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Diet of *Didelphis aurita* and *Micoureus paraguayanus* and the fruit availability in a semideciduous Atlantic forest in Southern Brazil

Dieta de *Didelphis aurita* e *Micoureus paraguayanus* e a disponibilidade de frutos em uma floresta Atlantica semidecidual no sul do Brasil

Janaina Casella[1]
janacas@gmail.com

Abstract

This study analysed the effects of diets and resource partitioning among *Didelphis aurita* and *Micoureus paraguayanus*, and their relationships with food availability in a semideciduous Atlantic Forest of southern Brazil. Species were separated by sex, age and reproductive condition to compare with dietary data. The fruit availability in the area was quantified bimonthly through collection of fleshy fruits and flowers available on the ground of the study area. Individuals of *D. aurita* trapped in the canopy *vs.* those trapped on the ground, or even regarding age and sex classes, did not differ in regards to their diet composition. Animals studied were heterogeneous in relation to their diet composition, being significantly different from each other (p = 0.03). The largest diversity indexes observed for both species in faeces and in the environment occurred during the rainy season. Both species presented insects in their diets, but with natural tendency to consume fruits or vertebrates (*D. aurita*). Rhythms of fructification of *Piper* sp. correlated with consumption by *D. aurita* (r_s = 0.90, p = 0.03) and not by *M. paraguayanus* (r_s= 0.40, p = 0.60). There were tendencies where independent young and lactiferous females of *D. aurita* correlated to the peaks of fruit availability during the rainy season.

Key words: mammals, Didelphidae, resource availability, vertical strata, food habit.

Resumo

Foi analisado o efeito da dieta e partilha de recursos entre *Didelphis aurita* e *Micoureus paraguayanus*, e suas relações com a disponibilidade de alimentos em uma floresta Atlantica semidecidual do sul do Brasil. As espécies foram separadas por sexo, idade e condições reprodutivas para comparar com dados da dieta. A disponibilidade de frutos na área foi quantificada bimestralmente através da coleta de frutos carnosos e flores disponíveis no solo da área de estudo. Indivíduos de *D. aurita* capturados no dossel *vs.* capturados no solo, ou mesmo os que diferem em idade e sexo, não diferem no que diz respeito a composição da dieta. Em relação a composição da dieta, os animais estudados eram heterogêneos, sendo significativamente diferentes entre si ($p = 0,003$). Os maiores índices de diversidade observados nas fezes de ambas as espécies ocorreram durante a estação de chuva. Ambas espécies apresentaram insetos em suas dietas, mas com tendências naturais ao consumo de frutos ou vertebrados (*D. aurita*). Ritmos de frutificação de *Piper* sp. correlacionaram-se com o consumo por *D. aurita* (r_s = 0.90, p = 0.03) e não por

[1] Graduate Program of Ecology and Conservation, CCBS, Departament of Biology, Federal University of Mato Grosso do Sul, C.P. 549, 79070-900, Campo Grande, MS, Brazil.

M. paraguayanus ($r_s = 0.40$, $p = 0.60$). Houve tendências onde jovens independentes e fêmeas lactantes de *D. aurita* correlacionaram com os picos de disponibilidade de frutos disponíveis durante a estação chuvosa.

Palavras-chave: mamíferos, Didelphidae, disponibilidade de recursos, estrato vertical, hábito alimentar.

Introduction

The neotropical marsupials are generally known as small omnivore mammals, consuming all food types, and these animals are not specialists in any food category (Santori *et al*., 1995; Astúa de Moraes *et al*., 2003). Nevertheless, studies have shown didelphid marsupials as presenting divergent diets from the traditional omnivory, such as trends to frugivory (*Caluromys philander*), carnivory (*Lutreolina crassicaudata*) or insetivory (*Metachirus nudicaudatus*) (Charles-Dominique *et al*., 1981; Atramentowicz, 1988; Leite *et al*., 1996; Fonseca *et al*., 1996; Carvalho *et al*., 1999; Vieira and Astúa de Moraes, 2003; Astúa de Moraes *et al*., 2003). However, invertebrates are currently the main food resources for didelphid marsupials (Fonseca and Kierulff, 1989; Busch and Kravetz, 1991; Carvalho *et al*., 1999; Talamoni *et al*., 1999; Pinheiro *et al*., 2002), classified as being in the majority insectivore-omnivore (Robinson and Redford, 1986; Fonseca and Kierulff, 1989; Fonseca *et al*., 1996).

Didelphis aurita and *Micoureus paraguayanus* were more insectivore-omnivore, consuming food resources according to their proportion and availability in the environment (Leite *et al*., 1996; Cáceres *et al*., 1999; Cáceres, 2003; Carvalho *et al*., 2005). However, *D. aurita* has been considered as mostly omnivorous (Santori *et al*., 1995; Astúa de Moraes *et al*., 2003), but sometimes it is characterized as being mostly frugivore as well (Stallings, 1989; Cáceres and Monteiro-Filho, 2001; Cáceres *et al*., 2009). On the other hand, a more detailed analysis of the diet of *M. Paraguayanus* have indicated that this specie consumes, in general, a few vertebrates prey, a reasonable number of insects and sometimes large quantities of a select group of fruits (Cáceres *et al*., 2002; Casella and Cáceres, 2006). One of the factors that differentiate niches in a guild is the foraging strategy, which may be determined by body size and form. Differences among species in niches they occupy may allow the coexistence of a great number of species in communities (Medellín, 1991; Leite *et al*., 1996; Vieira, 2006). Besides, the vertical use of space by marsupials has considerable importance in the spatial separation of sympatric species. This increases the possibility of resource partitioning among them rather than competition (Charles-Dominique *et al*., 1981; Julien-Laferrière, 1991).

Most studies carried out in Brazil referring to diet or food partitioning among marsupials are related to biomes other than semideciduous forest, such as restinga (Santori and Astúa de Moraes, 2006), mixed ombrophyll forest (Cáceres and Monteiro-filho, 2001) and dense ombrophyll forest (Leite *et al*., 1996; Carvalho *et al*., 1999; Cáceres *et al*., 2002; Pinheiro *et al*., 2002; Cáceres *et al*., 2006). Data on diet for *Didelphis* and *Micoureus*, for example, are scarce and normally available for the dense Atlantic forest only (Leite *et al*., 1996; Carvalho *et al*., 1999). So, it has been mentioned the need of studying interactions among the diets of marsupials for better comprehension of their strategies of resource partitioning.

