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Natural history of the marsupial *Thylamys macrurus* (Mammalia, Didelphidae) in fragments of savannah in southwestern Brazil

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(Accepted 13 April 2007)

Abstract

The objective of this study was to furnish information on the natural history of the Neotropical marsupial *Thylamys macrurus* in the southern Cerrado of Brazil. A range expansion of the species was observed to the northeast of the Mato Grosso do Sul state, Brazil. Specimens were surveyed in fragments of savannah (40–600 ha) during dry and wet seasons in 2003 and 2004 with live-trap grids and pitfall lines. With an effort of 9767 trap nights and 2200 pitfall nights, we obtained 102 captures and 49 recaptures of *T. macrurus*. The data analyzed (57 males and 40 females) showed that males are more abundant in the dry season and females in the wet season. Young were recorded mostly during the wet season. *Thylamys macrurus* was scansorial, using the floor and the understorey. Sexual dimorphism was recorded, with males being larger than females. Information on ectoparasites is supplied.

Keywords: Ectoparasites, geographic distribution, Mammalia, population dynamics, sexual dimorphism, *Thylamys macrurus*

Introduction

The abundance, richness, and diversity of species in small mammal communities in the neotropics varies between different locations, caused by spatial and temporal phenomena particular to each region (Fonseca 1989; Bergallo 1994; Malcolm 1995).

Studies with small mammal communities in the Brazilian Cerrado have basically focused on central Brazil (e.g. Alho 1981; Mares et al. 1986), and other Cerrado sites have been mostly ignored by science. It is important to consider that the Cerrado is the second largest biome in Brazil, with 2 million km² (which represents 23% of all the Brazilian territory) and

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ISSN 0022-2933 print/ISSN 1464-5262 online © 2007 Taylor & Francis

DOI: 10.1080/00222930701520835

about 90 small mammal species, including several endemic species (Fonseca et al. 1996; Emmons 1997; Carmignotto 2004).

Among South American marsupials, the genus *Thylamys* stands out. It lives in open and shrub-like vegetation, from prairies to dry forest. There are nine different species of *Thylamys* presently known, with three of them occurring in Brazil: *T. karimii* (Petter, 1968), *T. macrurus* (Olfers, 1818), and *T. velutinus* (Wagner, 1842) (Redford and Eisenberg 1992; Palma 1995; Carmignotto and Monfort 2006). Little is known about the ecology and natural history of this genus and there are few studies on the ecology and behavior of *T. velutinus* in central Brazil (Vieira and Baumgarten 1995; Vieira and Palma 1996; Vieira 1999; Briani et al. 2004).

Thylamys macrurus is a small marsupial (about 50 g) for which ecological and biological characteristics have not yet been well studied. Biogeographical data characterize *T. macrurus* as a mouse opossum of the semideciduous forests of eastern Paraguay and Mato Grosso do Sul state in southwest Brazil (Palma 1995; Vieira 1995; Palma et al. 2002; Torres 2002; Palma and Vieira 2006), but still very little is known on the distribution of the species in Brazil. The limits of distribution of the southern Brazilian Cerrado species, including *T. macrurus* and *T. velutinus*, are not known. This region is dominated by a forested prairie (known as cerradão) with transitional areas of seasonal, semideciduous Atlantic Forest (Veloso et al. 1991).

For *T. macrurus* there are no available data published to date, therefore this study intends to furnish information on the distribution and ecology of this marsupial species. For ecology, the objectives of this study were to determine the abundance, seasonality, use of vertical strata, sexual dimorphism, and ectoparasites of *Thylamys macrurus* in fragments of Cerrado on Mato Grosso do Sul State, in the center-west region of Brazil.

Material and methods

Study area

The studied area is situated in the Paraguay River Basin, in the municipalities of Dois Irmãos do Buriti and Terenos (20°27'–20°34'S, 55°16'–55°19'W), about 70 km from Campo Grande (capital of Mato Grosso do Sul State). The vegetational structure of this region is that of Cerrado biome, particularly the cerradão (forested prairie).

Five fragments of different areas (40–600 ha) were studied, one of them had been formed approximately 2 years before the study dates, and the others had been fragmented for over 20 years.

