Diet of small mammals in Atlantic Forest fragments in southeastern Brazil[1]

Fábio Martins Vilar de Carvalho[2]
Paula Soares Pinheiro[2]
Fernando Antonio dos Santos Fernandez[2]
Jorge Luís Nessimian[3]

ABSTRACT - Diet of six species of small mammals (five marsupials and one rodent) was studied through analysing a total of 163 fecal samples obtained from live-trapping in Atlantic Forest fragments at Poço das Antas, Brazil, 1995-1999. For the marsupial *Micoureus demerarae* the most frequent food itens were arthropods from the orders Coleoptera and Hymenoptera, pupae and larvae of Diptera and Lepidoptera, and seeds of plants from secondary vegetation; freshwater crustaceans were also recorded. *Caluromys philander* also consumed mostly Coleoptera, Hymenoptera and seeds from secondary plants, but seeds were less diverse, more frequent and more abundant than for *M. demerarae*. Patterns recorded for the remaining marsupials included the importance of termites for *Metachirus nudicaudatus*, presence of a vertebrate (rodent) only for *Philander frenata*, and a diverse diet for *Didelphis aurita* despite a small sample size. The diet of the sixth species, *Akodon cursor*, included mostly insects and arachnids with seeds in lower frequency.

Key Words: diet, marsupials, rodents, Atlantic Forest, forest fragments, *Micoureus, Caluromys, Metachirus, Philander, Didelphis, Akodon.*

[1]Financiamento: Fundação O Boticário de Proteção à Natureza, The MacArthur Foundation, FAPERJ, FUJB, CNPq and PROBIO (PRONABIO/ MMA, supported by BIRD/GEF).
[2]Departamento de Ecologia and [3]Departamento de Zoologia, CCS, Universidade Federal do Rio de Janeiro, CxP. 68020, Ilha do Fundão, Rio de Janeiro, RJ, 21941-590, Brazil. E-mail FMVC: fcarval@biologia.ufrj.br

Rev. bras. de Zoociências
Juiz de Fora
V. 1 Nº 1
Dez/99
p. 91-101

INTRODUCTION

What an animal eats is surely one of the most important aspects of its relationship with its environment, and yet, little information of this kind is available for most Neotropical small mammals, although there has been considerable progress in the last years (CHARLES-DOMINIQUE *et al.* 1981; ATRAMENTOWICZ 1988; BUSCH & KRAVETZ 1991; LEITE *et al.* 1994, 1996; SANTORI *et al.* 1995, 1997; for a review on Brazilian species see SANTORI & ASTUA DE MORAES, *IN PRESS*). Filling this gap is important also because detailed knowledge of each species' autoecology is necessary to understand the ecological processes in which it is involved, such as its population dynamics and its interactions with other species within communities. In Neotropical mammalogy, the understanding of ecological processes is still incipient, partly because there is still so much to be done regarding the understanding of the patterns. Nowadays, with the increasing fragmentation of Neotropical forests (LAURANCE & BIERREGAARD, 1997), there is also a particularly urgent necessity of obtaining information on the autoecology of small mammals in forest fragments, as only by understanding what they need we will be able to find out how suitable the fragments are for them.

The present study had the goal of characterizing the diet of six species of small mammals in small fragments of the Atlantic Forest, a biome already intensely fragmented (DEAN 1996). Five of the species studied were marsupials (order Didelphimorphia): *Micoureus demerarae* (Thomas, 1905), *Caluromys philander* (Linnaeus, 1758), *Didelphis aurita* Wied-Neuwied, 1826, *Philander frenata* (Linnaeus, 1758) and *Metachirus nudicaudatus* (Desmarest, 1817). All are nocturnal; *M. demerarae* and especially *C. philander* are arboreal, whereas *P. frenata* and *D. aurita* are scansorial and *M. nudicaudatus* is exclusively terrestrial (EMMONS & FEER 1997). The sixth species studied, *Akodon cursor* (Winge, 1887), is a rodent (Muridae, Sigmodontinae), terrestrial and mostly diurnal (EMMONS & FEER 1997). Unlike the marsupials, *A. cursor* is not a typical forest species and in the study area it is restricted to the edges of the fragments and to the areas of open vegetation. (FERNANDEZ *et al.*, 1998).