Therefore, this study aims to analyze the diet of the black-eared opossum *Didelphis aurita* (Wied-Neuwied 1826) and of the woolly mouse opossum *Micoureus paraguayanus* (Tate, 1931) and it also intends to obtain information on relationships between the diet and the food availability.

Material and Methods

Study area

The National Park of Iguaçu is located in southern Brazil, near Misiones, Argentina, at coordinates 25º39’10.95”S and 54º26’14.53”W. The National Park of Iguaçu (PNI) is considered the largest Brazilian Conservation Unit in the domain of the Atlantic Rain Forest, with approximately 185 000 ha, and it is also one of the last reminiscences of that vegetation in the south of the country. It is represented by the semideciduous seasonal forest (in the most part of the area), mixed ombrophyll forest (north-eastern portion) and pioneer alluvial formation (IBAMA, 1999). The rainy period is from October to January and the dry period is from June to August. The mean annual temperature ranges between 18 and 20ºC, being 34 to 36º C the maximum monthly temperatures and -8 to 4ºC the minimum temperatures. The annual rainfall varies from 1500 to 1750 mm (data from SIMEPAR, the Meteorological System of Paraná). The hotter period is from November to April, and the colder period is from May to October.

This study included a 4 ha-grid inserted in the semideciduous seasonal forest, with an altitude of approximately 400 m above the sea level.

Captures and marking

The capture of marsupials was done by using 150 traps: 130 of wire mesh (90 large of 40x16x16 cm and 40 small of 20x15x15 cm in size) and 20 Sherman type (40x12x12 cm). The 100 wire traps (90 large and 10 small) were set in the canopy and other ones were set on the ground. The traps were set in November 2004, January, March, May and July 2005, being the ground traps activated in November. The captures occurred during 10 consecutive days in field phase, with a total of 50 days of sampling collection.

Ten transect lines were set 20 m apart from each other in the continuous forest, with 15 traps in each transect line. In each transect line 10 traps were placed in the canopy (20 m apart) and five on the ground (40 m apart). The canopy traps were lifted by mean of ropes (10 to 20 m high), positioned in wood platforms connected to trees (following Charles-Dominique *et al*., 1981). The traps were baited randomly with bacon, banana, pumpkin or pineapple, mixed with codfish liver oil. They were checked every morning and new baits were placed when necessary. The captured animals were identified according to species, weighed (in grams), sexed, checked for reproductive condition (pouch youth and milk production), and aged (by verifying dentition in accordance to Tyndale-Biscoe and Mackenzie, 1976). For individual identification, animals were marked with combinations of holes in the ears (Monteiro-Filho, 1987) and released.

Faecal samples and diet analyses

The faeces of the animals captured were collected on the floor of the cages after the release of the animals. The same faeces were stored in plastic bags for a posterior analysis in laboratory. Samples were washed with water by using a mesh sieve of 1 mm and analyzed in a stereoscopy. Seeds contained in each sample were separated at the species level, identified by using a guide and compared to a reference collection. The vertebrate items were identified at the class level based on the presence of feather, bones, fur and/or teeth. Insects were identified up to the order level through fragments of their body and legs.

To analyze possible differences between the diet compositions of the two species of marsupials, a multivariate analysis was used through the main coordinates (PCoA), the statistical program used was Past 1.89 (Hammer *et al*., 2001). The ordinations (matrix of the association) were done based on the presence-absence of food items in samples and calculated by the similarity index of Sorensen, known as Coefficient of Community (Costa *et al*., 2005). This index gives more importance to rare items in the samples, considering that more abundant data usually occur in many localities having a small contribution to these differences. (Costa *et al*., 2005). This test was used to compare the diet among individuals from both species. Due to the higher amount of samplings, comparisons were also performed for diet variations in *D. aurita*, taking into account age classes (young *vs*. adults) and sexes (male *vs*. female).

Faecal samples from the same individual in consecutive days of trapping were excluded from the analyses; avoiding pseudoreplication occasioned by recaptures in short time intervals (Cáceres, 2000). Thus, there was made an effort to the independence of the faecal samples when they occasionally came from the same animals.

In the interspecific analyses, when there was the capture of only one of the species in a given field phase, the data were excluded in order to standardize comparisons between species.

Fruit availability in the environment

The fruit availability in the study area was quantified by the collection of zoochoric fruits available on the ground along the 10 transect lines set for animal captures, all 1 m width, during the periods of capture and monitoring of the animals. Fruits and flowers were counted and placed in plastic bags and then weighed (in grams). The number of species of fruits and flowers was also evaluated in each field phase. Bushes of *Piper* sp. were evaluated due to previously known importance of the marsupial diets (Medellín, 1994; Henry, 1999; Cáceres *et al*., 2002), and compared with the presence of respective seeds in faeces. Bushes were counted in the study area within the same transect lines used for fruit availability. For all statistical analysis, the alfa value was 0.05.

Relationships of diet and fruit availability

In order to evaluate the relationship among the quantity of fruits (estimated by the seed number) consumed by *D. aurita* and *M. paraguayanus* and the total mass of zoochoric fruits available in the environment, the Spearman Correlation (r_s) was used. Such test was also used to verify the relationship between the number of seeds of *Piper* sp. present in faeces of the two marsupial species in relation with the fruiting plants of *Piper* sp. observed, besides the relationship between the diversity of seeds (calculated by the index of Shannon) and the diversity of fruit in the environment.

Results

Diet

Field work resulted in 8500 trap nights and 50 faeces collected, being 42 samples of *D. aurita* (33 animals captured) and eight of *M. paraguayanus* (four animals captured).

Both opossum species presented insects in their diets, but with a higher or lower consumption of fruits or vertebrate animals. *Didelphis aurita* was more omnivorous showing more similar frequencies of occurrence of the food categories among themselves. The consumption of vertebrates by *D. aurita*, such as birds and mammals, was also evidenced whereas for *M. paraguayanus* there was the main consumption of insects and some fruit species (Figure 1).

The most consumed insect categories were Coleopterans which were present in 92.9 % of the samples of *D. aurita* and in 87.5 % of *M. paraguayanus* (Figure 1).

