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HOME RANGE SIZE AND OVERLAP IN *LIOLAEMUS MULTIMACULATUS* (SQUAMATA: LIOLAMIDAE) IN PAMPEAN COASTAL DUNES OF ARGENTINA

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Abstract. The home range is the space used by individuals to carry out their life cycles. The Sand dune lizard (*Liolaemus multimaculatus*) is a vulnerable species, endemic to the pampas coasts of Buenos Aires and Río Negro Provinces in Argentina. The aim of this work was to assess home range size and overlap of the Sand dune lizard. The study was carried out at Mar Chiquita Provincial Reserve. Home range and overlap were calculated using the minimum convex polygon method. The mean ± SD home range size for all individuals was 45.90 ± 74.37 m^2 and no differences were observed between males and females ($p = 0.49$). However, an analysis without outlier individuals showed more accurate values for females (21.31 ± 17.59 m^2) and males (33.52 ± 24.62 m^2), and differences between sex were observed ($p = 0.04$). The relationship between body size and home range size was not significant ($p = 0.41$). Home range overlap was high (22 to 58%; Fig. 2) and did not show differences between males and females ($p > 0.05$ in all cases). Our results showed some similarities with the Brazilian sand lizard (*Liolaemus lutzae*) in which home range value is only up to 1.5 units higher than in *L. multimaculatus*. Further studies about this species' social system are necessary to understand the observed patterns.

Keywords. Space use, Sand lizard, Dune grasslands.

Introduction

Knowledge about space use is essential to understand animal ecology and behavior (Garshelis, 2008). The space that individuals use to carry out their life cycles is the home range (Rose 1982). Home range size represents the minimum area in which individuals find all necessary resources for their survival, including food, water, mates, nest sites and shelters (Stamps, 1983, Christian and Waldschmidt, 1984, Wone and Beauchamp, 2003). The information about home range allows us to know resource preferences of animals (Perry and Garland, 2002) and is of great importance to understand social systems (Stone and Baird, 2002).

As social systems displayed by groups are dynamic, it is common that home range changes depend on population density, abundance and distribution of food and predators, weather and many other factors (Lott, 1991). Additionally, home range size and overlap can vary according to size, sex and different classes (= hierarchies) of individuals (Stamps, 1977, Eadie and Fryxell, 1992, Sinervo and Lively, 1996, Baird *et al.,* 1996).

Although iguanian lizards are useful subjects for studies of space use patterns (Huey *et al.,* 1983), most of the studies about home range and social systems have been mainly carried out in the Northern hemisphere or Australia (Christian and Waldschmidt, 1984, Martins, 1994, Perry and Garland, 2002). In South America, some home range studies have been performed, mainly on species of the genus *Liolaemus,* especially on Chilean species (Jaksic and Nuñez, 1979, Jaksic *et al.,* 1980, Fuentes, 1981, Medel *et al.,* 1988, Jaksic, 2001, Schulte II *et al.,* 2004), whereas Argentinean species are poorly studied (Simonetti and Ortiz, 1980, Halloy, 1996, Halloy and Robles, 2002, Frutos *et al.,* 2007). There is also a study of the Brazilian sand lizard, *Liolaemus lutzae* (Rocha, 1999).

The Sand dune lizard (*Liolaemus multimaculatus*) is a small, diurnal, sand-dwelling liolaemid lizard, endemic to the pampean coasts of Buenos Aires and Río Negro Provinces in Argentina, that occurs only in dune grasslands (Cei, 1993). This lizard is an insectivorous, sit-and-wait predator, and a territorial species (Chebez and Kacoliris, 2008) with sexual dimorphism (Vega, 1997). Sand dune lizard populations are currently restricted to six small and isolated dune areas (Kacoliris *et al.,* 2006). Four of these areas are considered as "Grassland Valuable Areas" for South America (Bilenca and Miñarro, 2004) because they are important for the conservation of Pampean biodiversity. Due to their low densities, relictual distribution and human disturbances to their habitat, the Sand dune lizard was categorized as a vulnerable species

(Lavilla *et al.,* 2000). However, there are currently no accurate studies about the space use patterns of this lizard.

The aim of this work was to assess home range size and overlap patterns in a population of *Liolaemus multimaculatus* that inhabits the coastal Pampas of Buenos Aires province, Argentina. The hypothesis advanced here is that home range patterns vary between individual categories; this is based on the fact that Sand dune lizard is a territorial species with sexual dimorphism, so adult males might be expected to require a larger territory to cover their energy and mating requirements. Such hypothesis predicts that: (a) the home range of males is larger than that of females, (b) home range of adults is larger than that of juveniles and (c) the overlap is smaller between males than females. The results are discussed within the framework of other home range studies in liolaemid species.

