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Spatial and temporal patterns of richness and abundance in the anuran assemblage of an artificial water reservoir from the semiarid central region of Argentina

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Abstract. This constitutes the first study of anuran fauna composition of an artificial permanent water reservoir, in a semiarid ecosystem of San Luis. Species richness, relative abundance, spatial distribution and pattern of summer activity were estimated in the anuran community of the Embalse La Florida, an artificial water reservoir in the semiarid central region of the sierras of San Luis, Argentina. This reservoir represents one of the few sources of water available for reproduction and early development of amphibian species in the zone. We identified anurans using call surveys during two summers at fifteen sites, belonging to four zones around the shorelines of the reservoir. Eight amphibian species (*Rhinella arenarum*, *Melanophryniscus stelzneri*, *Leptodactylus bufonius*, *Leptodactylus mystacinus*, *Odontophrynus americanus*, *Odontophrynus occidentalis*, *Pleurodema tucumanum* and *Hypsiboas cordobae*) were recorded at the shores of the embalse. The highest species richness (seven) was detected in the preserve located on the north shore. Species richness analyzed by month or survey was not correlated with weather variables. The highest relative abundance of anurans was detected at the highly modified campsites area, which may provide stable food and refugia. Relative abundance of all anuran species was positively correlated with precipitation. This permanent water reservoir may act as an important site of amphibian fauna concentration, which is important to monitor and preserve.

Keywords: amphibians, community, dry forest, permanent reservoir, species composition.

Introduction

Arid environments where climate conditions produce a combination of seasonally high ambient temperatures and low humidity may challenge amphibians, whose hydration state and environmental temperature have a major influence on their physiology and behaviour (Rogowitz, Cortés-Rivera and Nieves-Puigdoller, 1999; Wilmer, Stone and Johnston, 2000). The role of permanent water bodies in arid or semiarid environments is not clear. On the one hand, some studies suggest amphibians are able to persist and remain widely distributed in arid areas without permanent water sources (Burkett and Thompson, 1994). Other authors suggest permanent water bodies are very important for native wild animal species that rely on drinking water or water as habitat for part of their life cycle (Landsberg et al., 1997). Even when temporary ponds are available, sources of permanent water may be important for amphibians, since temporary water bodies may have wider fluctuations in chemical and physical characteristics that may restrict growth and reproduction to short and irregularly wet periods (Lahr, 1997).

The central region of San Luis belongs to an extensive dry forest, characterized by a low and open xerophytic woodland (Anderson, Del Aguila and Bernardón, 1970; Moglia and Giménez, 1998). This area is occupied by a sierras system, where annual rainfall of 500 to 600 mm is concentrated mostly in the warm season (October-April) and mean temperature varies from 23°C in January to 10°C in July. Embalse La Florida is a permanent artificial wa-

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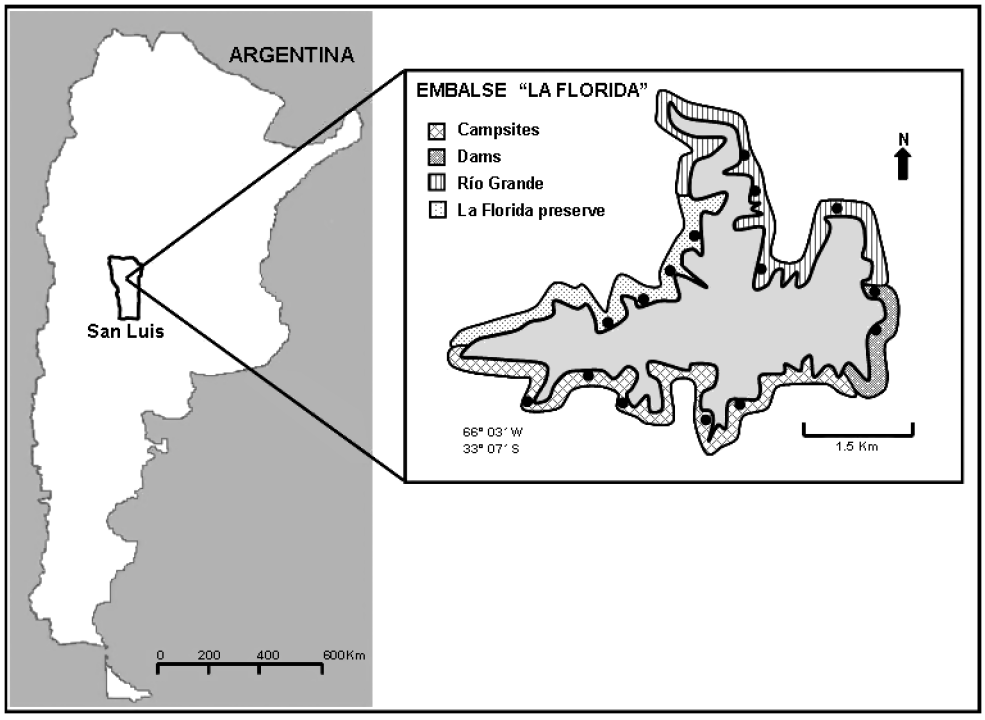

