Diet of two marsupials, *Lutreolina crassicaudata* and *Micoureus demerarae*, in a coastal Atlantic Forest island of Brazil

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Summary. – As little is known of the feeding ecology of Neotropical marsupials, we studied the food habits and the role in seed dispersal of two sympatric didelphid marsupials, *Lutreolina crassicaudata* and *Micoureus demerarae* in Southern Brazil. The study area is on Santa Catarina Island, in secondary Atlantic Forest. As a part of a two-year (1998-2000) study, animals were trapped and their feces collected on the ground and in the understory for a six months period (March to August 1998) on a grid of 127 traps. *L. crassicaudata* was trapped only on the ground, mainly near a creek, and *M. demerarae*, mainly in the understory. Thirteen fecal samples of *L. crassicaudata* were collected, and 30 for *M. demerarae*. *L. crassicaudata* consumed mainly crabs and beetles, whilst *M. demerarae* consumed mainly beetles and ants. Invertebrate diversity was high in the diet of both species, particularly that of *L. crassicaudata*. Conversely, fruit diversity eaten was low, but highest for *M. demerarae*. *L. crassicaudata* ate more seeds (e.g. *Cecropia*) than did *M. demerarae*. The dietary overlap between these two marsupials was high (96 %), and both species are thought to be seed dispersers in their respective habitats.

Résumé. - Il y a peu d'informations sur l'écologie de l'alimentation des marsupiaux néotropicaux, c'est pourquoi une étude a été menée sur le comportement alimentaire et la dissémination des graines chez deux marsupiaux didelphidés sympatriques, *Lutreolina crassicaudata* et *Micoureus demerarae*, dans le Sud du Brésil. Le site d'étude était situé dans l'île de Santa Catarina, une île couverte de forêt atlantique secondaire. Au cours d'une étude d'une durée totale de deux ans (1998-2000), les animaux ont été capturés par piégeage au sol et dans le sous-bois pendant six mois (mars à août 1998) sur une grille de piégeage comprenant 127 pièges, dans le but de récolter leurs fèces. *L. crassicaudata* a été capturé uniquement au sol, principalement près d'un cours d'eau, alors que *M. demerarae* a été capturé essentiellement dans le sous-bois. Treize échantillons de fèces ont été récoltés pour *L. crassicaudata*, contre 30 pour *M. demerarae*. L'étude de ces fèces a montré que *L. crassicaudata* consommait principalement des crabes et des coléoptères, alors que *M. demerarae* consommait principalement des coléoptères et des fourmis. La

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diversité en invertébrés était élevée dans le régime alimentaire des deux espèces, principalement *L. crassicaudata*. Inversement, la diversité en fruits était faible, mais plus élevée chez *M. demerarae*. *L. crassicaudata* consommait de plus grandes quantités de graines (par exemple *Cecropia*) que *M. demerarae*. Cependant, le recouvrement des régimes était élevé (96 %) entre les deux marsupiaux, et les deux espèces peuvent être considérées comme des disséminateurs efficaces dans leurs habitats respectifs.

KEY WORDS: *Lutreolina crassicaudata*, *Micoureus demerarae*, diet, marsupials, Brazil.

INTRODUCTION

In Brazil, the marsupial family Didelphidae includes about 44 species (Fonseca *et al.*, 1996) for most of which little is known about diet. Detailed studies on their food habits and also on their role in seed dispersal are available for fewer than 10 didelphid marsupials, including *Didelphis* spp., *Philander* spp. and *Caluromys philander* (Charles-Dominique *et al*. 1981 ; Codero and Nicolas 1987 ; Atramentowicz 1988 ; Monteiro-Filho and Dias 1990 ; Medellín 1994 ; Leite *et al*., 1996 ; Santori *et al*. 1995 ; Carvalho *et al*. 1999 ; Cáceres & Monteiro-Filho 2000 ; Cáceres in press a, b). Besides, these mentioned studies were not developed only in Brazil but were scattered in the Neotropics. In order to contribute with additional information on the feeding ecology of didelphid marsupials, this paper presents a study on the diet and the role in seed dispersal of two sympatric marsupial species in an Atlantic Forest of Southern Brazil.