Materials and Methods

The study site comprised an 80 ha coastal dune area located within Mar Chiquita Provincial Reserve (37°37'S, 57°16'W) in Buenos Aires Province, Argentina. Three different natural habitat types occur in the area. Ecotone grasslands: psammophytic grassland on stable dune substrate, located between the coastal dunes and Pampas grasslands, with high and homogeneously spread vegetation cover. Sand grasslands: psammophytic grasslands with low to medium vegetation cover, dominated by plant species adapted to high salinity conditions, mobile substrate and low water availability. Interdunes: humid lowlands with a mix of grasslands and hygrophytic plants. Sand grasslands and interdunes are distributed as patches in a matrix of active dunes with scarce or no vegetation cover (Cabrera, 1976). Exotic forests of *Pinus* sp. and *Acacia* sp. also occur within the study site.

Surveys to assess *L. multimaculatus* home range were performed during January and February of 2006 and 2007. Each survey began at 11:00 h, corresponding to the peak of daily activity for this species (Vega *et al.,* 2000) and finished at 16:00 h. The search for lizards was done by four observers using the visual encounter survey method, which allows extensive examination of all microhabitat types (Crump and Scott, 1994). The lizards were manually captured and marked using an individual toe clipping code (Woodbury, 1956) by removing the distal one-third of the toe with sharp scissors; once the marks were healed, individuals were released at the point of capture. This kind of mark does not have secondary effects on terrestrial lizards (Bórges-Landáez and Shine, 2003, Paulisen and Meyer, 2008), they are permanent and cannot be overlooked by the observer. Before any movement was made, the location of each lizard was recorded with a GPS. Gender, size and mark number were recorded for each captured individual. Sex determination was based on external secondary sex characters (Cei, 1993) whereas size was based on the snout-vent length, measured with dial calipers (accuracy: 0.05 mm).

Home range size was calculated using the minimum convex polygon method (MCP), which allows comparisons with other species cited in the literature (Hayne, 1949, Rose, 1982). The MCP method has some advantages compared to other statistical methods; *e.g.,* it is easy to calculate, accurate with an adequate number of observations and based on real observations of individuals. Moreover, MCP does not make any a priori assumptions about the pattern of space use of the lizards (Haenel *et al.,* 2003). Data area curves were generated using the detection number and the cumulative home range area for the mean of all individuals. These area curves calculate the minimum number of necessary detections for generating robust MPC's. Data were fitted with a curvilinear regression ($y = b0 + b1 / x$; $p < 0.05$). The curves showed that an average of seven location points explained 80% of the estimated home range size. For this reason, the lizards with a low number of detections were not used in the analyses. Home range analyses were made only with lizards with 8 ± 3 (mean ± SD) detections (67% of lizards with seven or more detections). Two different analyses were made: a) including all individuals (pooled analysis) and b) without outliers (individuals with home range extremely larger than the majority). Home-range overlap was estimated between: a) individuals vs. overall individuals; b) males vs. males; c) males vs. females; d) females vs. females and e) females vs. males. Home range and overlap analyses were made using the BIOTAS software program.

The mean values for home range and overlap for males and females were compared using a null test with 10,000 permutations in Rundom Express V2S software. The relationship between home range size and snout-vent length was assessed by a null test with 10,000 permutations, using the program Rundom Express VPC. Null tests were selected over parametric tests because they do not need any a priori assumption about data distribution (Manly, 1997). These analyses are based on Knuth's P algorithm for data

shuffling (Manly, 1997), KISS random number generator (Marsaglia, 1999) and P-value computation in sampled tests (Noreen, 1989).

Results

Pooled analysis

The mean ± SD home range size for all individuals was 45.90 ± 74.37 m^2 (n = 60; range 4 and 468 m^2). For male lizards only, home range size was 39.87 ± 79.57 m^2 (n = 24; range 3.96 and 290 m^2), while for the females, home range size was 54.96 ± 66.41 m^2 (n = 36; range 3.96 and 468 m^2). No differences were observed in home range sizes between males and females (t = 15.1; p = 0.49; 10,000 permutations). The relationship between body size (SVL) and home range size was not significant (R = 0.13, p = 0.41; 10,000 permutations).

