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NEW DATA ON THE NATURAL HISTORY AND MORPHOMETRICS OF *Lutreolina crassicaudata* (DIDELPHIMORPHIA) FROM CENTRAL-EASTERN ARGENTINA

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ABSTRACT: We provide new data on the natural history and morphometrics of one of the least studied didelphid marsupial species, *Lutreolina crassicaudata*. Field work was conducted in central-eastern Argentina during two consecutive years. Juveniles and sub-adults were captured during summer and autumn. Reproduction showed seasonality with a continuous breeding period from spring to summer (September to February). The analysis of 17 scats belonging to 17 individuals showed mainly seeds and vegetal remains, as well as amphibians, birds and invertebrates. Sexual dimorphism in juveniles and sub-adults was registered for the first time, being males larger and heavier than females.

RESUMEN: Nuevos datos sobre la historia natural y morfometría de *Lutreolina crassicaudata* (Didelphimorphia) del centro-este de la Argentina. En este trabajo proporcionamos nuevos datos sobre la historia natural y morfometría de una de las especies de marsupiales didélfidos menos estudiadas, *Lutreolina crassicaudata*. El trabajo de campo se llevó a cabo en el centro-este de la Argentina durante dos años consecutivos. Los individuos juveniles y subadultos fueron capturados durante el verano y el otoño. La reproducción mostró estacionalidad, con un período de crianza continuo durante primavera y verano (septiembre a febrero). El análisis de 17 heces pertenecientes a 17 individuos presentó principalmente semillas y restos de vegetales, como así también anfibios, aves e invertebrados. Se registró dimorfismo sexual en las clases de edad juveniles y subadultos, siendo los machos más grandes y pesados que las hembras.

Key words. Diet. Opossum. Reproduction. Seasonal fluctuation. Sexual dimorphism.

Palabras clave. Dieta. Dimorfismo sexual. Fluctuación estacional. Reproducción. Zarigüeya.

INTRODUCTION

The thick-tailed or red opossum, *Lutreolina crassicaudata* Desmarest, 1804, is the only living species of the genus *Lutreolina* (Marshall, 1978). It has a wide and discontinuous distribution, occurring in southern Brazil, Argentina (as far south as Buenos Aires, La Pampa and Mendoza), Uruguay, Paraguay and part of Bolivia; and in a disjunct area in northern South America encompassing Colombia, Venezuela and Guyana (Hershkovitz, 1972; Marshall, 1978; Flores et al., 2007). This opossum is one of the least studied didelphid marsupial

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species (Redford and Eisenberg, 1992; Santori et al., 2005). It is nocturnal and crepuscular, and it is common near to areas with permanent water (Hunsaker, 1977; Olrog, 1979; Regidor et al., 1999). Feeding habits of this marsupial have only been studied in two localities of south-eastern Brazil (Monteiro-Filho and Dias, 1990; Cáceres et al., 2002). In Argentina, only Regidor et al. (1999) conducted an annual study on its reproduction. Thus, scarce information is available in relation to topics such as population characteristics, age structure, and reproduction or movements.

This work aims to study the seasonal trapping success among different habitats, reproduction, age structure, sex ratio, diet composition, and morphometrics of *L. crassicaudata* in a coastal area of central-eastern Argentina, in order to partially fill in the gap in our knowledge about this species.

MATERIALS AND METHODS

Study area

Fieldwork was conducted in the Reserva Ecológica Costanera Sur (34º 36´ S, 58º 27´ W, 350 ha, Ciudad Autónoma de Buenos Aires, Argentina; mean annual temperature = 17.6 ºC, mean annual precipitation = 1062 mm; 1981-1990 period [http://www.meteofa.mil.ar]). This reserve is a coastal protected area, next to the La Plata River, a few blocks away from the heart of the city and government buildings, and was built by gaining land to the river using demolition debris and river silts (Marcomini and López, 2004). The landscape in this area includes a complex mosaic of tall grasslands, humid prairies and lagoons mixed with small woods of *Tessaria integrifolia* and *Salix humboltiana*, and bushy patches dominated by *Ricinus communis*, *Baccharis salicifolia* and *Erythrina crista-galli*. The community of small rodents (species with <500 g) in this area is dominated by the sigmodontines *Deltamys kempi* and *Oligoryzomys flavescens*, the non-native murines *Mus domesticus* and *Rattus norvegicus* and the cavy *Cavia aperea* (Teta et al., 2007).