Figure 1. Location of Embalse La Florida in San Luis, Argentina and zones of the reservoir where surveys were performed. Black dots indicate sites surveyed into each zone.

ter reservoir located in the Río Quinto River basin and has two tributaries, El Trapiche and Río Grande Rivers (fig. 1), which provide water, oxygen and dissolved materials to the reservoir. The watershed provides water for irrigation and consumption to one third of the province population. Heavy metals and organochlorine pesticides have been detected (in water, sediments and fauna samples), particularly in the south shore (Antón et al., 2003; Cid et al., 2007; Jofré, Antón and Caviedes-Vidal, 2008; Cid et al., 2009).

In semiarid regions of Argentina there are no studies of diversity, abundance and distribution of amphibian species associated with permanent water bodies. The information available for San Luis province is restricted to species distribution maps, or a few sporadic surveys in different areas of the province (Cei, 1980; Gallardo, 1987; Lavilla and Cei, 2001; Guerreiro, Baldoni and Brigada, 2005; Gutierrez, 2007). The aims of the present study were to: (a) assess the species richness, (b) estimate the abundance, (c) describe the spatial distribution and (d) evaluate the climate influence on temporal activity patterns of the anuran amphibians dwelling on the Embalse La Florida, a permanent water reservoir in the semiarid central region of San Luis, Argentina.

Materials and methods

We identified anurans through vocalization surveys (Zimmerman, 1994) during two summers: from October 2001 to March 2002 and in November and December 2002. The protocol used for call surveys was a modified version of that used for the North America Amphibian Monitoring Program (NAAMP, 1999). We surveyed 15 different sites, belonging to four zones on the shores of the reservoir, a total of 11 times (table 1). Each survey began one half hour after sunset and lasted a total of two hours. We visited all the survey points (15) in the same night and stayed for 3 to 5 minutes at each, identifying all the anuran species vocalizing. At each point we recorded environmental variables and conditions (temperature, humidity, wind, rain, cloud cover). We identified anurans to species by comparing them with recorded vocalizations of the amphibians of Argentina (Straneck, De Olmedo and Carrizo, 1993). Rank abundance esti-

Table 1. Description of zones and location of study sites where vocalization surveys were performed in La Florida.

Coast	Zone	Description	Sites surveyed
South	Campsites	Coast extension of 10 km with yacht clubs and campsites. High anthropic influence.	5
	Dams	Extension of 1.5 km, with two dams of around 300 m in length each. High anthropic influence.	2
North	Río Grande	Coast sides close to the mouth of the Grande River. Low anthropic influence.	4
	La Florida Preserve	Floro-faunistic preserve. Low anthropic influence.	4

mations of calling males (values from 0 to 3) were used as a measure of relative abundance to quantify the activity of anuran species at each surveyed point.

The similarity between the four sampled zones in species composition and relative abundance was estimated using a hierarchical agglomerative cluster analysis with average linkages and Euclidean distances. To classify the different zones, data of species composition and abundance of the survey period replicated on both years (November-December) were used. This analysis was performed with the software Community Analysis Package (CAP) version 3.11 (Seaby, Henderson and Prendergast, 2004). Rank abundance estimations (average values per survey and species) for the first summer (October 2001-March 2002) were related to average temperature (°C), average relative humidity (%) and total precipitation (mm), using Spearman Rank correlation.