MATERIAL AND METHODS

Study area

The study site was on a coastal island (Santa Catarina Island) of southern Brazil, at 27º43’S and 48º32’W, in the Parque Municipal da Lagoa do Peri. It is covered with secondary Atlantic Forest vegetation and has a hilly relief. The regional annual temperature and humidity average 20.5ºC and 82 %, respectively, and the total annual rainfall is 1384 mm (IPUF 1978). The colder months are mainly June to August and the warmer months are October to April.

Captures

We captured marsupials with a grid of 127 traps set in the study area, including 73 traps set on the ground and 54 at a 2 m height in the understory. Twenty of the traps set on the ground were of median size (45 x 21 x 17 cm) and the rest were small (26 x 19 x 9 cm). All understory traps were small. The stations had one understory and one ground trap each, and were set in 11 lines, having 7 stations per line, except the first and last lines which had only five stations. The distance between each line and between each station on a line was 15 m. All median sized traps were set at 30 m intervals. Traps were baited with banana mixed with peanut butter and were monitored daily for four consecutive days each month. During 6 months, from March to August 1998, feces were collected but trapping period extended from April 1998 to March 2000.

Diet analysis

The marsupials captured were identified and, since they commonly defecate when trapped, their feces were collected on the trap site, after the release of the animal. One fecal sample was considered as being all feces produced by one animal in a night. Feces were then washed in laboratory with a 1 mm mesh sieve. Food remains from feces were identified by comparison with reference collections of animals and seeds from the region. When seeds were present, they were counted in each fecal sample.

The diet of marsupials was analysed by using the frequency of occurrence method, that is, the percentage of food items regarding all fecal samples collected for one marsupial species. To verify the dietary overlap between the two marsupials, we calculated the Morisita Index of Niche Overlap (Krebs 1989). For this calculation, the species level was considered for fruits, the order level for invertebrate items and the class level for vertebrates. The diversity of food in the diet of opossums was estimated with Levins' Standardized Measure of Diversity (Krebs 1989). This measure ranges from 0 to 1, with 0 meaning no diversity and 1 meaning the maximum diversity. The Mann-whitney U test was used to verify possible significant differences between the quantities of seeds consumed by the two opossums (Siegel 1981).

RESULTS

After a total effort of 12000 trap-nights, we achieved 45 captures of the thick-tailed opossum, *Lutreolina crassicaudata* (Desmarest, 1804), and 89 captures of the mouse opossum, *Micoureus demerarae* (Temminck, 1824). Nonetheless, only 3048 trap-nights were used for collection of feces, resulting in 13 (from 5 individuals recaptured 13 times) and 30 fecal samples (from 8 individuals), respectively, for these species.

Dietary richness, diversity and overlap

Both marsupial species were omnivorous and showed 96 % of dietary overlap (C = 0.96 from a maximum of 1.00), with some differences being seen in the frequen-cies of each item consumed. Although both species showed high consumption of fruits (77 to 92 % of frequency of occurrence), in terms of animal items *L. crassicaudata* fed mainly on crabs (54 %), beetles (46 %) and vertebrates (30 %), which differed from the frequencies of *M. demerarae*, that fed mainly on beetles (53 %) and hymenopterans (43 %), particularly ants (Table 1). The diversity of food items differed between opossums, with the diversity of invertebrates being higher for *L. crassicaudata* (B_A = 0.52 versus 0.47 for *M. demerarae*) and the diversity of fruits being higher for *M. demerarae* (B_A = 0.39 versus 0.28 for *L. crassicaudata*). In fact, the consumption of fruits by *M. demerarae* was more even than that of *L. crassicaudata*, presenting more seed species (e.g. *Ottonia martiana* and *Maclura tinctoria*) and lower frequencies of consumption (Table 1). Thus *M. demerarae* dropped on average 25 ± 40 seeds per fecal sample/night, whereas *L. crassicaudata* dropped 765 ± 1990 seeds per fecal sample/night. *Lutreolina crassicaudata* consumed fruits at higher rates such as of *Cecropia glaziovii* and *Piper*, which can be seen by the large mean and total number of seeds found in feces (Table 2). These differences in the amount of seeds ingested between both marsupial species were significant for *C. glaziovii* ($P < 0.05$; N = 22 ;

U = 30.0) but not for *Piper* sp.1 ($P > 0.30$; N = 16 ; U = 20.0). Therefore, *M. demerarae* consumed seeds at smaller quantities (Table 2). Most seeds dropped by the two marsupials were undamaged due to their intact external anatomy.