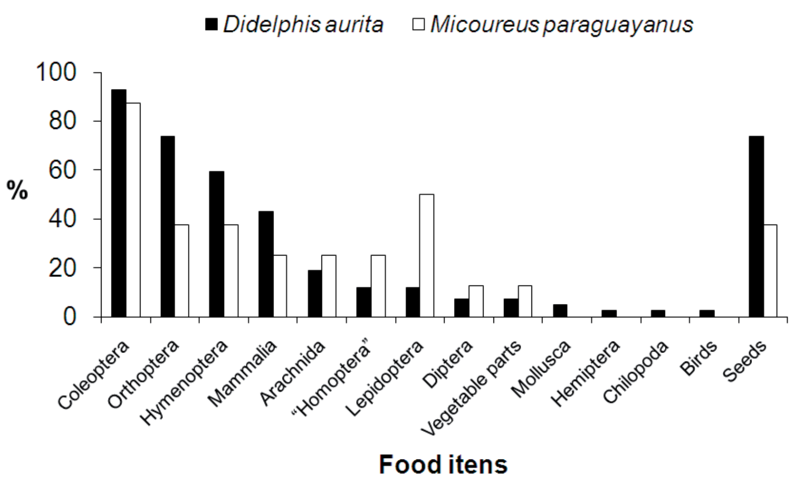

Figure 1. Percentage of food items in faeces of the marsupials *Didelphis aurita* and *Micoureus paraguayanus* in a seasonl semideciduos forest of the Iguaçu National Park, southern Brazil.

A total of 29 753 seeds was found in faecal samples of *D. aurita*, including *Piper* sp., *Cecropia pachystachya*, and *Jaracatia spinosa*. For *M. paraguayanus*, the total was 1803 smaller seeds, including *Piper* sp. There were a high proportion of whole, not damaged seeds (> 90%) in comparison to a small proportion of damaged seeds, for both marsupial species.

In a general view, marsupials showed heterogeneous diet compositions, differing significantly between both species ($P = 0.03$; F = 3.921; g.l. = 4 and 84; Pillai Trace = 0.238).

Individuals of *D. aurita* captured in the canopy *vs*. those captured on the ground did not differ significantly in the diet composition ($P = 0.68$; F = 0.390; g.l.= 2 and 30; Pillai Trace = 0.025). Only young individuals were captured in the canopy (age classes 2 and 3).

There were no significant differences in the diets between age classes ($P = 0.290$; F = 1.288; g.l. = 2 and 30; Pillai Trace = 0.079) or within sexes ($P = 0.90$; F = 0.106; g.l. = 2 and 30; Pillai Trace = 0.007) of *D. aurita*.

Frugivory and seasons

Avoiding pseudoreplication occasioned by recaptures in short time intervals a total of 33 faeces of *D. aurita* and eight faeces of *M. paraguayanus* were analyzed for seasonal variation in the diets. The highest number of seeds in faeces was registered in January for *D. aurit* and in March for *M. paraguayanus* (Table 1, Figures 2a, 2b).

The mass of zoochoric fruits in the environment was higher in July, followed by March. The highest abundance of fruits was in March, with 12 plant species. The greatest peak of biomass in July is attributed to *Citrus aurantium*, an exotic species whose fruit is large, which was responsible for 51% of the total mass of fruits. When the *C. aurantium* was excluded, the peak of zoochoric fruits changed to March. The biomass of fruits was smaller in January. The total biomass of flowers in the environment was greater in November, being the flowers of the Sweet Palm Tree, *Euterpe edulis*, the main responsible for this peak (Table 2).

The highest diversity indexes observed in faeces occurred during the wetter season (September to March), being 0.306 for seeds in faeces of *D. aurita* in March, and 0.43 in faeces of *M. paraguayanus* in January, whereas the highest index for the environment was 0.63 in November. The correlation analysis among diversity of fruits in the environment *vs.* diversity of fruits in faeces of *D. aurita* revealed a positive trend ($r_s = 0.90$; $Pp = 0.03$) (Figure 3a), whereas for fruits in the environment *vs.* diversity of fruits in faeces of *M. paraguayanus* there was seen no relationship ($r_s = 0.40$; $P = 0.60$) (Figure 3b).

The highest number of fruiting *Piper* sp. observed was 73 in January, declining in the next months. The mean number of seeds of *Piper* sp. in faeces of *D. aurita* and *M. paraguayanys* was higher in January (1935) and March (203), respectively. The analysis of correlation between the number of fruiting plants of *Piper* sp. *vs.* the average number of respective seeds in faeces of *D. aurita* showed a positive trend ($r_s = 0.90$; $P = 0.04$) (Figure 3c) whereas there was no relation seen for *M. paraguayanus* ($r_s = 0.60$; $P = 0.40$) (Figure 3d).

Frugivory and reproduction

Only *D. aurita* was captured with pouch young during the study. The largest litter size was with 12 individuals in November 2004, averaging 4.5 cm in length. There was not a trend to a relationship between the mean pouch young length and richness of seeds in faeces of *D. aurita* ($r_s = 0.41$; $P = 0.49$) (Figure 4a). However, there was a significant relationship between the number of independent young of *D. aurita* and the richness of seeds species consumed during the study ($r_s = 0.95$; $P = 0.01$) (Figure 4b), with peaks of independent young mainly in November and in January.

Discussion

Seasonal forests can have reasonable influence on animal diets, making them seasonally dependent of feeding resources. However, in a general view, the diets of marsupials seen here are very similar to those reported in more dense Atlantic forest sites (Carvalho *et al*., 1999; Cáceres and Monteiro-

Table 1. Mean number of seeds present in faeces of didelphid marsupials in the Iguaçu National Park, southern Brazil. Higher numbers of Piper sp. seeds were responsible for peaks observed for both species.

Months/Species	***Didelphis aurita***	***Micoureus paraguayanus***
	Mean ⬅ SD	Mean ⬅ SD
November 2004	109 ⬅ 188 (172 %)	-
January 2005	1962 ⬅ 2215 (113 %)	211 ⬅ 244 (116 %)
March 2005	217 ⬅ 510 (235 %)	594 ⬅ 0 (0 %)
May 2005	35 ⬅ 29 (83 %)	3 ⬅ 0 (0 %)
July 2005	100 ⬅ 39 (39 %)	196 ⬅ 146 (74 %)
Total	29 787	1802

Note: Standard deviation is given and the coefficient of variation is in parentheses.

