HABITAT LOSS AND ITS EFFECTS ON AMPHIBIANS DIVERSITY IN THE ARID CHACO OF CÓRDOBA, ARGENTINA

Final Report

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Background

Relationships between vertebrate species richness and environmental heterogeneity as well human actions have been studied at different scales and in several groups (Wiens & Rotenberry, 1981; Ceballos et al., 1999; Atauri & de Lucio, 2001; Tews et al., 2004). Among vertebrates, amphibians and their habitat relationships have been analyzed, showing that diversity patterns are related to habitat configuration and composition (Hecnar & M`Closkey, 1996; Parris & McCarthy, 1999; Lane et al., 2007).

The sensitivity of amphibians to habitat modifications determines that changes in land use and severe anthropogenic alterations in forested landscapes have a great impact on amphibian communities around the world (Guerry & Hunter, 2002; Beja & Alcazar, 2003; Peltzer et al., 2006).

The Great American Chaco is a mosaic of environments with the most extensive forests after Amazonia. Its 1.3 million km^2-areas comprise sectors of four countries: Argentina, Paraguay, Bolivia and Brazil (Bucher, 1982). These forests have been subjected to intense human-induced modification, such as logging, fire and overgrazing. At least 80% of the original forest area in the province of Córdoba has been lost (Zak et al., 2004).

The intense anthropogenic disturbances occurring in the Chaco region have affected soil physical and biological parameters, and forest degradation has negatively influenced populations and community structure of different vertebrates (Lopez de Casenave et al., 1998; Altritcher & Boaglio, 2004; Leynaud & Bucher, 2005). However, the response of amphibian communities to the loss of Chaco forest has not been evaluated yet. Understanding the habitat-amphibian relationship is crucial, since this vertebrate group is highly sensitive to man-induced habitat changes and has undergone alarming declines in the last years (Gardner et al., 2007; Nystrom et al., 2007).

We aim at analyzing the impact of forest degradation on breeding amphibian communities in the arid Chaco region.

The specific aims of this project were:

1. To quantify and describe the amphibian diversity patterns in the arid Chaco region.
2. To analyze possible relationships between amphibian diversity and local vegetation characteristics at the breeding sites in the area.
3. To evaluate possible associations between water parameters of breeding ponds and amphibian diversity.
4. To analyze the relationship between forest loss and degradation and amphibian diversity at a landscape scale in the arid Chaco of Córdoba Province, Argentina.

Materials and Methods

The study area is located in central Argentina, and covers western and north-western portions of Córdoba Province (Figure 1). Most of the area was originally covered by Chaco forests and halophytic shrubs; in the last 30 years, however, the forests underwent a severe transformation to scrublands. Currently degraded shrubs and forests together with halophytic vegetation are part of a heterogeneous mosaic.