Opossum survey

This study was part of a survey of small mammals conducted in the study area; for this reason the sampling design was not specific for marsupials. Eight capture sessions were conducted in April (middle autumn), June (early winter), and October (middle spring) 2004; February (late summer), May (late autumn), August (late winter), and November (late spring) 2005; and February (late summer) 2006, in three different habitats: 1) pure stands of pampas grass (*Cortaderia selloana*); 2) mixed woods of *Tessaria integrifolia* and *Ligustrum* spp.; and 3) coastal bushy areas (locally known as "matorrales ribereños"), dominated by the exotic *Ricinus communis*, and the native *Baccharis salicifolia* and *Erythrina crista-galli*. We used two or three lines, spaced at 150 m, of 20 Tomahawk-like live traps in each habitat during each trapping season, with a total of 540 trap-nights for April, June, and October 2004 and February 2005, and 360 trap-nights for May, August, and November 2005, and February 2006. Traps were active for three consecutive nights and were baited with beef and carrot. The distance between neighbor traps was 10 m. Captured animals were immobilized with ketamine-acepromacine (average dose: 24 and 2.4 mg/kg of live weight, respectively) following Perez Carusi et al. (2009), marked with numbered plastic ear tags for individual identification and then released in the same point where they were captured. Animals were treated in accordance with the guidelines of the Sociedad Argentina para el Estudio de los Mamíferos (Giannoni et al., 2003). For each animal we recorded external measurements, weight, sex, and reproductive condition. Reproductively active females (pregnant, with pouch young or with evidence of lactation) were distinguished from reproductively inactive ones. We consider the breeding period as from the pregnancy to the weaning of the litter, and the reproductive season as from the first mating to weaning of the last litter. Forty-four individuals were categorized in five dental age classes (class I: younger than three months; II: from 3 to 4.5 months old; III: from 4.5 to 5 months old; IV: from 5 to 5.5 months old and V: older than six months) based on the sequence of tooth eruption of the postcanine cheekteeth, following Regidor et al. (1999).

Unfortunately, almost all captured individuals removed their ear tags. Therefore, we could only discriminate newly captured individuals from other with at least one previous capture by searching for the mark done by the ear tag. The animals that had this mark were remarked. Consequently we could neither estimate abundance nor movements using the capture-mark-recapture method, and had to calculate trap success ([number of captures / number of trap-nights] x 100). Litter size was quantified by direct observation of the pouch. The approximate birth date (capture date minus assigned age) of juvenile and sub-adult individuals was estimated. Sex ratio

of trapped individuals was calculated including all sexed animals (excluding pouch young).We also estimated the sex ratio of the cohort (individuals born in the same reproductive season) belonging to the spring 2004-Summer 2005 period.

Faeces of 17 different individuals were collected in the trap site. The faeces were washed in the laboratory using a 1 mm mesh sieve. Food remains from faeces were identified, when possible, by comparison with reference collections of animals from the region deposited in Facultad de Ciencias Exactas y Naturales (UBA). The diet was analysed using the frequency of occurrence method, which represents the number of samples where the food item was present, divided by the total number of samples collected.

Statistical analysis

A two way analysis of variance (ANOVA) with one repeated measure factor test (Winner, 1971) and multiple Scheffé contrasts (Zar, 1996) were performed to detect seasonal (repeated measure factor) and spatial trapping success fluctuations. The response variable analysed was trap success of each sample line. All assumptions required by the test were fulfilled.

A Chi Square goodness of fit test (Zar, 1996) was used to assess any significant difference from a 1:1 sex ratio. The assumption of equal sex catchability was seasonally fulfilled (Begon, 1979). Data from summer 2006 were not included in statistical analysis because two fire events could have affected the activity of *L. crassicaudata* in the area.