Analysis without outliers

The a posteriori analysis showed that the great SD observed was due to a few individuals (Fig. 1). In the case of females, only 8% (n = 3) of the individuals showed home ranges larger than 100 m^2 (with a mean of 244 m^2) whereas for males, 14% (n = 3) of the lizards showed home ranges larger than 100 m^2 (mean 205 m^2, n = 3). An analysis without these outlier individuals showed more precise home range values for females (21.31 ± 17.59 m^2) and males (33.52 ± 24.62 m^2). When these values were considered, a null test showed differences in home range between males and females (t = 12.21; p = 0.04; 10,000 permutations).

Home range overlap was high (22 to 58%; Fig. 2) and did not show differences between males and females (p > 0.05 in all cases).

Discussion

When the mean value for all individuals was compared to the mean values without the outliers, home range sizes differed. This difference was greater for females than for males, mainly due to one female with a home range of 468 m^2. The results of the present study show similarities with a study of *Liolaemus lutzae* in Brazil, in which the mean home range size was 59.8 ± 33.7 m^2 (only 1.50 m^2 higher than that of *L. multimaculatus*) for males and 22.3 ± 16.1 m^2 for females (only 1.05 m^2 higher than *L. multimaculatus*) (Rocha, 1999). Other studies about home range in Argentinean *Liolaemus* species include: a) *Liolaemus koslowskyi,* that showed values of 140.0 ± 125.3 m^2 for males and 25.0 ± 28.3 m^2 for females (Frutos, 2001); b) *Liolaemus melanops,* with home range values of 70.9 ± 37.4 m^2 for males and 42.1 ± 51.3 m^2 for females (Frutos *et al.,* 2007), and c) *Liolaemus quilmes,* with 132.2 ± 82.7 m^2 for males and 29.2 ± 9.5 m^2 for females. The values estimated for *L. lutzae* are more similar to the ones for *L. multimaculatus* than those of other species, which could be related to the similar habits of these two species. The results for the second group (without the outliers) is probably the best approximation for the Sand dune lizard, taking into account its territoriality (Chebez and Kacoliris,

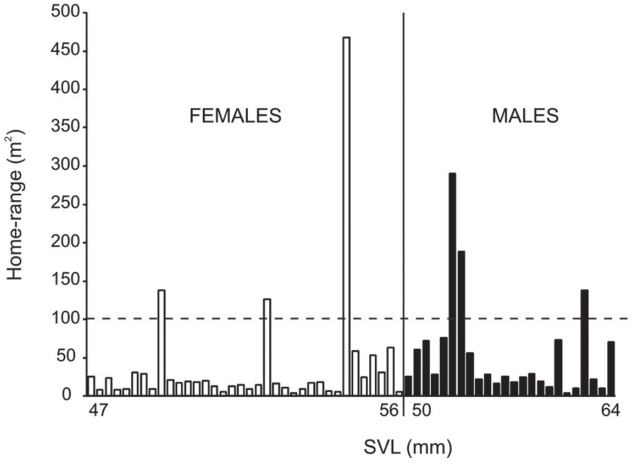

Figure 1. Home range for Sand dune lizard showing individuals with areas larger than 100 m^2. Individuals are arranged by gender first and then by SVL.

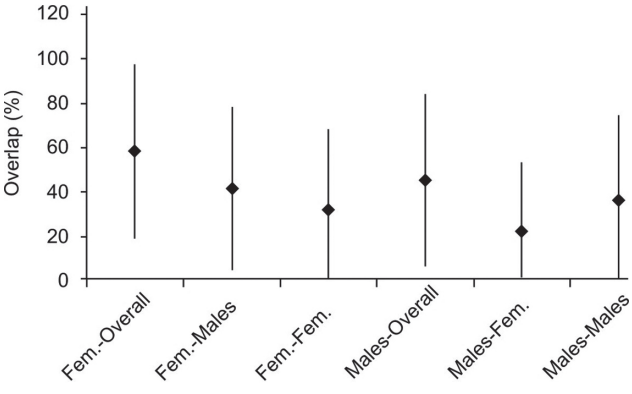

Figure 2. Home range overlap between lizard categories. Data area presented as mean ± SD of the percentage of overlap between each combined pair of lizard categories. Fem.: females.

2008) and the possible existence of different classes of individuals in the social system.