TABLE 1. – Frequencies of occurrence (in %) of food items in the feces of two sympatric marsupial species in Atlantic Forest of Santa Catarina Island, southern Brazil.

Food items	*Micoureus demerarae* (N = 30)	*Lutreolina crassicaudata* (N = 13)
Animals	97	100
Aves	7 (2)	15 (2)
Bones	-	15 (2)
Decapoda	33 (10)	54 (7)
Blattariae	7 (2)	-
Coleoptera	53 (16)	46 (6)
Hymenoptera	43 (13)	23 (3)
Lepidoptera	7 (2)	15 (2)
Orthoptera	3 (1)	15 (2)
Diplopoda	7 (2)	15 (2)
Opiliones	23 (7)	31 (4)
Fruits	77	85
Arecaceae	-	8 (1)
Cecropiaceae		
Cecropia glaziovii	37 (11)	85 (11)
Moraceae		
Ficus sp.	7 (2)	15 (2)
Maclura tinctoria	7 (2)	-
Piperaceae		
Piper sp.1	27 (8)	62 (8)
Piper sp.2	7 (2)	-
Ottonia martiana	23 (7)	-
Solanaceae		
sp.1	-	8 (1)
sp.2	-	8 (1)
Species non identified	10 (3)	8 (1)

Number of occurrence in parenthesis.

Seasonal feeding

Larger quantities of seeds (e.g. *Cecropia*, *Piper*, *Ficus* and *Ottonia*) appeared in feces of both marsupials mainly during the warmer and rainy months, namely March and April 1998, but extending in higher numbers until May, and becoming absent or in lower numbers in feces during the colder months (June to August) (Fig. 1).

Foraging strategies

As an indication of different foraging strategies between both marsupials, all captures of *L. crassicaudata* occurred on the ground and 93 % of them within 20 m of a

TABLE 2. – Minimum, maximum, total number and mean of seeds found in fecal samples of two sympatric marsupials from the Atlantic Forest of Santa Catarina Island in southern Brazil.

Lc = *Lutreolina crassicaudata*, Md = *Micoureus demerarae*. SD = Standard deviation.
N is the number of times each seed species was recorded regarding all fecal samples of one marsupial.

Marsupial	Seed species	Total number	Mean ± SD	Minimum	Maximum	N
Lc	*Cecropia glaziovii*	2263	206 ± 244	2	725	11
Md		306	28 ± 41	1	117	11
Lc	*Ficus* sp.	742	371	11	731	2
Md		2	1	1	1	2
Lc	*Piper* sp.1	7170	896 ± 2275	1	6500	8
Md		337	42 ± 73	1	189	8
Md	*Piper* sp.2	66	33	14	52	2
Md	*Maclura tinctoria*	14	7	2	12	2
Md	*Ottonia martiana*	132	19 ± 19	1	46	7

