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## SEVEN-YEAR RELATIVE ABUNDANCE IN TWO SYNTOPIC NEOTROPICAL LIZARDS, *LIOLAEMUS QUILMES* AND *L. RAMIREZAE* (LIOLAEMIDAE), FROM NORTHWESTERN ARGENTINA

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**R E S U M E N.** — Estudios sobre la abundancia relativa de poblaciones de lagartos simpátricos pueden ayudar a conocer sus historias de vida y, a largo plazo, a estimar potenciales problemas de conservación. A través de los años, pueden emerger patrones de coexistencia entre dos o más especies, tales como los efectos de una especie sobre la otra, o el efecto de las precipitaciones y la temperatura, o la abundancia de la presa y la presión de predación. Aquí reportamos un estudio de siete años sobre la abundancia relativa de dos especies Neotropicales del Noroeste de Argentina, *Liolaemus quilmes* y *L. ramirezae*. Estas dos especies se encuentran en sintopía en un sitio llamado Los Cardones. Monitoreamos un área de 60 x 60 m, dos a cinco días, cada uno o dos meses, a lo largo del período de actividad de los lagartos, desde el año 2000 al 2007. Durante este periodo, la abundancia relativa de *L. quilmes*, tomado como el número promedio de adultos avistados por monitoreo por mes, permaneció estable, mientras que la de *L. ramirezae* aumentó en los últimos dos años. La abundancia relativa de una población no afectó a la otra a lo largo de los años ni tampoco la de machos y hembras de *L. quilmes*. Aunque la cantidad de precipitaciones varió significativamente a lo largo de los años, no estuvo asociada a la abundancia relativa de cada población. Las dos especies muestran diferencias en su uso del hábitat y en sus preferencias alimenticias lo cual podría facilitar la coexistencia. Sin embargo, a parte de considerar estos parámetros ecológicos, también habría que considerar limitantes históricos para poder explicar los patrones observados hoy.

**PALABRAS CLAVE:** Abundancia relativa, lagartos, *Liolaemus*, Noroeste Argentino.

**A B S T R A C T.** — Studies on the relative abundance of sympatric lizard populations can give insight into their life histories and, if long-term, can help estimate potential conservation problems. Through the years, patterns of coexistence between two or more species may emerge, such as the effect of one species over the other, or the effect of factors such as precipitation and temperature, or prey abundance and predator pressure. Here we report a seven-year study on the relative abundance of two Neotropical species from Northwestern Argentina, *Liolaemus quilmes* and *L. ramirezae*. These two species are found in syntopy at a site called Los Cardones. We monitored an area of 60 x 60 m, two to five days, every one or two months, throughout the activity period of the lizards, from 2000 to 2007. During that time, the relative abundance of *L. quilmes*, taken as the average number of adults sighted per survey per month, remained stable during the seven-year study whereas that of *L. ramirezae* increased in the last two years. The relative abundance of one population did not affect the other over the years nor did that of male and female *L. quilmes*. Although the amount of precipitation varied significantly over the years, it was not associated to the relative abundance of each population. The two species show differences in their habitat use and in prey preferences which may facilitate coexistence. However, besides taking into account these ecological parameters, historical constraints must also be considered in order to explain the patterns observed today.

**KEYWORDS:** Relative abundance, lizards, *Liolaemus*, Northwestern Argentina.

## INTRODUCTION

Information on the relative abundance of individuals in a population can serve as an indicator of its health. The longer the study, the better an estimation can be made (Ferguson *et al.*, 1980; Andrews, 1991; Pough *et al.*, 1998). In the short term, it is difficult to observe species variations and the factors that may be involved. Therefore long-term studies are needed to understand better the natural history of a species (e.g., Sexton, 1967; Jones and Ballinger, 1987; Fitzgerald *et al.*, 1999) and evaluate management strategies in case significant changes are observed (e.g., Martori *et al.*, 2002). Population densities are not static and they may vary among locations and years in the same species depending on conditions and physiological requirements that are constantly changing (Heatwole and Taylor, 1987; Pough *et al.*, 1998). Although population parameters of a species may vary during the year due to changes in resource availability such as food, water, or refuges, climatic conditions and the reproductive state of the animals (Rocha, 1998; Van Sluys, 2000), it is expected that the relative abundance of a stable population will not vary significantly over the years (Begon *et al.*, 1986; Pimm and Redfearn, 1988).