In the matrix surrounding the studied fragments a grass species (*Brachiaria* sp.) is predominant and inside the fragments there is sometimes a dominance of bamboos which is a common condition for the savannah fragments on Mato Grosso do Sul due to constant fire and human pressure (e.g. pasture) (Pott and Pott 2003).

Methods

For distributional data, we collected marsupials in several regions of the Cerrado biome in Mato Grosso do Sul state, in order to find new records of *T. macrurus*. Trapping was carried out by using 100 Young wire traps, placed mostly on the ground, divided into five transect lines, and spaced 10 m apart within each transect. Effort averaged 350 trap nights per locality sampled. Pitfall traps were also used (buckets ranging from 20 to 100 liters),

usually in 100 m transect lines of 5–10 buckets. Bait was a mixture of bacon, pumpkin, and commercial codfish liver oil.

For ecological data, trapping was conducted in August, September, November, and December 2003 and February, May, and July 2004, during the dry and wet seasons of both years. Trapping sessions lasted 5–10 consecutive nights. In each fragment grids were set with 7×7 or 9×5 traps, each 20 m apart from each other, covering an area of 1.40 or 1.28 ha, respectively. Additionally, a Sherman trap was set in each transect line in the understorey (about 1.5 m height), and two pitfall trap lines were set in each fragment, each with 10 buckets of 108 liters, 10 m apart from each other. The pitfall trap lines were at least 100 m apart from the trap grid and 200 m apart from each other. One-third of these lines were set on the edge of the fragments, the remaining ones were set at least 200 m inside the fragment.

Captured animals were marked, measured (head-body, tail, ear, hind feet; in mm), weighed (in g), and released. Individual age class was classified according to Tyndale-Biscoe and Mackenzie (1976).

Some individuals of *T. macrurus* were examined for ectoparasites, which were collected before releasing the animal. Parasites were preserved in 70% ethanol. Voucher specimens were deposited in the Instituto Oswaldo Cruz (FIOCRUZ).

Data analysis

Relative abundance was determined by dividing the number of individuals by capture effort and multiplying by 100 for each type of trap.

The Chi-squared test was used to test the difference in abundance between males versus females and adults versus young in the two seasons (dry and wet). Another Chi-squared (goodness of fit) was used to test escape behavior. That is, once the animal was released its method of escape was observed and recorded, either terrestrial (running away on the ground) or arboreal (climbing into the nearest tree it found).

To test the existence of sexual dimorphism, a *t* test (for independent data) was used on mass, head-body length, tail length, ear length, and hind-foot length. Differences between adults and young were tested using a Mann-Whitney *U* test, since data were scarce (Ayres et al. 2003).

Results

Distribution

Thylamys macrurus was recorded in four new localities in the Mato Grosso do Sul state: (1) Inocência (Lindos Campos farm; $19^{\circ}49'S$, $51^{\circ}32'W$); (2) Dois Irmãos do Buriti (Sao Cristóvão farm; $20^{\circ}30'S$, $55^{\circ}18'W$); (3) Aquidauana (Piraputanga; $20^{\circ}27'S$, $55^{\circ}30'W$); and (4) Aquidauana (UEMS; $20^{\circ}25'S$, $55^{\circ}40'W$). The record in Inocência comprises a range extension of the species north- and eastward in the Brazilian Cerrado. Previous and actual records are shown in Figure 1, from Paraguay to the southern Brazilian Cerrado. From this distribution analysis, it was noted *T. macrurus* inhabiting open vegetations, not occurring in fully semideciduous forests. For a comparative view, the southernmost distribution of *T. velutinus*, a congeneric species that ranges northward in the Cerrado, is shown (Figure 1).



Figure 1. Map showing the actual distribution of the marsupial *Thylamys macrurus* in Paraguay and Brazil. Point 1 refers to the range expansion of this species north- and east-ward in the Brazilian Cerrado. Black (new records) and white (previous records) circles are of *T. macrurus*; white square is of *T. velutinus* in its southernmost record. Localities: Brazil, Mato Grosso do Sul: 1, Inocência; 2, Dois Irmãos do Buriti; 3, 4, Aquidauana. Previous records: 5, 6, Cáceres et al. (forthcoming), Carmignotto and Monfort (2006) (Bonito); 7, Vieira (1955) (Campo Grande); 8, Carmignotto and Monfort (2006) (Bodoquena); 9, Palma and Vieira (2006) (Bonito). Paraguay: 10, Palma et al. (2002) (Concepción); 11, 12, Torres (2002) (Asunción and Sapucay). Biomes: Ce, Cerrado (savannah); Ch, humid chaco; Fe, semideciduous forest; Pa, Pantanal.

