species (terrestrial frogs) between the Triângulo Mineiro and other localities varied from 11 (Serra da Canastra, HADDAD *et al.*, 1988) to 15 (Brasília). These low percentages of shared species (34-47%) may result from the heterogeneity of habitats found in the Cerrado biome, which represents a mosaic of different vegetation types, including gallery forests, veredas, mesophytic forests, dry forests, and altitudinal fields, among others (CAVALCANTI & JOLY, 2002; OLIVEIRA-FILHO & RATTER, 2002), with several isolated highlands (Serra da Canastra and Serra do Cipó). This heterogeneity and discontinuity of habitats helps to explain the existence of species with discontinuous distributions (e. g. *Ameerega flavipicta* (Lutz, 1925), *L. syphax* and *L. cunicularius*) and the species turnover (beta-diversity) among montane localities (Serra da Canastra and Serra do Cipó) and even within the Triângulo Mineiro (present study). The regional heterogeneity found in Cerrado biome is thought to have little effect upon the composition of the herpetofauna, since lizards present a higher turnover in South American forest habitats (COLLI *et al.*, 2002). This statement apparently does not hold for frogs, because their ecological needs (HADDAD & SAWAYA, 2000; TOLEDO *et al.*, 2003, present study) are substantially different from those of lizards which are less dependent on humidity for dispersion and reproduction.

It has been suggested that the great anuran diversity, as that observed in the Amazonia (CRUMP, 1974) and in the Atlantic Forest (DUELLMAN, 1988, 1999; HEYER *et al.*, 1990), may be explained by their high levels of

precipitation and the extensive forest cover and the topographic heterogeneity (DUELLMAN, 1999). However, the number of terrestrial frogs found in the Triângulo Mineiro was similar (Boracéia, São Paulo, ca. 29 spp; HEYER *et al.*, 1990) or even larger (GIARETTA *et al.*, 1997, 1999) than forested localities in southeastern Brazil. Our results call attention to the possibility that the distinguishable rich terrestrial frog fauna of the Atlantic Forest (e. g. Boracéia, HEYER *et al.*, 1990) is due to a disproportional contribution of its riparian species.

The Leptodactylid and Leiuperidae frogs represent a large portion of the frog fauna of American tropics (DUELLMAN, 1988). In the region of Triângulo Mineiro, as well as in other localities from the Cerrado biome, they are ubiquitously represented, mainly by the foam nesting species of *Physalaemus* and *Leptodactylus*. Examples of widely distributed species within the Cerrado are *L. furnarius*, *L. fuscus* (Schneider, 1799), *L. labyrinthicus*, *L. ocellatus*, *L. syphax*, *P. centralis*, *P. cuvieri* and *P. saltica*. *Leptodactylus cunicularius* was known from relatively higher elevations (HADDAD *et al.*, 1988; CARDOSO & HADDAD, 1992), and its presence in Galheiro indicates an influence of the surrounding highlands in this locality, as also indicated by the presence of *Scinax canastrensis* (Cardoso & Haddad, 1982) (Hylidae) (OLIVEIRA FILHO & KOKUBUM, 2003) in the same area.

In southeastern Brazil there are approximately 20 *Ischnocnema* species (FROST, 2007; HEINICKE *et al.*, 2007), of which 19 are forest dwellers. The number of Brachycephalidae species in open areas, which includes most of the Cerrado physiognomies, may be constrained by their terrestrial reproductive mode, which relies on consistently high humidity (LYNCH & DUELLMAN, 1997).

In spite of the intense human-generated environmental disturbance, with just 15% of its original natural areas remaining (CAVALCANTI & JOLY, 2002), the Triângulo Mineiro region still presents a rich frog fauna, what can be attributed to the relatively recent history (< 60 years) of major human disturbances, such as intensive agriculture and damming. A supposed natural resistance of the frogs of Cerrado, which evolved in a seasonally dry environment subject to natural disturbances such as fires, could also have played a role in their persistence. At present most of the terrestrial frog species from lowland Cerrado are found in open plant formation and in human generated areas and may not be threatened by moderated habitat alteration such as free ranging cattle farming. In fact, from the sixteen recognized threatened species of anurans in Brazil (MINISTÉRIO DO MEIO AMBIENTE, 2003), just one is a Cerrado species. Special attention on conservation may be paid to those species that were not represented in pitfall sampling, (e. g. *L. mystaceus* and those non-terrestrial frogs (Hylidae) restricted to forest), which may have small and fragmented local populations and are restricted to particular habitats, thus being more susceptible to changes in the environment. We emphasize that a very different situation is expected if extensive agriculture (with complete removal of natural vegetation) is implemented, which may fill water bodies with earth and contaminate them with chemicals and fertilizers. At present days, sugar cane and soybean plantations are the worse threats.

The data on Cerrado herpetofauna is still scarce

(HEYER, 1988) and large areas of this biome never were surveyed (COLLI *et al.*, 2002). The present taxonomic resolution is far from satisfactory and this may hinder detailed comparisons among areas as well. Because of the rapid degradation of the Cerrado biome in recent years, and the insufficient data on its fauna, extensive censuses in different localities are still necessary for the establishment of priority and political areas of conservation. Our data on richness and abundance can be useful to future species monitoring. Considering its biological diversity, as illustrated here for terrestrial frogs, and rate of destruction, those lowland (< 800m alt.) Cerrado environments deserve implementation of conservation programs. Establishment of major reserves should include as much the diversity of the Cerrado physiognomies (especially forests) as possible, but effective protection of the small water courses and its surrounding habitats would have a great positive impact on the preservation of the diversity of frog species in the Cerrado.

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