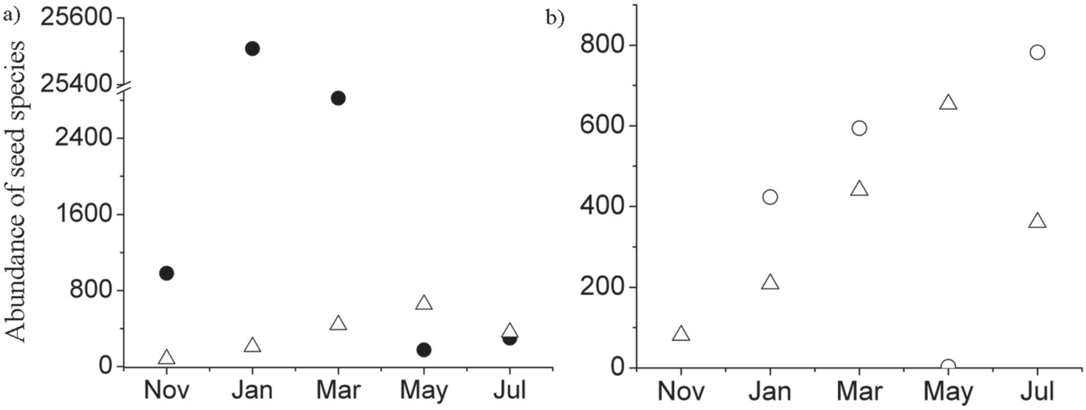

Figure 2. Abundance of seed fruit species in faeces of the marsupials (circle): (a) *Didelphis aurita* and (b) *Micoureus paraguayanus* compared to the fruit abundance of the environment (triangule) in the Iguaçu National Park, southern Brazil.

Table 2: Biomass of fleshy fruits and flowers (in grams) between November 2004 and July 2005 in the Iguaçu National Park, southern Brazil.

	November	January	March	May	July
Fruits					
Citrus aurantium	780 (5)	380 (3)	170 (2)	646 (6)	**1075** (8)
Guarea kunthiana	450 (32)	357 (28)	977 (187)	556 (416)	844 (136)
Euterpe edulis	20 (5)	105 (152)	375 (**546**)	122 (139)	140 (186)
Porcelia sp.	270 (1)				
Cecropia pachystachya		15 (1)			
Jaracatia spinosa			197 (5)		
Ocotea sp.		15 (11)	21 (18)	1 (3)	
Chysophyllum sp.				72 (35)	1 (3)
Species unidentified	28 (38)	34 (20)	27 (72)	27 (55)	52 (28)
Number of species (unidentified)	7 (3)	7 (2)	12 (7)	8 (3)	5 (1)
Total mass	1548 (81)	902 (209)	1767 (440)	1413 (**654**)	**2111** (361)
Flowers					
Euterpe edulis	60 (**5892**)		- (142)		- (619)
Guarea kunthiana	110 (998)	45 (261)		12 (54)	
Chorisia speciosa			285 (75)		
Species unidentified	7 (21)	101 (109)	495 (1677)	200 (165)	250 (406)
Number of species (unidentified)	3 (1)	3 (2)	5 (3)	5 (4)	3 (2)
Total mass	170 (**6911**)	152 (370)	**794** (1894)	212 (219)	250 (1025)

The largest values are in bold. The hyphen indicates despicable mass (under 0.1 g). The total number of individuals is given in parentheses.