Results

Description of the community

Eight amphibian species were recorded for La Florida water reservoir, including representatives of the families Bufonidae: *Rhinella arenarum* (common toad) and *Melanophryniscus stelzneri* (redbelly toad), Cycloramphidae: *Odontophrynus americanus* (common lesser escuerzo) and *Odontophrynus occidentali*s (cururu lesser escuerzo), Leiuperidae: *Pleurodema tucumanum* (spotted-flanks four-eyed frog), Leptodactylidae: *Leptodactylus bufonius* (Vizcacheras' white-lipped frog) and *Leptodactylus mystacinus* (moustached frog), and Hylidae: *Hypsiboas cordobae* (Córdoba tree frog). During the first monitoring season of call surveys, the cumulative number of species was eight (fig. 2A). This value was reached at the fifth survey performed on December 18, 2001.

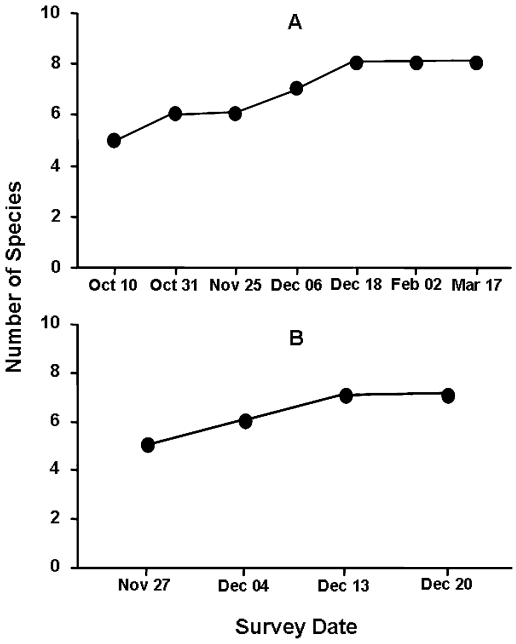

Figure 2. Cumulative number of species in both survey periods (A) October 2001-March 2002; (B) November-December 2002.

During the second survey season (November-December 2002), the maximum number of species detected was seven (fig. 2B) which was recorded on December 13, 2002. *Melanophryniscus stelzneri* was not detected during the second season of call surveys. The absence of this species during the second season was the only difference in species composition between survey periods. Furthermore, this species was reported calling only once with a rank abundance estimation of 1, and therefore was not included in statistical analyses.

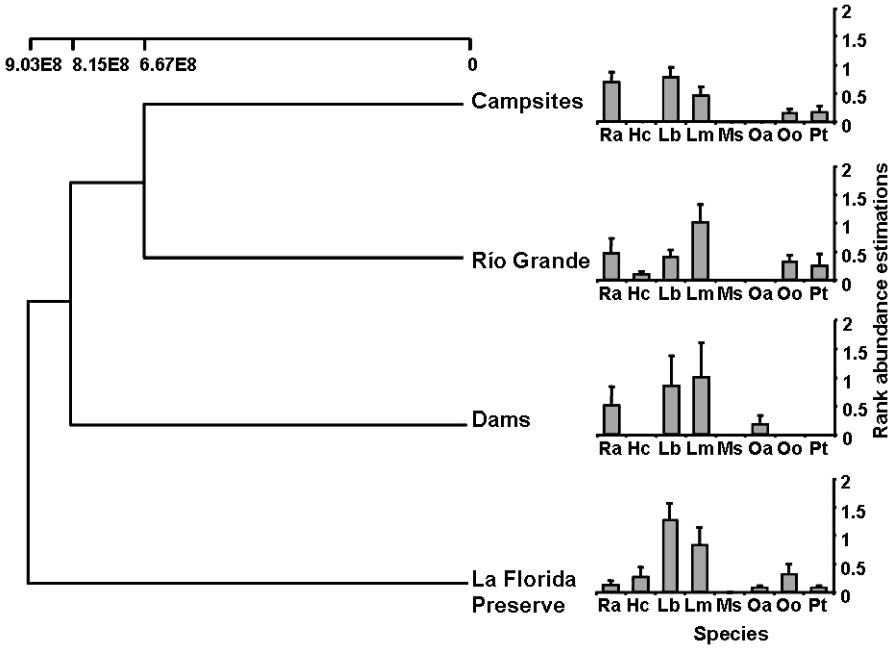

Figure 3. Similarity between zones surveyed in the Embalse La Florida, considering species relative abundance of November and December 2001 and 2002. Bars are average rank abundance estimations for all the dates and points surveyed on each zone.