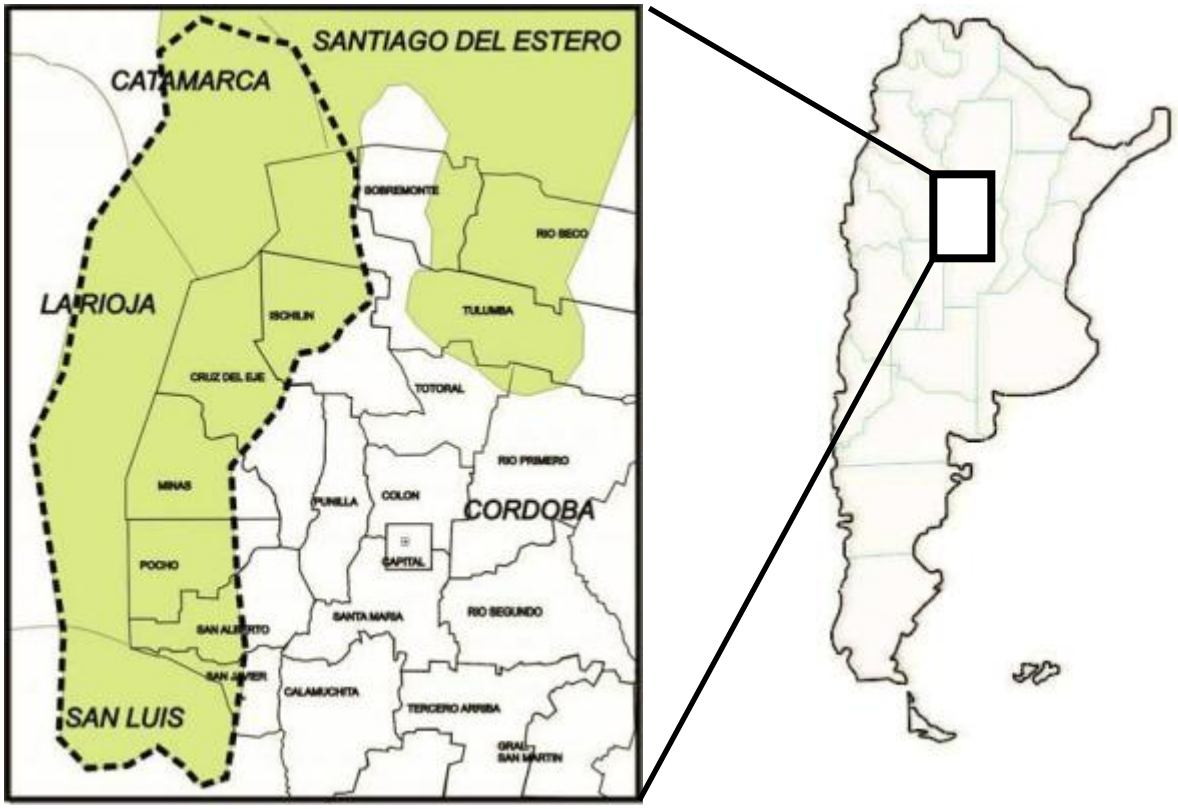


Figure 1. Geographic location of the study area. The dashed line represents the approximate borders of the arid Chaco sub-region.

Thirty ponds or breeding sites were selected within this area and were surveyed between November 2008 and April 2010.

At each pond we recorded the geographic position with a GPS system and using a time constrained search we recorded frogs from all possible microhabitats at dusk and night (Crump & Scott, 2001). Also an aural recording was conducted at each site with a Marantz PMD 660 digital recorder to assess the number of species in vocalization activity.

To assess the inventory completeness we used 3 species estimates: two parametric and one nonparametric (Clench's model, Chao1 and ICE, respectively). Sites were surveyed at least 3 times during the wet season 2 or 3 days after heavy rains.

To analyze the amphibian-landscape association, Landsat 5 TM satellite images of the study area were used (Figure 2). The proportion of different vegetation type covers were quantified in circular areas of 1000-m in diameter centred in the ponds.

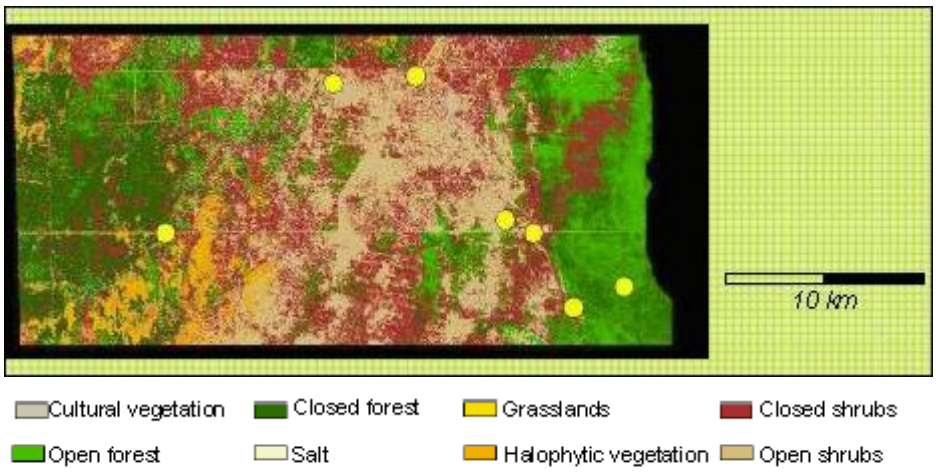


Figure 2. A representative portion of the study area showing the vegetation cover types quantified in the satellite images. Yellow spots represent 1-km-diameter areas around ponds where percentages of vegetation units were quantified.

We recorded 6 variables relative to local habitat: 1. Ph; 2. dissolved oxygen; 3. water conductivity; 4. tree cover on the water surface; 5 emerging vegetation cover (%), and 6. percentage of pond margins covered with herbaceous vegetation.

To establish relationships between the habitat variables measured and amphibian species richness we used a Spearman rank correlation analysis.

Then, a multiple regression analysis (stepwise method) was used to determine the relative importance of each independent variable on species richness. This analysis allows us to detect the variable combination that best explains the variation in species richness observed (Hecnar & M'Closkey, 1998; Atauri & de Lucio, 2001).