*Liolaemus quilmes* and *L. ramirezae* are two of more than 210 species belonging to the Neotropical genus *Liolaemus* (R. Espinoza, pers. com., 2008). They are diurnal, mainly insectivorous (Halloy *et al.*, 2006), and oviparous species (Ramirez Pinilla, 1992; Lobo and Espinoza, 1999, respectively). The first species belongs to the *darwinii* complex (Etheridge, 1993) and the second to the *alticolor* group (Lobo and Espinoza, 1999). Both species occur in northwestern Argentina although *L. ramirezae* has a more restricted range. They are found in sympatry in the semi-arid phytogeographic region of the Prepuna (Cabrera and Willink, 1980), in the Tu-

cumán province. *Liolaemus quilmes* is a dimorphic species, males being more colorful and slightly larger than females, whereas males and females of *L. ramirezae* cannot be distinguished from one another when sighted in the field.

Here we report on a seven-year study of the relative abundance (see Materials and Methods for definition) in two syntopic Neotropical species of lizards, *Liolaemus quilmes* and *L. ramirezae*, from northwestern Argentina. We investigated 1) whether the presence of one species affected the relative abundance of the other, 2) whether the relative abundance of male and female *L. quilmes* differed over the years, and 3) whether the amount of precipitation over the years was associated to the relative abundance of the 2 species. Temperature was not considered in this study as it was not consistently available.

## MATERIALS AND METHODS

Observations were conducted at a site called Los Cardones (26°40'1.5" S, 65°49'5.1" W, datum: WGS84; elevation 2725 m), starting in October 2000 through March 2007, which includes seven austral springs and summers, activity seasons for these lizards.

Within the selected site, we marked a grid of 60 x 60 m, subdivided into 5 x 5 m quadrants. The site was visited between two to five consecutive days every one or two months from October to March during the seven years of the study. We conducted visual encounter surveys, which are used for monitoring and for estimating the relative abundance of an assemblage (Heyer *et al.*, 1994). This technique does not estimate densities, or number of individuals per unit area, since not all individuals are visible when performing this type of survey (Heyer *et al.*, 1994). The visual encounter survey technique requires observers to walk systematically

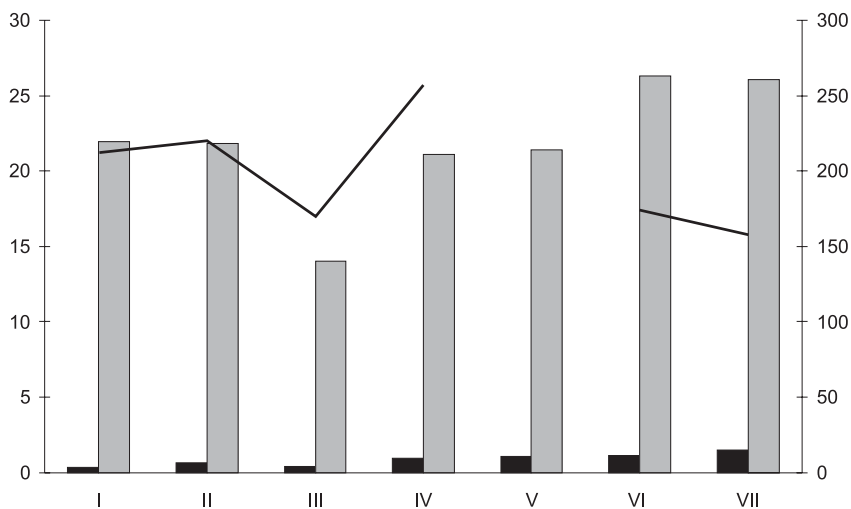
through an area for a specified period of time looking for animals. We performed 3 surveys per day at approximately 10:00, 13:00 and 16:00 hours. Each survey lasted on average 60 to 80 minutes. We walked systematically, following the coordinates, the starting point being selected randomly before each search. When a lizard was sighted, we identified the species and in the case of *L. quilmes* the sex. Only adults were considered. Some of the lizards were marked as part of other studies (Halloy and Robles, 2002, 2003; Halloy 2006, Halloy et al., 2007). Although not all of the lizards were marked, we estimated the probability of their resighting to be minimal and similar during a survey as we walked away from the initial point because these lizards are territorial (Halloy and Robles, 2002) and because, when frightened, they tend to run back to a nearby shrub or refuge. We calculated the relative abundance as the average number of adults sighted per survey per month.