Comparison of relative abundances

The tree obtained from the cluster analysis including anuran species composition and abundance of the survey period replicated on both years (November-December), separated the La Florida Preserve zone from the other three zones (fig. 3). The highest species richness (7) was detected in this zone. The Campsites and the Río Grande zones clustered together (fig. 3).

Temporal relative abundance of the anurans of the Embalse La Forida

Three species, *R. arenarum*, *O. occidentalis* and *O. americanus*, had an activity pattern with highest abundance in October and lower activity later in summer (fig. 4). The pattern of the other four species shown a peak of vocalization activity in December: both Leptodactylidae with calling activity identified during three months and *H. cordobae* and *P. tucumanum* with vocalizing activity concentrated exclusively in December (fig. 4). *Hypsiboas cordobae* had a relative abundance, estimated from calling intensity of males, ten times lower than the other species (fig. 4).

Weather influence on the anurans of the Embalse La Florida

Species richness analyzed by month or survey was not correlated (all $P > 0.05$) with weather variables (temperature, humidity and precipitation). Relative abundance (survey average) of *L. mystacinus* was positively correlated with environmental temperature (Spearman correlation index $= 0.93$; $P < 0.05$) and negatively with humidity (Spearman correlation index $= -0.74$; $P < 0.05$). Negative correlations of relative abundance values were detected for *O. americanus* with temperature (Spearman correlation index $= -0.9$; $P < 0.05$) and *L. bufonius* with humidity (Spearman correlation index $= -0.76$; $P < 0.05$). Relative abundance of all anuran species was positively correlated with precipitation (Spearman correlation index $= 0.73$; $P < 0.05$).

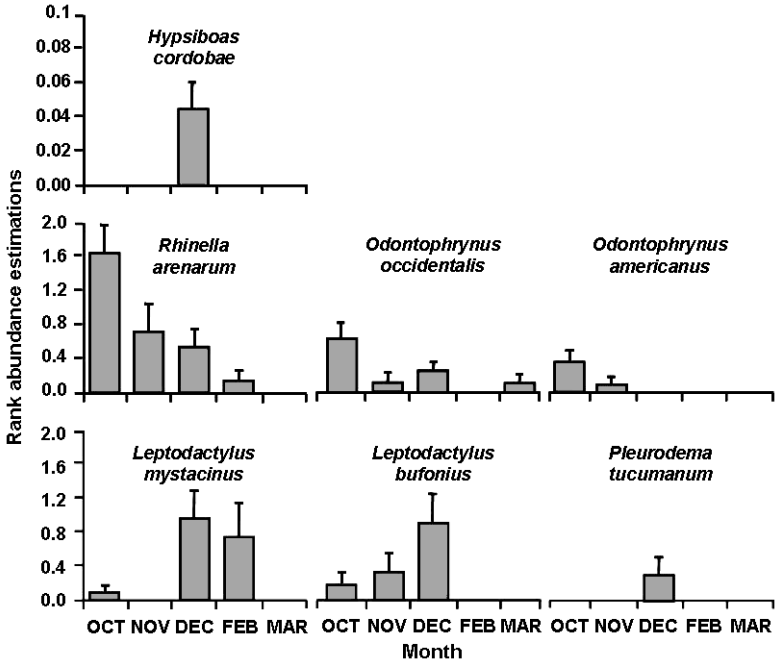

Figure 4. Monthly average of rank abundance estimations for the anuran species recorded at La Florida from October 2001 to March 2002.

The environmental temperature of the second period of surveys (November-December 2002) was significantly lower than the temperature of the first period ($(F)_{1,12} = 14.12$; $P < 0.001$). However, the number of species detected during the November-December sample period did not differ significantly between years (Mann-Whitney $U = 62.00$; $P = 0.56$).

Discussion

This constitutes the first study of anuran fauna composition of an artificial permanent water reservoir, in an arid ecosystem of the central zone of the sierras of San Luis. Most species detected in La Florida have been described as inhabiting the province and are not new records for the area (Cei, 1980; Gallardo, 1987; Lavilla and Cei, 2001). The only exception, *P. tucumanum*, is recorded in this region for first time, expanding its distribution from the western limits of the province of San Luis (Cei, 1980) to the central sierras.