All the studies of *Liolaemus* species have shown high values of SD, which could be related to the pooling of all values in the same analysis (*e.g.* dominant and weak individuals). Depending on spatial requirements and the distribution of key resources in the environment, social behavior among lizards can vary from defense of exclusive areas (= territories) to formation of dominance hierarchies (Alberts, 1993). Studies on *Chamaeleo chamaeleon* have demonstrated that individuals of the same species can have different home ranges sizes. In some cases, male individuals protect defined areas in space and time (Cuadrado, 1999), whereas in other cases males protect one female; for this reason, the area protected can vary in space and time depending on the movements of the females (Cuadrado, 2001). In the present study, a very small number of lizards of both sexes showed larger home ranges (up to 10 m^2) than the majority of individuals. Several explanations are possible (a) that larger home ranges correspond to weak individuals (within the social system) rejected from many other places by dominant individuals, (b) an age factor in which young adults are traveling over wider areas or (c) events of predation, that could push the lizard away from its home range (including human activity). Telemetry studies are needed in order to understand the causes of these differences.

Gender-related size differences were not significant for the pooled data sets, but size was different (greater in males than females) when the outlier values were avoided. The first result agrees with those for *L. melanops* while the second result agrees with the studies on *L. lutzae, L. koslowskyi* and *L. quilmes.* As seen in other lizard species (Perry and Garland, 2002), dominant males usually need a home range size that is sufficient to cover their energy and mating requirements. Consequently, gender-related differences could probably exist in Sand dune lizards, and such differences could be hidden when all individuals are included in the same analysis.

Some studies showed that individual body size is positively correlated with home range size because larger individuals have higher energetic requirements (Haenel *et al.,* 2003). However, our study did not show evidence of such a relationship in *L. multimaculatus.* These results are similar to those obtained for other congeneric species: *L. melanops* (Frutos *et al.,* 2007) and *L. koslowskyi* (Frutos, 2001). In many cases, individual hierarchy could be more important than energetic requirements with regards to home range size (Perry and Garland, 2002). Alternatively, the energetic requirements for Sand dune lizard might not be a limiting factor in relation to home range size.

Overlap was high in every case and no differences were found in overlap patterns between males and females. Extensive overlaps between individuals have been recorded in other lizard species (Kerr and Bull, 2006) and are related to social behavior such as dominance hierarchies and territorial defense (Kaufmann, 1983, Halloy and Robles, 2002). The results regarding females of Sand dune lizard (low overlap) disagree with the observations in *L. lutzae* (Rocha, 1999), *L. melanops* (Frutos *et al.,* 2007), *L. quilmes* (Halloy and Robles, 2002) and *L. koslowskyi* (Frutos, 2001). On the contrary, in the case of *L. melanops* male overlap was high, similar to the results from *L. multimaculatus.* This pattern could be related to infrequent defensive behavior at least in the postreproductive season (Ferner, 1974, Wone and Beauchamp, 2003). Another factor that affects the Sand dune lizard is the low amount of suitable microhabitats (Kacoliris *et al.* in press.), which could probably drive males to share their home ranges.

The results of the present study are generally in agreement with those predicted by Christian and Waldschmidt (1984) for lizards with the same size and trophic level. *Liolaemus multimaculatus* is an insectivorous lizard with a sit-and-wait behavior which leads to scarce movement around a large area to find food, which in turn reduces the necessary area for it to live in.

Resumen

El área de actividad es el espacio que los individuos utilizan para realizar sus ciclos vitales. La Lagartija de las dunas (*Liolaemus multimaculatus*) es una especie vulnerable, endémica de las costas pampeanas de las provincias de Buenos Aires y Río Negro en Argentina. El objetivo de este trabajo fue el de evaluar el tamaño del área de actividad y el solapamiento en la Lagartija de las dunas. El estudio se realizó en la Reserva Provincial de Mar Chiquita. El área de actividad y el solapamiento fueron calculados utilizando el método del mínimo polígono convexo. La media ± DS del tamaño del área de actividad para todos los individuos fue de 45.90 ± 74.37 m^2 y no se observaron diferencias entre machos y hembras ($p = 0.49$). Sin embargo, un análisis sin individuos extremos mostró valores más precisos para hembras (21.31 ± 17.59 m^2) y machos (33.52 ± 24.62 m^2), y

diferencias entre sexos fueron observadas (p = 0.04). La relación entre tamaño corporal y área de actividad no fue significativa (p = 0.41). El solapamiento en el área de actividad fue alto (22 hasta 58%) y no mostró diferencias entre machos y hembras (p > 0.05). Nuestros resultados mostraron algunas similitudes con la lagartija arenícola brasilera (*Liolaemus lutzae*) en la cual el valor del área de actividad es solamente de hasta 1.5 unidades mayor que en *L. multimaculatus*. Estudios adicionales sobre el sistema social en esta especie son necesarios para comprender los patrones observados.

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