Results

Twelve anurans belonging to 5 families were recorded in the area (Bufonidae: 2 species; Leptodactylidae: 3 species; Leiuperidae: 4 species; Ceratophrydae: 2 species and Hylidae: 1 species).

Here we provide some brief comments about these species and their habitats.

Family Leptodactylidae

Leptodactylus mystacinus

This is an infrequent species with low relative abundance in the area. It is found in ponds surrounded by forests.

Leptodactylus bufonius

The most frequent and abundant species in the area. It was found in all sites surveyed. It inhabits both degraded and forested areas. It is also found in saline areas. It is endemic to the South American Chaco region.

Primary Chaco forest in Chancaní, a provincial protected area.

Leptodactylus ocellatus

This is the rarest species in the arid Chaco region. It was found in a single pond located at Chancaní Provincial Reserve. It has semi-aquatic habits.

Pleurodema guayapae

This is an abundant species inhabiting forest areas and scrublands. However, it is more abundant in halophytic environments It has fossorial habits and explosive reproduction. Endemic to the Chaco Region

An artificial farm dam that supplies water to livestock. These ponds are important sites for amphibian reproduction and diversity across the area.

Pleurodema nebulosum

This is a rare and scarce species that inhabits halophytic shrubs near salt marshes in the northern portion of the area. It has fossorial habits and explosive reproduction.

Pleurodema tucumanum

A common species. It was found associated mainly with non-halophytic vegetation. It has fossorial habits and explosive reproduction.

Physalaemus biligonigerus

It is a very abundant species; however, it is only found in non-halophytic areas. It has fossorial habits and explosive reproduction.

Familia Bufonidae

Rhinella arenarum

It is a very abundant species inhabiting all types of habitats in the area. It is a terrestrial toad with prolonged reproduction.

Rhinella schneideri

It is a rare species associated with the northern portion of the Arid Chaco. It has terrestrial habits and prolonged reproduction. It is the biggest species in the area and is endemic to the South American Chaco region.

An amphibian reproductive site surrounded by closed and degraded shrublands.

Family Ceratophrydae

Chacophrys pierotti

A rare species directly associated with saline areas. It has fossorial habits and explosive reproduction. It is endemic to Saline areas in of the Chaco region.

Lepidobatrachus llanensis

It is an uncommon species associated with temporary ponds in saline areas. It has fossorial habits and explosive reproduction. It is endemic to the Chaco region.

Phyllomedusa sauvagei

It is a relatively common species; however, it is mostly associated with forested sites. It has arboreal habits and is endemic to the Chaco forests.

Species Richness and frog abundance: Average species richness was 4.97 (minimum 2, maximum 8). Relative abundance and occurrence of each species are shown in figures 3 and 4.

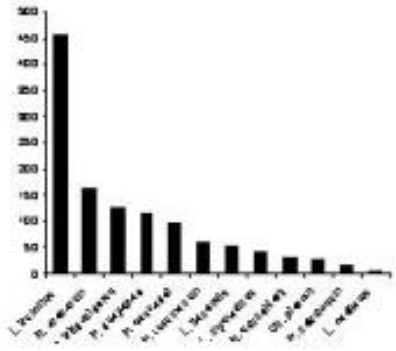


Figure 3. Relative abundance of the species recorded at the survey sites.

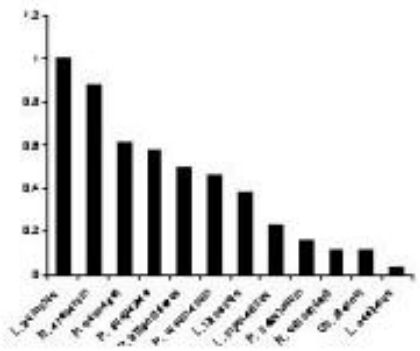


Figure 4. Occurrence of species recorded at the survey sites.

Richness estimates indicated that more than 92% of the species present were recorded (Table 1).

Table 1. Estimated species richness in the arid Chaco region based on parametric and non parametric methods. Species richness in the area estimated with the three models used and inventory completeness.

Method	*Estimated species richness*	*Inventary completeness (Observed/expected richness *100)*
Clench	13	92.3%
ICE	12.5	96%
CHAO1	12	100%

Four variables were significantly correlated with anuran species richness (Figures 5 to 8). The values of these variables and the correlation coefficients are presented in table 3. Two variables had a negative coefficient (water conductivity and isolation) and two variables had a positive coefficient (tree cover and forest percentage in the landscape).