MATERIALS AND METHODS

The study area was a set of eight small Atlantic Forest fragments, known as "Ilhas dos Barbados", located in the south part of Poço das Antas Biological Reserve, in Rio de Janeiro state (22°30'- 22°33' S, 42°15'- 42°19' W). Areas of the fragment vary from 1.4 to c. 15ha, and they are separted by a matrix of open vegetation composed mostly of grasses, bracken and pioneer trees. The area was described in further detail by PIRES & FERNANDEZ (1999).

Small mammals were live-trapped in the fragments from March 1995 to July 1999, using Sherman and Tomahawk traps. Their feeding habits were determined from the analysis of the contents of fecal samples obtained upon capture. The samples were kept under refrigeration, and later washed with flowing water on a sieve with 1mm mesh. After sieving, the samples were analysed using binocular magnifying glasses. The items found were separarated in the following categories: arthropods, seeds, plant material (leaves and fibres), hair and non-identified material. Arthropods were separated in orders. The frequency of ocurrence of each order in the diet of a mammal species was calculated as the number of samples which presented parts attributable to the order divided by the total number of samples obtained for that mammal species. In the case of Arachnida, the three orders found - Acari, Opiliones and Araneae - were pooled as a single group because their frequencies were regarded as too small to be analysed separately. Seeds were separated in morphospecies, counted, and their frequencies of occurrence were calculated by the same procedure as used for arthropods. Seeds were also counted in each sample to evaluate their abundances. For the two species with largest sample sizes, *Micoureus demerarae* and *Caluromys philander*, the abundances of seeds (when present in the samples) were compared using the non-parametric Mann-Whitney test (ZAR 1999).

The Shannon index (LUDWIG & REYNOLDS 1988) was used to evaluate the diversities of food items in the diet of *Micoureus demerarae* and *Caluromys philander*. Diversity of arthropods and diversity of seeds were analysed separately as the probabililities of preserving arthropod parts and seeds are likely to be very different, violating the assumptions of the diversity index. To test wether the difference between Shannon indices was significant or not, Hutcheson's t-test was used, as recommended by ZAR (1999).

RESULTS

The number of samples analysed for each species and the frequency of occurrence of each item of the diet are in Table 1. Arthropods were found in all 163 samples analysed. Thirteen different orders of this group were recorded in the samples from *M. demerarae*; the two most frequent were Coleoptera and Hymenoptera. Diptera e Lepidoptera were well represented by larvae and pupae. An interesting result was the presence of freshwater crustaceans (Copepoda and Isopoda, one sample each). To our knowledge, this is the first ever record of use of these resources by *M. demerarae*.

Other marsupials also showed a broad spectrum of utilization of arthropods in their diet. Hymenoptera and Coleoptera were the most frequent orders in the diet of *C. philander*, just as for *M. demerarae*. For *P. frenata*, despite the small number of samples, four arthropod orders were recorded: Coleoptera, Hymenoptera, Arachnida and Diptera. Bones of two individuals of rodents from the subfamily Sigmodontinae were also found in a sample from *P. frenata*. For *M. nudicaudatus*, the most frequent orders were Hymenoptera, Arachnida and Isoptera. *D. aurita* had only two samples, but that was enough to record no less than five arthropod orders (Hymenoptera, Coleoptera, Arachnida, Orthoptera and Diptera). The only rodent studied, *A. cursor*, had Hymenoptera as the order most frequently recorded, followed by Arachnida and Coleoptera.