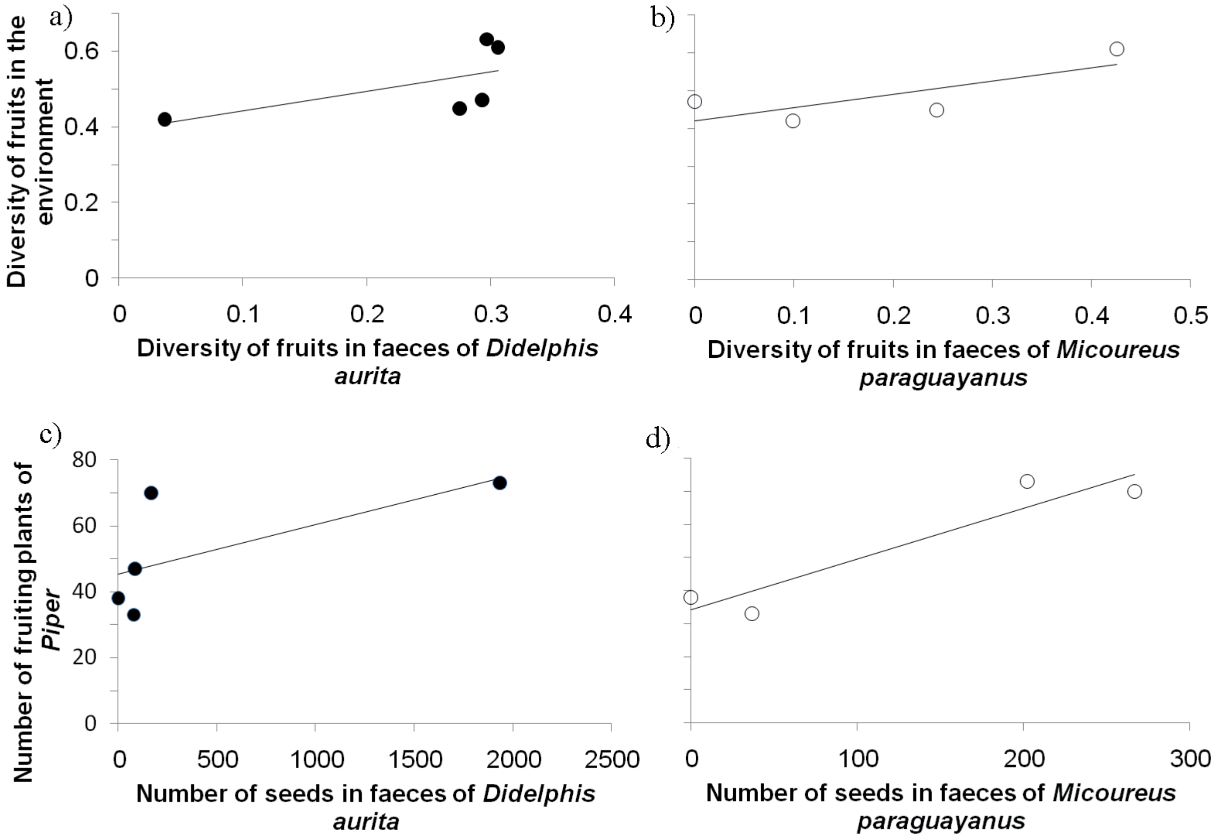

Figure 3. (a) Correlation of Spearman among diversity for zoochoric fruits present in the environment and diversity of fruits in faeces of the marsupials (b) *Didelphis aurita* and (c) *Micoureus paraguayanus*. Correlation of Spearman among number of fruiting individuals of Piper sp. observed in the study area and mean number of seeds of Piper sp. in faeces of (d) *Didelphis aurita* and (e) *Micoureus paraguayanus* in the Iguaçu National Park, southern Brazil.

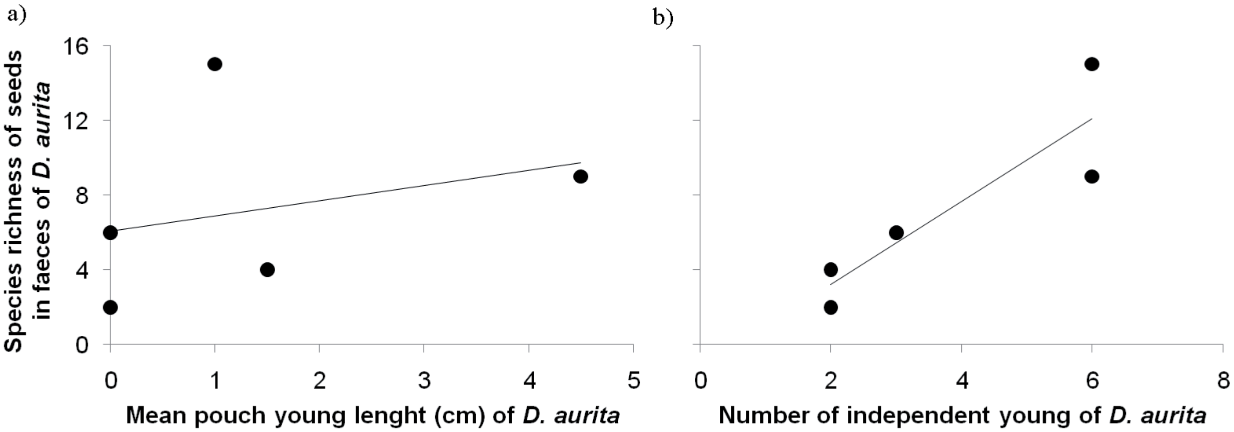

Figure 4. (a) Correlation of Spearman among richness of seeds species in faeces of *Didelphis aurita* and mean pouch young length (cm) of the opossum *Didelphis aurita*. (b) Correlation of Spearman among richness of seeds species in faeces of *Didelphis aurita* and number of independent young of Didelphis aurita sampled in the Iguaçu National Park, southern Brazil.

Filho, 2001; Cáceres *et al*., 2002). Probably, seasonal differences among the physiognomies present in the Atlantic Forest *sensu lato* (e.g. dense, mixed, and semideciduous forest) are not very large (M.D. Alive, *pers. comm*), providing similar dietary resources in terms of great taxonomic groups (e.g. Coleopterans). In spite of the most didelphid marsupials being commonly considered as insectivorous-omnivorous (Robinson and Redford, 1986; Fonseca and Kierulff, 1989; Fonseca *et al*., 1996), differences in this omnivory can be seen when more detailed analyses are done. As an example, *D. aurita* consumed more vertebrate prey than *M. paraguayanus*, and this last species consumed more Lepidopterans, and such differences had already been observed elsewhere (Cáceres *et al*., 2002).

These differences were already emphasized in other communities of marsupials in more humid coastal places (Santori *et al*., 1995; Carvalho *et al*., 1999; Cáceres *et al*., 2002; Santori *et al*., 2004) or even in similar forests (Casella and Cáceres, 2006). The insectivorous habit seems to dominate among the neotropical small mammals (Fonseca and Kierulff, 1989), mainly in cursorial and escansorial ones (Vieira and Astúa de Moraes, 2003; Casella and Cáceres, 2006). The consumption of other items, such as fruits, seems to take place randomly, except for arboreal and frugivorous-omnivorous species which consume fruits more regularly (Charles-Dominique *et al*., 1981; Julien-Laferrière, 1999; Vieira and Astúa de Moraes, 2003; Vieira, 2006).

Micoureus paraguayanus is known as an arboreal species and, despite of having been captured only in the canopy here, it consumed fruits in lower frequency than *D. aurita*. However, body size differences between these species can be one of the reasons for such differences in diet, because the larger the body size, the more fruits will be found in the diet of such animal (Cáceres *et al*., 2002). It is important to note that *D. aurita* is 10 times larger in body size than *M. paraguayanus*, or more (Fonseca *et al*., 1996). Another factor can be the habitat which could drive diets for some specialities (Cáceres *et al*., 2002). Ecological segregation of marsupials is being suggested to be regulated by use of space rather than competition (Astúa de Moraes *et al*., 2003). The trend of *M. paraguayanus* for insectivory was verified in a dense Atlantic Forest site (Leite *et al*., 1996), but trends for frugivory was reported for the same species elsewhere (Cáceres *et al*., 2002).

The proportion of frugivory increases as the arboreal habit of species is dominant (Vieira and Astúa de Moraes, 2003). We would expect *M. paraguayanus* as more frugivore since the species is arboreal, but this was not seen here probably due to the low number of faeces collected here. On the other hand, scansorial species tend to exhibit a more balanced diet between arthropods and fruits (50: 50 %), such as the species of *Didelphis* (Atramentowicz, 1988; Cáceres and Monteiro-Filho, 2001).