The regression model obtained includes 2 variables (Table 4), which together explain a high proportion of the species richness variation observed. Both variables, forest percentage and isolation are components of the landscape structure.

Table 2. Descriptive statistics and correlation coefficient of variables significantly correlated with species richness ($p<0.05$).

Variable	*Mean ±SE*	*range*	*r*
Local			
Tree (%)	12.25±7.49 0	-87	0.49
ppm	39.44±33.29	10-1100	-0.50
Landscape			
Distance to water (km)	0.66±0.65	0.48-2.8	-0.53
Forests (%1000)	25.71±25.89	0-99.2	0.73

Table 4. Model obtained through multiple regression analysis.

Variable	*β*	*t*	R^2	
Const		8.79	11.12*	
isolation -		1.39	-2.50*	0.28
Forest cover		3.27	4.27*	0.50
Multiple regression model F= 14.96*				**0.67**

*P<0.01

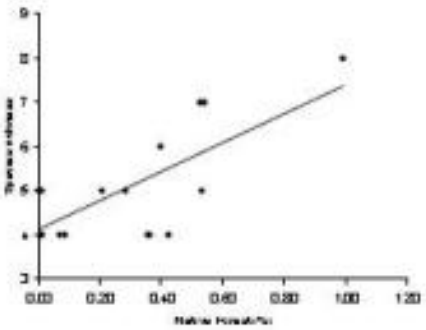


Figure 5. Relationship between forest cover around ponds and species richness.

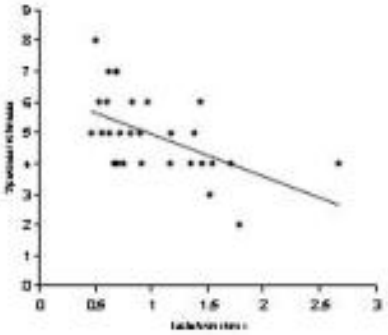


Figure 6. Relationship between distance to the nearest pond and species richness

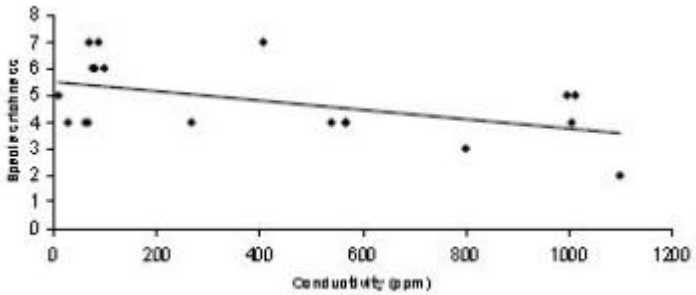


Figure 7. Relationship between water conductivity at the ponds and species richness.

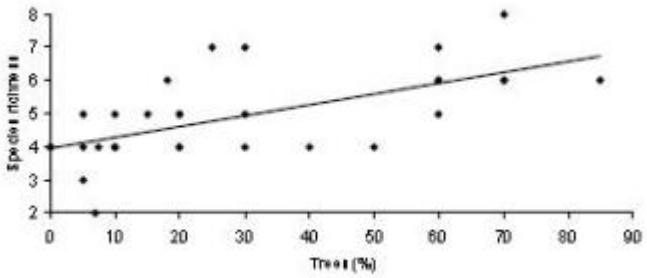


Figure 8. Relationship between tree cover in the sites and amphibian species richness.

Comments on the results obtained

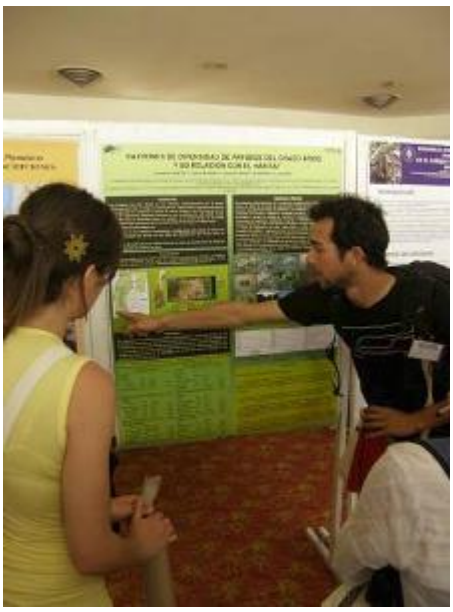
Our results indicate that amphibian diversity patterns of the arid Chaco region are related to habitat factors that operate at different scales. A great percentage of this variation is related to natural variations in habitat characteristics (e.g., natural variations in water conductivity as a result of a gradient determined by the saline basin). Also, local attributes of the ponds derived from humans activities such as tree cover percentage at breeding sites are related to the richness variations observed.