With the goal of detecting sexual dimorphism in body length and body weight in juvenile and sub-adult individuals, two one-way analysis of covariance (ANCOVA, Milliken and Johnson, 2002) were performed using age as a covariate in order to remove the strong effect of age on the dependent variables. The final body size of this opossum is reached during an advanced stage of the adult phase (Cabrera and Yepes, 1960) and therefore it is highly variable in individuals older than six months. For this reason, adults were excluded in these analyses and only individuals belonging to age classes ≤ six months old (juveniles and sub-adults) were included. All assumptions required by the test were fulfilled.

RESULTS

Natural history

After a two year study, 3600 trap nights resulted in 103 captures, corresponding to 80 individuals. Overall, sex ratio was 53% males and 47% females (n=77, three individuals could not be sexed) and did not differ significantly from 1:1 ($x^2=0.32$; $P=0.57$). The cohort belonging to spring 2004-summer 2005 showed a sex ratio of 62% males 38% females (n=16) and also did not differ significantly from 1:1 ($x^2=1$; $P=0.32$). Considering the total number of captured individuals, trap success showed seasonal fluctuations (F=3.2; df=6, 18 and $P=0.02$) with high peaks in autumn, and low ones in spring (S=5.09; df=6, 18; $P=0.007$; **Fig. 1**). Opossums showed similar trap success in all sampled habitats (F=1.17; df=2, 3 and $P=0.42$).

Individuals of all age classes were captured during the study period. Juveniles and sub-adults (all younger than 5.5 months old) were captured during summer and autumn. Adult females (older than 6 months old) carrying pouch young or presenting turgent nipples were captured in all habitats during spring, summer (n=6, **Fig. 2**) and exceptionally, one in winter. In addition, estimated birth dates of juveniles and sub-adults (n=19) were between September and February (spring and summer; **Fig. 3**). Litter size was 8, 9 and 11 for three females.

The analysis of faecal contents revealed that *L. crassicaudata* consumed a great variety

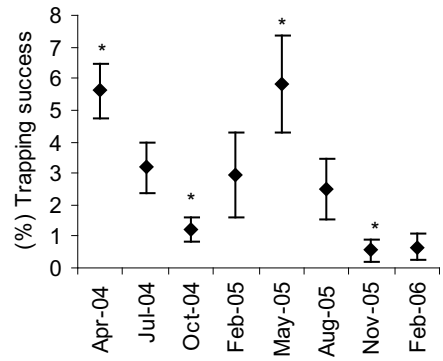

Fig. 1. Mean seasonal variation in trap success (± standard deviation) for *Lutreolina crassicaudata* from central-eastern Argentina during the years 2004-2006. * Significantly different $P < 0.01$

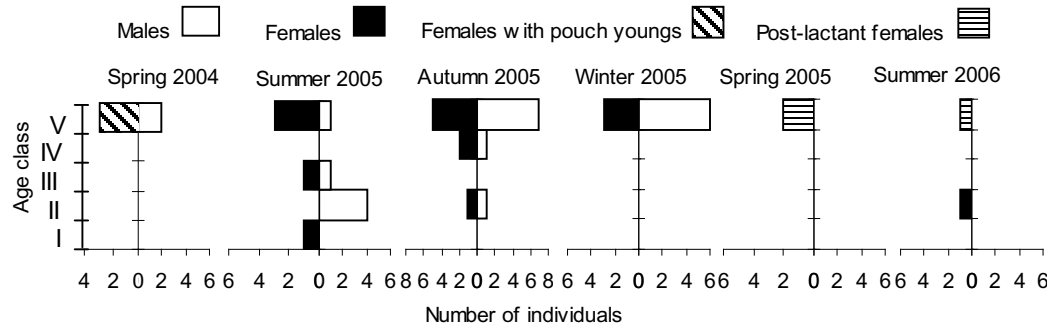

Fig. 2. Age, sex and reproductive condition of 50 individuals of *Lutreolina crassicaudata* from central-eastern Argentina captured between spring 2004 and summer 2006. Age class I (younger than 3 months), II (from 3 to 4,5 months old), III (from 4,5 to 5 months old), IV (from 5 to 5,5 months old) and V (older than 6 months). Data from autumn and winter 2004 was not included due to uncertainties in assigned ages.