Ecology

With an effort of 9767 trap nights and 2200 pitfall nights, 102 individuals captured and 49 recaptures (151 total) of *T. macrurus* were recorded, resulting in trapping successes of 1.26% (123 captures) and 1.27% (28 captures), respectively (Table I).

There were no differences between the relative abundance for any method of capturing *T. macrurus* (on the ground or in the understory live trap, or pitfall). However, a tendency toward a higher efficiency was shown on pitfalls. Males were captured more often in pitfalls and young were not captured in the understory traps. Both sexes were captured at similar rates in the understory relative to traps on the ground, with a tendency to a higher number of males on the ground (Table I).

In the study, 57 males and 40 females were captured in total (five unknown). Most of the male captures were in the dry season ($N=35$), and females were more abundant in the wet season ($N=27$; $P=0.009$; $df=1$; $\chi^2=6.742$) (Figure 2). Only one juvenile was captured in the dry season (July 2004) and most of them during the wet season ($N=32$; $P<0.001$; $df=1$; $\chi^2=32.747$) (Figure 2).

Table I. Relative abundances of the marsupial *Thylamys macrurus* in different types of traps in fragments of arboreal savannah of southeastern Brazil.

	Trap type ^a		
	Live trap: terrestrial	Live trap: arboreal	Pitfall
Trap nights	8915	852	2200
Males	0.42 (37)	0.47 (4)	0.73 (16)
Females	0.35 (31)	0.35 (3)	0.27 (6)
Young	0.30 (27)	0.00 (0)	0.27 (6)
Adults	0.46 (41)	0.82 (7)	0.72 (15)
Total	0.80 (71)	0.82 (7)	1.05 (22)

^aNumber of captured individuals in parentheses.

Considering its escape behavior, *Thylamys macrurus* used more on-the-ground escapes than arboreal ones ($P<0.001$; $df=1$; $\chi^2=16.026$), with 32 escapes on the ground and seven by climbing into the nearest tree. Despite that, when we consider only relative abundance for trapping results, adults were more frequent in arboreal traps (0.82) than terrestrial traps (0.46) (Table I).

There were significant differences between males and females, with weight, head-body length, ear length, and hind-foot length being greater in males (Table II). Although it was only marginally significant, the tail length was also greater in males. Comparing only sub-adult individuals, the only two significant differences were between head-body length and tail length ($P=0.034$, $N=7$, $U<0.001$), both of them also being longer in males. For young there were no significant differences between males and females ($P>0.16$, U test).

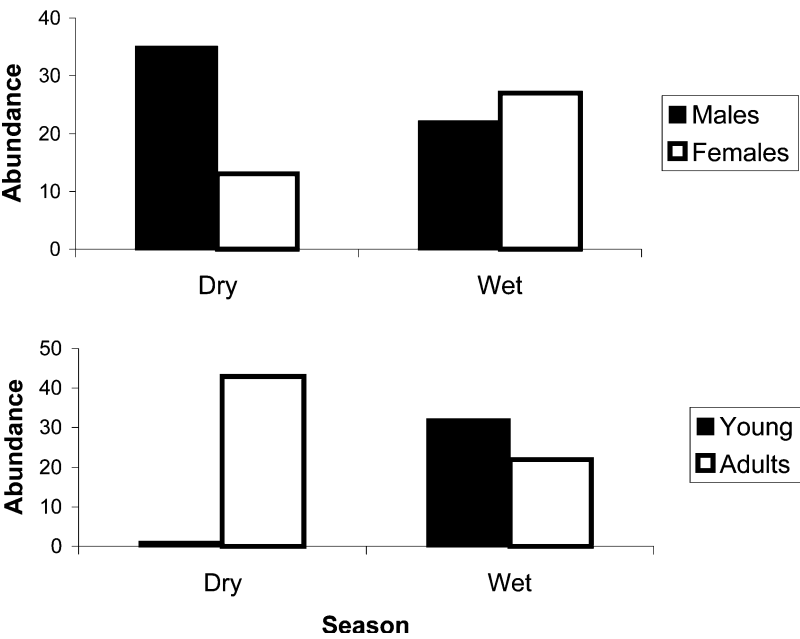


Figure 2. Abundance of males versus females, and young versus adults of the marsupial *Thylamys macrurus* in fragments of savannah of southeastern Brazil, during dry (April to September) and wet (October to March) seasons, 2003 and 2004.