Only one of the species found, *M. stelzneri*, could be considered to be of conservation concern, since Lavilla, Richard and Scrocchi (2000) categorized it as vulnerable with conservation threatened. This species' abundance in La Florida was underestimated by the methodology used (nocturnal call surveys), because of its diurnal habits (Manzano, Baldo and Barg, 2004). Employing diurnal visual encounter surveys, seven *M. stelzneri* (2.76 ± 0.24 g) were detected on two sites located on La Florida preserve in 45 minutes of searching.

The same six species were detected vocalizing in both years, with similar relative abundances in the Campsites zone; this zone had also the highest relative abundance when both periods of survey were averaged. Even though this is a highly modified area, mostly occupied by campsites and boat clubs, it may provide very stable food as a consequence of the artificial lighting, refugia and more stable environmental conditions. The highest number of species (7) was recorded in the zone La Florida Preserve, a

protected area which was the second in relative abundance. Attademo, Peltzer and Lajmanovich (2005) related high anuran diversity and richness directly to the proximity to protected forest in soybean fields of the central-northeast region of Argentina. Other habitat characteristics such as hydroperiod, pool area, tree canopy closure, leaf litter cover and emergent vegetation may also determine amphibian distribution, community composition and abundance (Burne and Griffin, 2005; Urbina-Cardona, Olivares-Perez and Reynoso, 2006).

Similarly to other studies (Attademo, Peltzer and Lajmanovich 2005), richness was not correlated to environmental variables. In our surveys, relative abundance of some species was negatively or positively related to environmental temperature, but the total relative abundance (for all species) was positively related to precipitation. Studies in tropical areas (Toledo, Zina and Haddad, 2003; Canelas and Bertoluci, 2007) have related the number of amphibian species and the species actively vocalizing to the total monthly precipitation and the average temperature. The positive correlation of vocalization activity with precipitation supports the idea that anuran breeding activity is closely related to the rainy season.

Even though *R. arenarum* breeds opportunistically almost throughout the year in the subtropical montane forest of northwest Argentina (Vaira, 2002), the maximum activity of this species in wetlands of San Juan province, at a similar latitude of San Luis, was recorded during October and November, as in La Florida (Sanabria, Quiroga and Acosta, 2005).

Leptodactylus mystacinus and *L. bufonius* vocalization activity in La Florida may be regarded as intermediate considering both length and intensity. Similarly, in an anuran community of southern Brazil, *L. mistacynus* vocalized for three months, a reproductive pattern intermediate between species active for more than five months and species with only a few nights of activity (Toledo, Zina and Haddad, 2003). Also similar to our observations, in central Brazil *L. mystacinus* was active in months of high rainfall, humidity and temperature (de Oliveira Filho and Giaretta, 2008; De-Carvalho et al., 2008).

Hylidae are always associated with permanent water bodies and flooding areas in humid forest habitats (Manzano, Baldo and Barg, 2004). In this study, vocalizations of *H. cordobae* occurred only during December of both years, whereas, *Hypsiboas pulchellus* called over a ten months period at Espinas stream (34°47′S, 55°22′W) in southern Uruguay (Canavero et al., 2008). The activity pattern of *O. americanus* in Uruguay was restricted to December and March (Canavero et al., 2008), whereas in La Florida this species was active earlier during the reproductive season, in October and November.

Canavero et al. (2008) propose that anuran calling activities vary on a seasonal scale in which the activity has a circannual rhythm and/or a response to changes related to season, and also at a shorter scale where temperature or rainfall are important variables. The differences observed in temporal patterns in calling activity may be influenced by rainfall and availability of breeding sites and the adjustments of calling and reproductive activity according to reproductive modes.

In conclusion, La Florida water reservoir is an important site in the semiarid region, because it is one of the few sources of water available for reproduction and early development of amphibians during the dry period. Moreover, given that habitat loss is the main cause of biodiversity loss and that the tourist town located on the shores of the reservoir has experienced an accelerated urban growth in the last several years, future studies should focus on analyzing the impact that urban development in this ecosystem has on the amphibians' species. Finally, it is important to implement conservation strategies to preserve amphibian breeding sites.

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