Results were analyzed using non-parametric statistics (Siegel and Castellan, 1988) since we could not assume normality nor homogeneity of the data. The average number of lizards sighted

per survey by species (or sex and species) by month was considered in the various analyses: Kruskal-Wallis one-way analysis of variance to compare the relative abundance of each species and of male and female *L. quilmes* over the years, a Mann-Whitney test to compare the relative abundance of male and female *L. quilmes*, a Spearman rank-order correlation coefficient for an association between the two species, a Chi-square goodness-of-fit test to compare the amount of precipitation over the years, and finally, the Kendall rank-order correlation coefficient for an association between each species and the amount of precipitation.

## RESULTS

*Relative abundances.*— There was no significant difference in the average number of adult lizards of *L. quilmes* sighted per survey, per month, over the years (KW = 7.85, df = 6,  $p > 0.05$ ; Fig. 1) whereas the difference was significant when considering *L. ramirezae* (KW = 16.92, df = 6,  $p < 0.05$ ), observing a greater number of lizards during the last two years of the study (Fig. 1).



**Fig. 1.** Average number of lizards per survey, per month (Y-axis, left) of two syntopic species, by year (X-axis), in Los Cardones, Tucumán, Argentina (*L. quilmes*, grey bars; *L. ramirezae*, dark bars) and amount of precipitation in mm (dark line, Y-axis, right; no information available for 2005).

With respect to male and female *L. quilmes*, there was no significant difference in the average number of adult males nor females sighted per survey, per month, over the years (KW = 9.04, df = 6,  $p > 0.05$ ; KW = 7.79, df = 6,  $p > 0.05$ , respectively; Fig. 2).

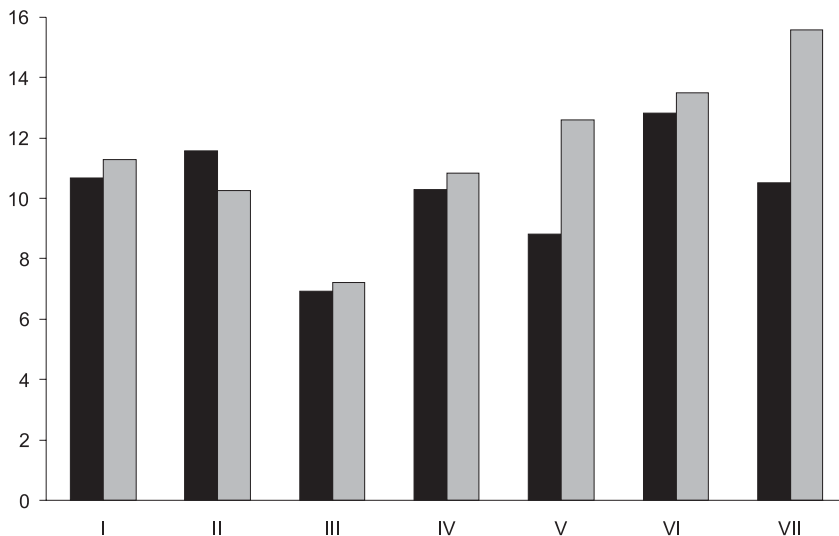
*Comparing relative abundances.*— No association was found between the two species indicating independence in the numbers sighted over the years ( $r_s = 0.5$ ,  $N = 7$ ,  $p > 0.05$ ; Fig. 1). During the seven years of the study, the proportion of one species to the other varied more than threefold. We found on average 1 adult *L. ramirezae* for every 34 adult *L. quilmes* ( $\bar{X} = 34.47 \pm 30.17$ ,  $N = 26$ ), ranging from 71 *L. quilmes* in the first year to 20 in the fifth and seventh year.

When comparing the relative abundances of male and female *L. quilmes*, there was no significant difference between the average numbers of adult males and females sighted per survey, per month, over the years, although there is a tendency for slightly more females than males, especially in the fifth and seventh year (Mann-Whitney test,  $z = -1.57$ ,  $p = 0.12$ , two-tailed, Fig. 2).