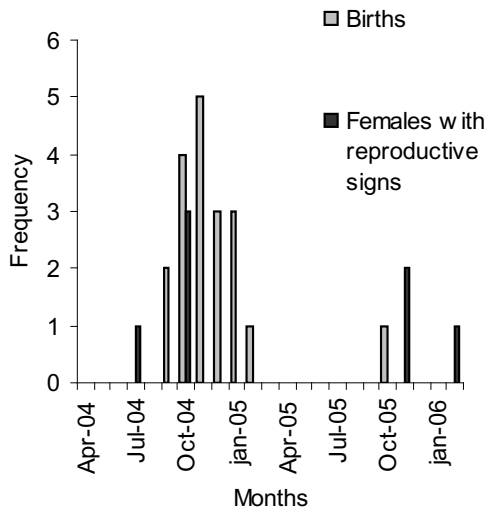

Fig. 3. Number of estimated births and females with reproductive signs (pouch young or turgent nipples) per month of 26 individuals of *Lutreolina crassicaudata* from central-eastern Argentina during 2004-2006.

of food. Seeds (4 morphotypes) and vegetal remains were the most frequent food items (29.4% for each one) followed by amphibians (17.3%), birds (11.8%), arthropods (11.8%) and snails (*Lymnaea sp*., 5.9%). On average 3.2±7.0 seeds per faecal sample were found.

Morphometrics

For juvenile and sub-adult individuals of *L. crassicaudata* (11 males and 8 females), the ANCOVA analysis showed that males were larger and heavier than females ($F = 17.7$; df = 1, 16; $P = 0.00$ and $F = 5.85$; df = 1, 16; $P = 0.03$, respectively; **Fig. 4**). Mean external measurements and weights of adult individuals (13 males and 12 females) are summarized in **Table 1**.

DISCUSSION

Sex ratio observed in this study is in agreement with another study on *L. crassicaudata* (Regidor et al., 1999). The lack of evidence of juvenile males dispersal in our study and the unbiased sex ratio registered for both the cohort and the total sample of captured individuals would suggest that juvenile males have difficulties to disperse, remaining in the same area in which they were weaned. This observation could be related to the isolated condition and reduced extension of this reserve, which hinder dispersal movements to other areas (Cherem et al., 1996).

Seasonal changes in abundance were found in *L. crassicaudata* by Regidor et al. (1999) and were recorded in other Neotropical marsupials like *Didelphis marsupialis* and *D. aurita* (Cáceres and Monteiro-Filho, 1998; Graipel and dos Santos Filho, 2006, respectively). In our case, in which trap success was used, the seasonality observed may reflect seasonality in abundance and/or other causes such as changes in the movement pattern of individuals (differences in

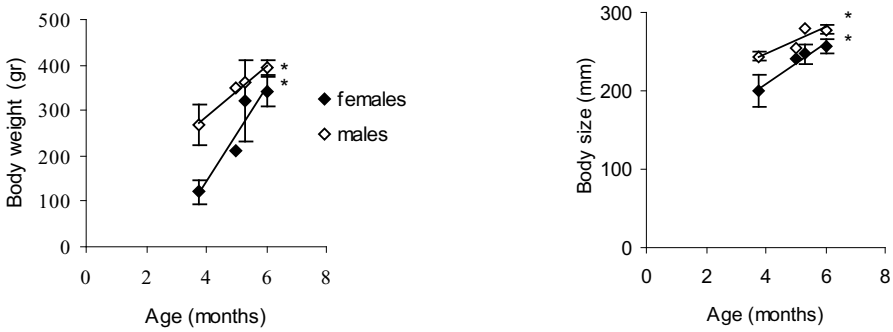

Fig. 4. Mean (± standard deviation) body size and weight of 19 individuals (11 males and 8 females) of *Lutreolina crassicaudata* from central-eastern Argentina during the years 2004-2006 grouped by age and sex. Ages in months were allocated using the midpoint of each age category.* Significantly different $P < 0.05$.

Table 1

Mean external measurements (in mm) and weight (in g) ± standard deviation of 12 adult females and 13 adult males of *Lutreolina crassicaudata* from central-eastern Argentina during the years 2004-2006 (unsexed individuals and pregnant females were not included).