Hence, *D. aurita* was more omnivorous than *M. paraguayanus* in the study area, showing a tendency to consume all kinds of items. This should be provided by its scansorial mode of locomotion, larger body size and opportunism. This dietary pattern has been observed in Brazil (Stallings, 1989; Santori *et al*., 1995; Cáceres and Monteiro-Filho, 2001, Cáceres *et al*., 2009), French Guiana (Charles-Dominique *et al*., 1981; Atramentowicz, 1988) and Venezuela (Cordeiro and Nicolas, 1987).

In spite of the simpatry of the animals studied, they are not syntopic most of the time, one dwelling mostly in the canopy (*M. paraguayanus*: Leite *et al*., 1996; Graipel *et al*., 2003) and the other on the ground (*D. aurita*: Leite *et al*., 1996; Graipel *et al*., 2003). Such differences, on the view of *D. aurita*, would also happen due to the exploration of resources found in the litter (Cáceres and Monteiro-Filho, 2001). Even young *D. aurita* captured substantially in the canopy did not overlap in feeding habits with the arboreal *M. paraguayanus*.Young *D. aurita* should make rapid incursions in the canopy, exploring more resources on the ground (Miles *et al*., 1981; Vieira, 2006). However, fruits and nectar could be consumed by *D. aurita* when in the arboreal stratum (Vieira *et al*., 1991; Vieira and Izar, 1999). On the other hand, *M. paraguayanus* seems to use the ground level during certain times of fruit rarefaction in the canopy (Cáceres *et al*., 2002).

Feeding differences among individuals of different ages were not observed in this study and neither in other place, although some differences in consumption of snakes have been observed (Cáceres, 2002). Nonetheless, differences for the gray four-eyed opossum *Philander frenatus* have been noticed (Santori *et al*., 1997).

The occurrence of strategies in which animals reproduce in periods when there is the highest amount of fruits is related to species that face seasonal fluctuations in the availability of resources. Normally, there is a synchronism between reproductive periods and fruit availability, which is markedly important in semideciduous forests. Marsupial species stop reproduction in times when there is a decrease in food availability, by exhibiting an anoestrous phase (Julien-Laferrière and Atramentowicz, 1990; Martins, 2004; Leiner and Wesley, 2007; Monteiro-Filho and Cáceres, 2006).

The production on flowers and fleshy fruits were more intense in the rainy season, as is expected for semideciduous seasonal forest (Smallwood and Howe, 1982; Terborgh, 1986; Van Schaik *et al*., 1993). The abundance of fruits can influence the reproductive success of vertebrates (Howe, 1986; Powlesland *et al*., 1997; Henry, 1999). In this study, during the wetter months (e.g. November to January), there were large quantities of fruits in the diet of *D. aurita,* which is thought to be associated with the effort and energy demands in reproduction of the species during this period (Julien-Laferrière and Atramentowicz, 1990; Monteiro-Filho and Cáceres, 2006). This opossum species spends high energy demand with lactation rather than pregnancy, and obligatory lactating phase and release of young from the pouch occur in favourable times, which is fruit and flower richest. The intensity of these plant resources evidenced here are thought to be very important nutritionally (such as sugars) for these mammals during this time, as have been observed for the *Piper* in the study area.

This strategy of reprodution in season with much fruit is related with species that face seasonal fluctuations in resource availability, there is synchrony between reproductive periods and fruit availability in the environment, even in less seasonal Forest (evergreen), with interruption of reproduction when there is a less food availability (Julien-Laferrière and Atramentowicz, 1990; Monteiro-Filho and Cáceres, 2006). Many species of marsupials didelphids behave this way, such as *Marmosops paulensis* (Leine, 2005), *D. marsupialis*, *P. opossum* (Julien-Laferrière and Atramentowicz, 1990) and *Gracilinanus microtarsus* (Martins, 2004).

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References

ASTÚA DE MORAES, D.; SANTORI, R.T.; FINOTTI, R.; CERQUEIRA, R. 2003. Nutritional and fibre contents of laboratory-established diets of neotropical opossums (Didelphidae). *In*: M. JONES; C. DICKMAN; M. ARCHERS (eds.), *Predators with pouches: the biology of carnivorous marsupials*. CSIRO, Collingwood, Australia, p. 229-237.

ATRAMENTOWICZ, M. 1988. La frugivorie opportuniste de trois marsupiaux didelphidés de Guyane. *Revue d`Ecologie (Terre et Vie)*, **43**:47-57.

BUSCH, M.; KRAVETZ, F.O. 1991. Diet composition of *Monodelphis dimidiata* (Marsupialia Didelphidae). *Mammalia*, **55**:619-621.

CÁCERES, N.C.; PRATES, L.Z.; GHIZONI-Jr, I.R.; GRAIPEL, M.E. 2009. Frugivory by the black-eared opossum *Didelphis aurita* in the Atlantic Forest of southern Brazil: Roles of sex, season and sympatric species. *Biotemas*, **22**(3):203-211.

CÁCERES, N.C.; DITTRICH, V.A.O.; MONTEIRO-FILHO, E.L.A. 1999. Fruit consumption, distance of seed dispersal and germination of solanaceous plants ingested by the common opossum (*Didelphis aurita*) in southern Brazil. *Revue d'Ecologie Terre et Vie*, **54**: 225-234.

CÁCERES, N.C. 2002. Food habits and seed dispersal by the white-eared opossum *Didelphis albiventris* in southern Brazil. *Studies on Neotropical Fauna & Environment*, **37**:97-104. http://dx.doi.org/10.1076/snfe.37.2.97.8582

CÁCERES, N.C. 2003. Use of the space by the opossum *Didelphis aurita* Wied-Neuwied (Mammalia, Marsupialia) in a mixed forest fragment of southern Brazil. *Revista Brasileira de Zoologia*, **20**:315-322. http://dx.doi.org/10.1590/S0101-81752003000200023

CÁCERES, N.C. 2000. *Dieta, adaptações à alimentação e dispersão de sementes por marsupiais do sul do Brasil.* PhD thesis, Universidade Federal do Paraná, Curitiba, p. 1-132.

CÁCERES, N.C.; BERGALLO, H.G.; MONTEIRO-FILHO, E.L.A. 2006. Dinâmica populacional de marsupiais brasileiros. *In*: N.C. CÁCERES; E.L.A. MONTEIRO-FILHO (eds.), *Os marsupiais do Brasil: biologia, ecologia e evolução*. Universidade Federal do Mato Grosso do Sul, Campo Grande, p. 229-240.