Table II. Mean and standard deviation of the morphological data for adult males and females of the marsupial *Thylamys macrurus* in fragments of savannah of southeastern Brazil.

Body parameters	Males	N males	Females	N females	df	t value	P
Mass (g)	52.4±12.2	37	41.0±10.0	17	52	3.361	0.001
Head-body length (mm)	122.4±11.1	31	111.3±5.3	12	41	3.313	0.002
Tail length (mm)	138.4±7.9	31	133.9±5.5	12	41	1.785	0.080
Ear length (mm)	21.4±2.8	30	19.2±2.4	12	40	2.221	0.032
Hind foot length (mm)	16.9±1.4	30	15.8±1.0	12	40	2.359	0.023

Ectoparasites *Argas miniatus* Korch, 1844 (ticks; N=17 individuals; 100% prevalence), Trombiculinae I (N=3; 17% prevalence) and *Gyropus lenti lenti* Werneck, 1936 (lice; N=1 individual; 17% prevalence) were recorded on *T. macrurus* (N=6 individuals analyzed).

Discussion

Distribution

Thylamys macrurus has been reported as occurring in semideciduous forests of eastern Paraguay and adjacent Brazil (Palma et al. 2002; Palma and Vieira 2006; Cáceres et al. forthcoming), but its distribution limits are still poorly known. Analyzing the known actual distribution, the species appears to occur in more open vegetation (Carmignotto and Monfort 2006; this study) than previously thought (e.g. Eisenberg and Redford 1999). Based on map distribution, the occurrence of *T. macrurus* in fully semideciduous forests (e.g. that of eastern Paraguay) is questioned here, since functional adaptations of *Thylamys* species are for open formations (Carmignotto and Monfort 2006; Palma and Vieira 2006). Therefore, its habitat will range from the humid chaco and transitional dry forests of central Paraguay to the dry forests and arboreal savannahs of southeastern Brazil (Mato Grosso do Sul state and adjacencies, including the Pantanal). The presence of *T. macrurus* in more forested habitats (e.g. arboreal savannahs) than other congeneric species (see Palma et al. 2002) could be explained by the scansorial mode of life of this species rather than cursorial (see later).

The range expansion of *T. macrurus* reported here is of about 350 km north and eastward in the Brazilian Cerrado, near the frontiers of Goiás and Minas Gerais states. The north and east limit of its distribution was Campo Grande, Mato Grosso do Sul state (Vieira 1955). This is important in view of the proximity of the known southern distribution limit of the congeneric species, *T. velutinus*, in southern Goiás (Carmignotto and Monfort 2006). A possible zone of sympatry between both species is then suggested along Sucuriú and Aporé rivers, in the northern Mato Grosso do Sul and southern Goiás states. This could be related to the modification of the character of the savannah, from more arboreal at the south (*T. macrurus*) to more open and shrub-land at the north (*T. velutinus*, see Veloso et al. 1991). In view of this, the occurrence of *T. macrurus* in the southern Pantanal is suggested, because of the proximity and partial dominance of the arboreal savannah (besides some semideciduous forests) in this region (Silva et al. 2000).

Ecology

The higher efficiency of trapping for male *T. macrurus* could be related to the social system of the species. The dimorphism in size, with males larger than females in *T. macrurus*,

supports this idea. When there are dimorphic characteristics, such as those related to movement and body size, this indicates at least a non-monogamous social system (Ostfeld 1990). Hence, a greater degree of movement is expected for males in population studies, as usually occurs for didelphid marsupials (Fleming 1972; Sunquist et al. 1987; Pires and Fernandez 1999; Cáceres 2003). These movements would possibly explain the higher rate of males captured in the different types of traps. The relatively low trapping of juveniles is thought to be an artifact of trap shyness (Begon et al. 1996) displayed by them (in response to terrestrial traps), wire-trap inadequacy relative to the small body size (M. E. Graipel, personal communication), or even low extent of movement (e.g. resulting in smaller home ranges) inherent to this life phase (Fitch and Shirer 1970).