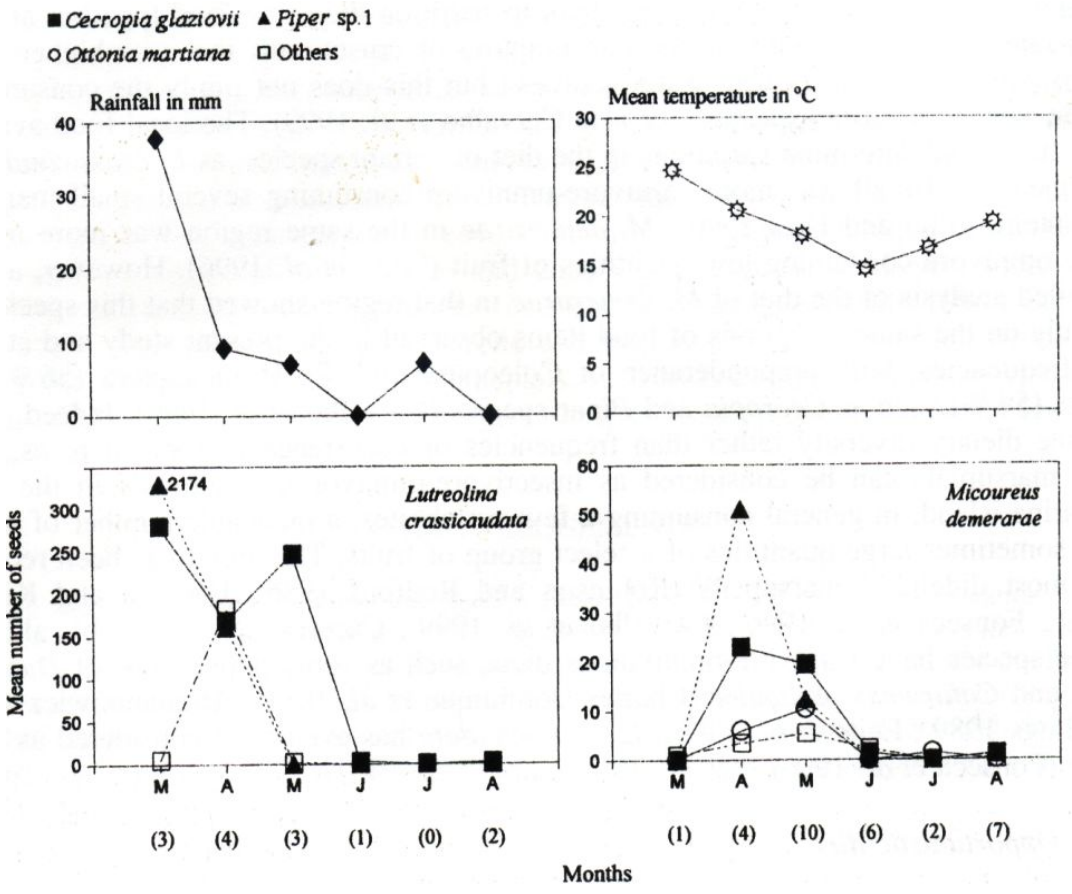

Fig. 1. – A comparative view of the seasonality during the study period (1998) regarding rainfall, temperature (above) and fruit consumption (mean number of seeds in fecal samples) by two didelphid marsupials (below) in the Atlantic Forest of the Santa Catarina Island, southern Brazil. Numbers below each month are sample sizes (n° of feces). The number 2174 (below, left) belongs to the real mean value of the respective triangle for *L. crassicaudata*.

creek, whereas the captures of *M. demerarae* were mainly above ground (83 %), independent of the creek distance. In addition, for *M. demerarae* the ratio of ground to understory captures showed a marginally significant negative correlation (Spearman Rank Order ; Siegel 1981) to the frequencies of occurrence of seeds in feces (R = -0.76, N = 6 months, P = 0.08) ; in other words, when *M. demerarae* was trapped more on the ground there were less fruits in its diet.

DISCUSSION

Feeding strategies

Although the two marsupials studied are sharply different in the habitat use level, with *L. crassicaudata* being terrestrial prefering to live near creeks and streams (Marshall 1978 ; Monteiro-Filho and Dias 1990) and *M. demerarae* being strongly arboreal (Charles-Dominique *et al.* 1981 ; Leite *et al.* 1996, this study), we found a high dietary overlap between them. A possible explanation is that *M. demerarae* descends to the ground when food availability is low (as was estimated based on fruits consumed in our study), where it forages for similar food to that eaten by *L. crassicaudata*. But the high dietary overlap between opossums may also be explained by a probable local limitation of food resources, leading them to partition the same food type but at diffe-rent rates. A good example is the consumption of crustaceans that was higher for *L. crassicaudata*, that lives near water sources, but this does not imply in the consumption on the same crustacean species (see also Carvalho *et al.* 1999). The local food availabi-lity thus could determine variations in the diet of certain species, as *L. crassicaudata* in Southeastern Brazil was more carnivore-omnivore consuming several small mammals (Monteiro-Filho and Dias 1990). *M. demerarae* in the same region was more insectivore-omnivore consuming low quantities of fruit (Leite *et al.* 1996). However, a more detailed analysis of the diet of *M. demerarae* in that region showed that this species fed mainly on the same categories of food items observed in the present study and at similar frequencies, with preponderance of Coleoptera (63 %), Hymenoptera (56 %) and fruits (59 %) such as *Cecropia* and *Piper* species (Carvalho *et al.* 1999). Indeed, based on the dietary diversity rather than frequencies of occurrence of food in feces, these two marsupials can be considered as insectivore-omnivorous mammals in the Santa Catarina island, in general consuming a few vertebrates, a razonable number of insects and sometimes large quantities of a select group of fruits. This trend has been recorded for most didelphid marsupials (Robinson and Redford 1986 ; Fonseca and Kierulff 1989 ; Fonseca *et al.* 1996 ; Carvalho *et al.* 1999 ; Cáceres in press a, b), although some species have frugivore-omnivorous diets, such as some populations of *Didelphis* spp. and *Caluromys philander* (Charles-Dominique *et al.* 1981 ; Atramentowicz 1988 ; Stallings 1989 ; Leite *et al.* 1996). *L. crassicaudata* has even been considered as piscivore (Fonseca *et al.* 1996).