	Males	**Females**
Head and body	316.7 ± 31.3	285.4 ± 24.9
Tail	280.5 ± 19.2	259.7 ± 18.3
Ear	17.1 ± 4.9	19.1 ± 5.7
Hind foot (with claws)	49.2 ± 2.4	43.7 ± 2.1
Hind foot (without claws)	45.1 ± 2.1	40.5 ± 3.3
Weight (g)	737.2 ± 339.7	490.4 ± 127.1

time invested searching for food, mates and/or exploring new territories may lead to seasonal fluctuations in trap success). Likewise, the trap success registered during the summer of 2005 could be partially ascribed to the contribution of juveniles and sub-adults born during spring of 2004, while the peaks registered in autumn could reflect the contribution of the whole breeding period. The presence of juveniles, sub-adults and females carrying pouch young or with turgent nipples during a specific period of the year (spring and summer in Argentina) is in agreement with Regidor et al. (1999) and was found also in other Didelphids (Fleming, 1973; Tyndale-Biscoe and Mackenzie, 1976; Julien-Laferriere and Atramentowicz, 1990; Cherem et al., 1996; Cáceres and Monteiro-Filho, 1998; Graipel and dos Santos Filho, 2006; Perez Carusi et al., 2009). In our case (temperate latitudes), the fact that almost all females captured at the beginning of spring were in a breeding condition could show a population pattern in response to advantages that females have if they breed young during a season with favorable temperature and widely available resources. This result differs from studies performed in tropical and subtropical latitudes where reproduction begins earlier in response to resource availability (Cáceres and Monteiro-Filho, 1998). Despite that Regidor et al. (1999) concluded that *L. crassicaudata* exhibited two breeding periods, the first one beginning in late September and the second one in late December or early January, we found a continuous breeding period through September to February. The presence of a female

with pouch young in winter 2004 (13th July, probably associated with loss of progenies) and an estimated birth date in early February may extend the reproductive season cited for the species by Regidor et al. (1999), reflecting interannual fluctuations in this period and/or incomplete previous samplings.

The food items consumed by *L. crassicaudata* confirm the omnivorous habit of this opossum. Cáceres et al. (2002) found, for the same species in southern Brazil, an average of 765 ± 1999 seeds per faecal sample. The greater amount of seeds found in Brazil in comparison with the average observed in the Reserva Ecológica Costanera Sur could reflect differences in the number of seeds per fruit, seed size and/or their availability in different latitudes and biomes. Since Didelphid marsupials do not have incisive teeth specialized to crack seeds, and as seeds ingested were found undamaged, these items were assumed to represent fruit consumption (Carvalho et al., 2005). In terms of animal items, *L. crassicaudata* fed on amphibians, birds and invertebrates. Although some authors considered this species as a frequent predator of rodents (Olrog, 1979; Cajal, 1981; Streilein, 1982; Barquez et al., 1991; Díaz and Barquez, 2002), and despite the high rodent abundance found in rodent samplings in the same study area at the same time of our work (Teta et al., 2007; Cavia et al., 2009), we did not find small mammal remains in faecal samples. In the Reserva Ecológica Costanera Sur, *L. crassicaudata* could be considered as an omnivorous mammal, feeding on the same food items observed in southern Brazil (Cáceres et al., 2002) but with lower frequencies of insects and fruits.

Morphometric data presented here are in agreement with Regidor et al. (1999), who found that adult males were heavier than females in Buenos Aires province. However, we did not include adult individuals in the statistical analysis since the size of this opossum is highly variable in individuals older than six months. Standard deviation values reported for body weight and length (see **Table 1**) suggest the importance of considering the effect of age in the analysis. Furthermore, sexual dimorphism in juveniles and sub-adults was registered for the first time and showed different strategies in energy allocation to growth between males and females from early stages of growth. Sexual dimorphism is often associated with intrasexual competition among males for mating opportunities (Darwin, 1871), and may indicate the mating system of the species (Webster, 1992). In some Didelphid species it is known that males compete with other males for oestrous females in the breeding season (Sunquist et al., 1987; Ryser, 1992). Thus, the sexual dimorphism found in *L. crassicaudata* might be indicative of some degree of polygyny in this species.

Despite our relatively small sample size, we provide new data on poorly known aspects of the natural history of *L. crassicaudata*. Long-term studies and specific field surveys are still needed to complete a more detailed picture of this species.

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