Male *T. macrurus* were more frequent in the population during the dry season, which extends until September in the region of study. If we assume that the onset of reproduction in this species is similar to other didelphid marsupials, i.e. highly seasonal with starting in the winter (late dry season), and that this is corroborated here by the fact that young *T. macrurus* occurred effectively (except one case) in the wet season, we could postulate that male abundance and its presumed increased movement rate in the dry season are reflections of the onset of reproduction. Thus, males would search for females during these late dry and cold times in a typical didelphid marsupial pattern (Atramentowicz 1982; Ryser 1992; Pires and Fernandez 1999; Cáceres 2003). If this happens, the higher abundance of young *T. macrurus* in the wet season would be explained (see Cáceres 2000; Julien-Laferrière and Atramentowicz 1990; Bos and Carthew 2003).

Conversely, females (more abundant in the wet season here) are expected to be more active in the wet season due to their lactation and parental care. Parental care requires more effort by females, leading to increasing movement to obtain suitable resources (Atramentowicz 1982; Julien-Laferrière 1995). Because of this, female *T. macrurus* would be trapped more often in this season.

Results indicate that *T. macrurus* is scansorial since it is capable of climbing trees occasionally. This pattern is not found in other congeneric species in Brazil (*T. velutinus* and *T. karimii*), which do not have body adaptations for climbing, specifically in the tail and fingers. In the cursorial species *T. velutinus* and *T. karimii*, tail tip and fingers are shorter in comparison with *T. macrurus* (Carmignotto and Monfort 2006). Proportionally longer extremities, such as tail tip and fingers, are related to more arboreal habits (Eisenberg and Wilson 1981; Vieira 2006). Understorey and canopy-dwelling species appear to have reasonable to high levels of success in forest fragments, as seen in the Atlantic Forest for marsupials (Fonseca 1989; Fernandez et al. 1998; Goulart et al. 2006). This could be the case for *T. macrurus* in fragments of the forest savannahs because the species is one of the most abundant locally (Napoli 2005; N. C. Cáceres, unpublished data), and has morphological adaptations for climbing trees (Carmignotto and Monfort 2006). Forest savannahs, as is the case in the study area, are expected to be richer in species which is explained by its vertical complexity (M. V. Vieira and A. R. T. Palma, in preparation), facilitating the occurrence of more arboreal species. Contrarily, the more cursorial *T. velutinus* from savannahs of central Brazil is more common in more open habitats and/or in early successional stages (Vieira 1999; Briani et al. 2004; Carmignotto and Monfort 2006).

On ectoparasites, although *A. miniatus* is considered an avian parasite in Nearctic and Neotropical regions (Camicas et al. 1998; Evans et al. 2000; Serra-Freire 2001), mammals were recorded as hosts for this species (Doss et al. 1974), including other marsupials (Lorosa et al. forthcoming) but not *T. macrurus*. Therefore, *T. macrurus* is a newly recorded

host for *A. miniatus*. Similarly, *T. macrurus* is a newly recorded host for *G. lenti lenti*, since these lice have only been reported in rodents (Werneck 1948; Cardozo-de-Almeida et al. 2003). Chiggers (Trombiculinae I) are parasites of marsupials (Wharton and Fuller 1952; Brennan and Goff 1977). Due to the absence of sensilla, specific identification was not possible here, impeding the discussion of the record, in spite of no previous records of chiggers on *T. macrurus*.

Acknowledgements

We thank the Universidade Federal do Mato Grosso do Sul for partial support in the field (UEMS, CPAQ and the Programa de Pós-Graduação em Ecologia e Conservação at UFMS), M. M. A. Gomes for helping with ectoparasite sheet preparation, the owners of the farms where ecological studies were carried out (A. A. Giroto, of the São Cristovão farm, and C. Gandini, of the Nova Aliança farm), and A. P. Carmignotto for helping in the final drafts of the manuscript. L. Z. Prates, C. F. Vargas, A. A. M. Tombini, and C. S. Goulart helped in the field. Distributional collections were possible with the financial support of FUNDECT/MS, FINEP/MCT, and Ministério do Meio Ambiente of Brazil (ProBio). G.S.G is a Posdoc CNPq fellow. We also thank an anonymous referee who contributed greatly to the final version of the manuscript.

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