Opportunistic diet

The opposums studied fed on fruits in a seasonal scale apparently resembling the fruit availability in the field, since tropical and subtropical forests show seasonal patterns of fructification (Smithe 1970 ; Charles-Dominique *et al.* 1981 ; Foster 1982 ; Galleti and Aleixo 1998). The feeding opportunism of opossums in general is well known in the Neotropics (Atramentowicz 1988 ; Medellín 1994 ; Cáceres *et al.* 1999).

Diet and body size

As well as the difference in habitat use between the two opossums, they also differ in body size, with *L. crassicaudata* averaging 530 g and *M. demerarae* averaging 100 g (Fonseca *et al.* 1996). This could explain the large difference in quantities of seeds consumed by *L. crassicaudata* or even the low diversity of animal items found for *M. demerarae*, which should satiate its nutritional requirements with a smaller quantity of animals consumed (see Julien-Laferrière and Atramentowiz 1990, for other marsupial genera). Analysing available data, there appears to be a trend for the median sized marsupials to ingest more vertebrates, as is the case of *L. crassicaudata* and the gray four-eyed opossum *Philander frenata* (230 - 360 g), whereas smaller marsupials ingest more arthropods and fewer vertebrates, as is the case of *M. demerarae* and the gracile mouse opossum *Gracilinanus microtarsus* (Monteiro-Filho and Dias 1990 ; Leite *et al.* 1996 ; Santori *et al.* 1997 ; Carvalho *et al.* 1999 ; Talamoni *et al.* 1999 ; this study), but there are exceptions such as the median-sized brown four-eyed opossum *Metachirus nudicaudatus* (290 g) which is strongly insectivore (Santori *et al.* 1995 ; Cáceres in press a).

Role on seed dispersal

For seed dispersal, both species could generate differential seed rains, just because they ingest seeds at different rates and occupy different habitats. The high consumption of fruits from pioneer plants, such as *Cecropia* (whose seeds remained alive after having passed through the gut of *L. crassicaudata* – N.C. Cáceres, personal observation), by opossums deserves emphasis (see also Monteiro-Filho and Dias 1990 ; Leite *et al.* 1996 ; Carvalho *et al.* 1999 ; Grelle and Garcia 1999). *Cecropia* is an important colonizing plant (Tabarelli and Mantovani 1999) and is often seen in disturbed or open habitats in South and Southeastern Brazil. The possible role in seed dispersal by didelphid marsupials has been shown in several studies (Charles-Dominique *et al.* 1981 ; Atramentowicz 1988 ; Monteiro-Filho and Dias 1990 ; Leite *et al.* 1996 ; Vieira and Izar 1999), particularly regarding pioneer or secondary plants (Medellín 1994 ; Cáceres *et al.* 1999 ; Carvalho *et al.* 1999 ; Grelle and Garcia 1999 ; Cáceres and Monteiro-Filho 2000 ; Cáceres in press a, b). Marsupials, such as *Lutreolina* and *Micoureus*, may be considered as seed dispersers, since they show at least the main ecological requirements for it.

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