CÁCERES, N.C.; GHIZONI-JR., I.R.; GRAIPEL, M.E. 2002. Diet of two marsupials, *Lutreolina Crassicaudata* and *Micoureus demerarae* in a coastal Atlantic Forest island of Brazil. *Mammalia*, **66**:331-340. http://dx.doi.org/10.1515/mamm.2002.66.3.331

CÁCERES, N.C.; MONTEIRO-FILHO, E.L.A. 2001. Diet, home range and activity of *Didelphis aurita* (Mammalia, Marsupialia) in a forest fragment of southern Brazil. *Studies on Neotropical Fauna & Environment*, **36**:85-92. http://dx.doi.org/10.1076/snfe.36.2.85.2138

CARVALHO, F.M.V.; FERNANDEZ, F.A.S.; NESSIMIAN, J.L. 2005. Food habits of sympatric opossums coexisting in small forest fragments in Brazil. *Mammalian Biology*, **70**:366-375. http://dx.doi.org/10.1016/j.mambio.2005.08.003

CARVALHO, F.M.V.; PINHEIRO, P.S.; FERNANDEZ, F.A.S.; NESSIMIAN, J.L. 1999. Diet of small mammals in Atlantic Forest fragments in southeastern Brazil. *Revista Brasileira de Zoociências*, **1**:91-101.

CASELLA, J.; CÁCERES, N.C. 2006. Diet of four small mammal species from Atlantic forest patches in South Brazil. *Neotropical Biology and Conservation*, **1**:5-11.

CHARLES-DOMINIQUE, P.; ATRAMENTOWICZ, M.; CHARLES-DOMINIQUE, M.; GERARD, H.; HLADIK, A.; HLADIK, C.M.; PRÉVOST, M.F. 1981. Les mammiferes frugivores arboricoles nocturnes d´une Forest guyanaise: interrelations plantes-animaux. *Revue d`Ecologie (Terre et Vie)*, **35**:341-435.

CORDEIRO, G.A.; NICOLAS, R.A. 1987. Feeding habits of the opossum (*Didelphis marsupialis*) in Northern Venezuela. *Fieldiana Zoology*, **39**:125-131.

COSTA, F.R.; MAGNUSSOM, W.E.; LUIZAO, R.C. 2005. Mesoscale distribution patterns of Amazonian understorey herbs in relation to topography, soil and watersheds. *Journal of Ecology*, **93**:863-878. http://dx.doi.org/10.1111/j.1365-2745.2005.01020.x

FONSECA, G.A.; HERMANN, G.; LEITE, Y.; MITTERMETER, R.; RYLANDS, A.; PATTON, J. 1996. Lista anotada dos Mamíferos do Brasil. *Occasional Pappers Conservation Biology*, **4**:1-38.

FONSECA, G.A.B.; KIERULFF, M.C.M. 1989. Biology and natural history of Brazilian Atlantic Forest mammals. *Bulletin of Florida Museum of Natural History. Biological Sciences*, **34**:99-152.

GRAIPEL, M.E.; MILLER, P.R.M.; GLOCK, L. 2003. Trapping small mammals in the forest understory: a comparison of three methods. *Mammalia*, **67**:551-558.

HAMMER, Ø.; HARPER, D.A.T.; RYAN, P.D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica*, **4**:1-9.

HENRY, O. 1999. Frugivory and the importance of seeds in the diet of the orange-rumped agouti (*Dasyprocta leporine*) in French Guiana. *Journal of Tropical Ecology*, **15**:291-300. http://dx.doi.org/10.1017/S0266467499000826

HOWE, H.F. 1986. Seed dispersal by fruit-eating birds and mammals. *In*: D.R. MURRAY (ed.), *Seed dispersal*. Sydney, Academic Press Sydney, p. 123-189.

IBAMA. 1999. Plano de manejo do Parque Nacional do Iguaçu, PR. Available at: http://www.ibama.gov.br/siucweb/unidades/parna/planos_de_manejo/17/html/index.htm. Access on: Nov. 15, 2005.

JULIEN-LAFERRIÈRE, D. 1991. Organisation du peuplement de marsupiaux en Guyane Française. *Revue d`Ecologie (Terre et Vie)*, **46**:125-144.

JULIEN-LAFERRIÈRE, D. 1999. Foraging strategies and food partitioning in the neotropical frugivorous mammals *Caluromys philander* and *Potos flavus*. *Journal of Zoology*, **247**:71-80.

JULIEN-LAFERRIÈRE, D.; ATRAMENTOWICZ, M. 1990. Feeding and reproduction of three didelphid marsupials in two neotropical Forest (French Guiana). *Biotropica*, **22**:404-415. http://dx.doi.org/10.2307/2388558

LEINE, N.O. 2005. *Ecologia alimentar e reprodutiva de Marmosops paulensis (Didelphimorphia: Didelphidae) em uma área de Mata Atlântica no sudeste de São Paulo.* MSc thesis. Universidade Federal de Campinas, Campinas.

LEINER, N.O.; WESLEY, R.S. 2007. Seasonal variation in the diet of the brazilian slender opossum (*Marmosops paulensis*) in a montane atlantic forest area, southeastern Brazil. *Journal of Mammalogy*, **88**(1):158-164. http://dx.doi.org/10.1644/06-MAMM-A-088R2.1

LEITE, Y.L.R.; COSTA, L.P.; STALLINGS, J.R. 1996. Diet and vertical space use of three sympatric opossums in a Brazilian Atlantic forest reserve. *Journal of Tropical Ecology*, **12**:435-440. http://dx.doi.org/10.1017/S0266467400009640

MARTINS, E.G. 2004. *Ecologia populacional e área de vida da cuíca Gracilinanus microtarsus (Marsupialia: Didelphidae) em um cerradão de Américo Brasiliense, São Paulo.* MSc thesis, Universidade Federal de Campinas, Instituto de Biologia, Campinas, 84 p.

MEDELLÍN, R.A. 1991. Ecomorfología del cráneo de cinco didelfidos: tendencias, divergencias e implicaciones. *Anales del Instituto de Biología de la Universidad Nacional Autônoma de México, Serie Zoología*, **62**:269-286.