*Precipitation over the years.*— There was a significant difference in the amount of rain fallen over the years ( $X^2 = 35.9$ , df = 5,  $p < 0.05$ ; Fig. 1). No information was available for 2005. No association was found between the amount of rain fallen and *L. quilmes* or *L. ramirezae*, indicating that the relative abundance of this population was not affected by rain in the amounts recorded (Kendall coefficient  $\tau = 0.33$ ,  $N = 6$ ,  $p > 0.05$ ;  $\tau = 0.20$ ,  $N = 6$ ,  $p > 0.05$ , respectively, Fig. 1).

## DISCUSSION

Results indicate a stable population for *L. quilmes* over the 7-year period. These results agree with results reported in Halloy and Robles for this species (2003) in which no significant differences were found among females or males over a 3-year period (2 of which overlap with the present study). Although annual patterns indicate stable populations, variations may occur within a year from one season to the next as recorded in Halloy and Robles (2003) where the relative abundance of males increased during the reproductive season



**Fig. 2.** Average number (Y-axis) of male and female *L. quilmes* per survey, per month, by year (X-axis), in Los Cardones, Tucumán, Argentina (males, dark bars; females, grey bars).

whereas that of females decreased. The reverse occurred during the post-reproductive season.

With respect to *L. ramirezae*, an increase in numbers was observed over 7 years. The two species did not affect each other at this site nor did the amount of precipitation affect any of the two species. It is not clear why the increase in *L. ramirezae* since other comparisons did not show significant changes in the values recorded. Two years may possibly be too short a time span to advance any conclusions although it may indicate a population affected by some presently unknown biotic or abiotic factor (e.g., Andrews, 1991; Martori *et al.*, 2002). Andrews (1991) monitored populations of *Anolis limifrons* from 4 to 19 years in central Panama, at 21 different sites. She found significant fluctuations that did not indicate long-term effects. This author also found that although population fluctuations were weakly associated to changes in rainfall over the years, changes could also reflect responses to a changing local environment such as variations in predatory and/or prey activity.

Various studies have shown sympatric lizard species to separate along at least one ecological niche, such as use of habitat, food, or time (e.g., Pianka, 1969; Dunham, 1983; Nuñez, 1996). Although syntopic at Los Cardones, these two diurnal species seem to occupy different microhabitats with some overlap. *Liolaemus quilmes* is more of a generalist in its habitat use. It is found on rocks, close to different types of shrubs and on sandy open soil. *Liolaemus ramirezae*, on the other hand, is more restricted to rocks. Although no interactions were observed between the two species in the field, on rare occasions, they were seen basking on the same rock (pers. obs.).

With respect to diet, differences have been found between the two species, *L.*

*quilmes* eating significantly more Hymenoptera than *L. ramirezae*, whereas the latter ate more Coleoptera and Hemiptera (Heteroptera) (Halloy *et al.*, 2006). Thus with similar prey availability, the lizards used resources differently (also see Martori *et al.*, 2002). Although the differences observed in habitat use and diet preferences may minimize competition and contribute to a relatively stable coexistence (Dunham, 1983; Mead and Boback, 2006), resource partitioning does not necessarily imply competition nor does it demonstrate what mechanisms could be involved if it were the case (Pough *et al.*, 1998). As these authors point out, resource partitioning can result from predation or physiological and morphological constraints or simultaneous occurrence of multiple mechanisms of interaction. Therefore differences in diet among coexisting species may be interpreted as the result of avoiding competition, but they could also be the result of independently evolved differences in morphology or behaviour.

In our study, the two *Liolaemus* species were not affected by the amount of precipitation possibly because the observed variation did not differ much from the annual average of  $192 \pm 32$  mm recorded between 1987 and 2002 for that area (Ing. Mansilla, Observatorio Ampimpa, Tucumán, pers. comm.). Although the amount of precipitation may affect these lizard populations indirectly by affecting their main prey items such as insects (Wolda, 1978; Dunham, 1983; Martori *et al.*, 1998), other factors, ecological as well as historical, may be involved (Jones and Ballinger, 1987; Martori and Aun, 1994). The present study will be continued and other variables, such as temperature, will be considered as well as other sites with these species in allopatry in order to further understand the dynamics of these populations.

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