However, the most important variables operate at a major level and are related to landscape configuration and composition. These findings have great relevance for conservation and formulation of management strategies. The deforestation process in the Chaco region is alarming and will be, according to our results, a strong and negative factor for amphibian diversity. According to our models, isolated ponds surrounded by landscapes of low forest cover impoverish amphibian communities.

At present we are working on analyses to establish possible relationships between the variables measured and abundance of particular species that can be used as bio-indicators of landscape degradation.

Outcomes and other data associated with the Project.

- Scientific presentations: We presented the data collected at the scientific meeting. We presented the work entitled **"Patrones de diversidad de anfibios del Chaco árido y su relación con el hábitat" (Diversity patterns of amphibian from the arid Chaco and their habitat relationships) at the X Congreso Argentino de Herpetología (X Argentine Congress of Herpetology, November 2009.**



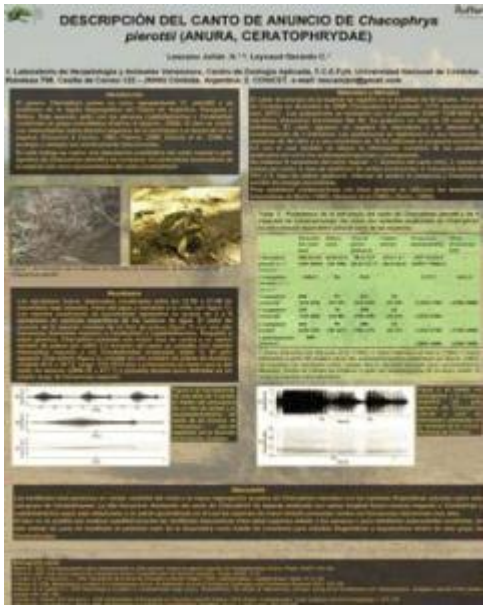
Photos of the presentation at the X Congreso Argentino de Herpetología.

Three scientific articles are being prepared to be submitted for publication in international scientific journals. The works are entitled:

Amphibian Diversity of the Arid Chaco, central Argentina: local habitat and landscape relationships.

The importance of artificial wetlands for amphibian diversity and conservation in the arid Chaco, central Argentina.

The Advertisement call of *Chacophrys pierottii*, with some considerations on bioacoustics of the Ceratophryini clade (Anura, Ceratophrydae).



During field trips we recorded vocalizations of species of the family Ceratophrydae, which were unknown. The data were presented at the X Congreso argentino de Herpetología and a scientific article is being prepared for publication.

- **Students training**

Valuable data on breeding site selection, abundance and conservation of an arboreal species (*Phyllomedusa sauvagii*) were gathered. This frog endemic to the Chaco has a particular reproduction mode and is closely associated with vegetation.

Data were collected partly by the authors and partly by Cecilia Garcia Martinelli, a student of Biological Sciences at the Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Argentina.

The data will be used to develop the student's thesis work entitled

Selección de sitios de reproducción de la rana mono (*Phyllomedusa sauvagii*) en el Chaco Árido de Córdoba, Argentina

(Selection of breeding sites of the Chacoan monkey frog (***Phyllomedusa sauvagii***) in the Arid Chaco of Córdoba, Argentina)

A nest of *Phyllomedusa sauvagii* and an individual vocalizing from the vegetation. The characteristics of the breeding sites were quantified during field work.

- **Dissemination activities:** We conducted activities were conducted together with local park rangers from the arid Chaco protected areas. In addition, printed material was elaborated on the species of the area and the province of Córdoba.

A brochure was elaborated with illustrations of the amphibian species of Córdoba and arid Chaco region, their distribution and conservation status.

Also, at the Centro de Zoología of the National University of Córdoba, a lecture was given, which was entitled

Estado de conservación de los anfibios de Cordoba: una evaluación de los principales factores de riesgo

(Conservation status of amphibians from Córdoba: an evaluation of the main risk factors)

During that lecture, conservation issues affecting amphibians from central Argentina were discussed: emerging diseases, introduction of exotic species and habitat loss and degradation. The results from this project were presented on this occasion.

Photos of the presentation given at the Centro de Zoología Aplicada.

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