MEDELLÍN, R.A. 1994. Seed dispersal of *Cecropia obtusifolia* by two species of Opossums in the selva Lacandona, Chiapas, Mexico. *Biotropica*, **26**:400-407. http://dx.doi.org/10.2307/2389234

MILES, M.A.; SOUZA, A.A.; PÓVOA, A.A. 1981. Mammal tracking and nest location in Brazilian forest with an improved spool-and-line device. *Journal of Zoology*, **195**:331-347. http://dx.doi.org/10.1111/j.1469-7998.1981.tb03469.x

MONTEIRO-FILHO, E.L.A. 1987. *Biologia reprodutiva e espaço domiciliar de Didelphis albiventris em uma área perturbada na região de Campinas, Estado de São Paulo (Mammalia: Marsupialia).* MSc thesis, Universidade Estadual de Campinas, Campinas, 89 p.

MONTEIRO-FILHO, E.L.A.; CÁCERES, N.C. 2006. Biologia reprodutiva de fêmeas de marsupiais didelfídeos. *In*: N.C. CÁCERES; E.L.A. MONTEIRO-FILHO (eds.), *Os marsupiais do Brasil: biologia, ecologia e evolução*. Campo Grande, Universidade Federal do Mato Grosso do Sul, p. 99-110.

PINHEIRO, P.S.; CARVALHO, F.M.V.; FERNANDEZ, F.A.S.; NESSIMIAN, J.L. 2002. Diet of the marsupial *Micoureus demerarae* in small fragmentes of Atlantic Forest southeastern Brazil. *Studies on Neotropical Fauna & Environment*, **37**:213-218. http://dx.doi.org/10.1076/snfe.37.3.213.8575

POWLESLAND, R.G.; DILKS, P.J.; FLUX, I.A. 1997. Impact of food abundance, diet and food quality on the breeding of the fruit pigeon, *Parea hemiphaga novaeseelandiae chathamensis*, on Chatam Island, New Zealand. *Ibis*, **95**:178-192.

ROBINSON, J.G.; REDFORD, K.H. 1986. Body size, diet and population density of neotropical forest mammals. *American Naturalist*, **128**:665-680. http://dx.doi.org/10.1086/284596

SANTORI, R.T.; ASTÚA DE MORAES, D. 2006. Alimentação, nutrição e adaptações alimentares de marsupiais brasileiros. *In*: N.C. CÁCERES; E.L.A. MONTEIRO-FILHO (eds.), *Os marsupiais do Brasil: biologia, ecologia e evolução*. Campo Grande, Universidade Federal do Mato Grosso do Sul, p. 241-254.

SANTORI, R.T.; ASTÚA DE MORAES, D.; CERQUEIRA, R. 1995. Diet composition of *Metachirus nudicaudatus* and *Didelphis aurita* (Marsupialia, Didelphoidea) in Southeastern Brazil. *Mammalia*, **59**:511-516. http://dx.doi.org/10.1515/mamm.1995.59.4.511

SANTORI, R.T.; ASTÚA DE MORAES, D.; CERQUEIRA, R. 2004. Comparative gross morphology of the digestive tract in ten Didelphidae marsupial species. *Mammalia*, **68**:27-36. http://dx.doi.org/10.1515/mamm.2004.004

SANTORI, R.T.; ASTÚA DE MORAES, D.; GRELLE, C.E.V.; CERQUEIRA, R. 1997. Natural diet at a restinga Forest and laboratory food preferences of the opossum *Philander frenata* in Brazil. *Studies on Neotropical Fauna & Environment*, **32**:12-16. http://dx.doi.org/10.1076/snfe.32.1.12.13460

SMALLWOOD, J.; HOWE, H.F. 1982. Ecology of seed dispersal. *Annual Reviews Ecology*, **13**:201-228. http://dx.doi.org/10.1146/annurev.es.13.110182.001221

STALLINGS, J.R. 1989. Small mammal inventories in an eastern Brazilian park. *Bulletin of the Florida State Museum, Biological Sciences*, **34**:153-200.

TALAMONI, S.A.; COUTO, D.; LOPES, M.O.G.; CORDEIRO-JUNIOR, D.A. 1999. Dieta de algumas espécies de pequenos mamíferos do sudeste brasileiro. *Bios*, **7**:51-56.

TERBORGH, J. 1986. Community aspects of frugivory in tropical forests. *In*: A. ESTRADA; T.H. FLEMING (eds), *Frugivores and seed dispersal*. Dordrecht, Dr. W. Junk Publishers, p. 371-384.

TYNDALE-BISCOE, C.H.; MACKENZIE, R.B. 1976. Reproduction in *Didelphis marsupialis* and *D. Albiventris* in Colombia. *Journal of Mammalogy*, **57**:249-265. http://dx.doi.org/10.2307/1379686

VAN SCHAIK, C.P.; TERBORGH, J.W.; WRIGHT, S.J. 1993. The phenology of tropical forest, adaptive significance, and consequences for primary consumers. *Annual Review of Ecology and Systematics*. **24**:353-377. http://dx.doi.org/10.1146/annurev.es.24.110193.002033

VIEIRA, M.V. 2006. Locomoção, morfologia e uso do habitat em marsupiais neotropicais: uma abordagem ecomorfológica. *In*: N.C. CÁCERES; E.L.A. MONTEIRO-FILHO (eds.), *Os marsupiais do Brasil: biologia, ecologia e evolução*. Campo Grande, Universidade Federal do Mato Grosso do Sul, p. 145-158.

VIEIRA, E.M.; ÁSTUA DE MORAES, D. 2003. Carnivory and insectivory in neotropical marsupials. *In*: M. JONES; C. DICKMAN; M. ARCHERS (eds.), *Predators with pouches: the biology of carnivorous marsupials*. CSIRO, Collingwood, Australia, p. 271-284.

VIEIRA, M.F.; CARVALHO-OKANO, R.M.; SAZIMA, M. 1991. The common opossum, *Didelphis marsupialis*, as a pollinator of *Mabea fistulifera* (Euphorbiaceae). *Ciência & Cultura*, **43**:390-393.

VIEIRA, E.M.; IZAR, P. 1999. Interactions between aroids and arboreal mammals in the Brazilian Atlantic rainforest. *Plant Ecology*, **145**:75-82. http://dx.doi.org/10.1023/A:1009859810148

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