Frequencies of samples of seeds are in Table 1 (bottom). *M. demerarae,* the species with higher sample sizes, was the one which again presented the highest richness of food itens, as 21 different seed types were recorded in its samples. The abundance of seeds was higher in the samples from *C. philander* than in the ones from *M. demerarae* (averages 153.4 and 50.4 respectively); however, the difference was not significant ($U = 474.5$, $p = 0.15$),

Table 1 - Frequency of occurrence of arthropods and seeds in the diet of the small mammal species studied at Poço das Antas Biological Reserve, southeastern Brazil. Frequencies are expressed as porcentage of the number of fecal samples containing arthropods and seeds respectively (the number of samples for arthropods coincides with the total number of samples as all samples had arthropods). Sample sizes for each species in parenthesis.

	Micoureus demerarae (n = 109)	*Caluromys philander* (n = 25)	*Philander frenata* (n = 4)	*Metachirus nudicaudatus* (n = 4)	*Didelphis aurita* (n = 2)	*Akodon cursor* (n = 19)
Arthopods						
Hymenoptera	56.0	48.0	50.0	75.0	100.0	68.4
Coleoptera	63.3	52.0	100.0	50.0	100.0	36.8
Arachnida	25.7	16.0	50.0	75.0	100.0	42.1
Orthoptera	19.3	4.0	-	-	100.0	-
Lepidoptera	14.7	4.0	-	-	-	15.8
Hemiptera	15.6	4.0	-	25.0	-	21.1
Diptera	9.2	12.0	25.0	-	50.0	5.3
Isoptera	0.9	-	-	75.0	-	15.8
Blattodea	1.8	-	-	-	-	-
Neuroptera	0.9	-	-	-	-	-
Corrodentia	0.9	4.0	-	-	-	-
Copepoda	0.9	-	-	-	-	-
Isopoda	0.9	-	-	-	-	-
Diplopoda	-	-	-	25.0	-	-
Mammals						
Rodentia	-	-	25.0	-	-	-
Seeds						
Piper sp.	17.2	11.8	66.7	-	-	-
P. mollicomum	*6.3*	-	*33.3*	-	-	-
Cecropia sp.	10.9	35.3	-	25.0	-	11.1
Miconia sp.	-	5.9	-	-	-	-
Solanaceae	1.6	-	-	-	-	-
Non identified	64.0	47.0	-	75.0	100.0	88.9
(samples which had seeds)	64	17	3	4	2	9

probably due to the high dispersion of the data for both species. For *M. demerarae,* the seeds recorded most often were *Piper* sp. and *Cecropia* sp., whereas the most abundant were *Cecropia* sp. and *P. mollicomum*. For *C. philander*, the most frequent seeds, among only six morphospecies, were *Cecropia* sp. and *Piper* sp., whereas the most abundant were *Cecropia* sp. and *Ficus* sp. Regarding the remaining species, all seeds identified for *P. frenata* were from *Piper* spp., and the only ones for *M. nudicaudatus* and *A. cursor* were from *Cecropia* sp.

Although the diversity of arthropods in the diet was slightly higher in *M. demerarae* (H‘ = 1.777) than in *C. philander* (H‘ = 1.583), the difference was not significant ($t = 1.243$, $p > 0,20$). For seeds, on the other hand, their diversity in the diet was significantly higher in *M. demerarae* (H‘ = 2.095) than in *C. philander* (H‘ = 1.372) ($t = 3.04$, $p > 0.002$).

DISCUSSION

All species studied fed mostly on arthropods and fruits or seeds. The most frequent arthropod orders in the diet were, with few exceptions, Coleoptera and Hymenoptera (especially ants, family Formicidae). This is a expected pattern, as Formicidae is often the animal family with highest biomass in tropical wet forests (W. W. Benson, personal communication), whereas Coleoptera is the most diverse of all orders in nature. The high frequency of pupae and larvae of Lepidoptera and Diptera may be due to these forms being more nutritious than the adults and also easier to catch for small mammals (REDFORD & DOREA 1984). The presence of Diptera pupae may indicate consumption of carrion, at least for the carnivorous species, for whom it can be a way to obtain animal protein with low energetic costs (SANTORI *et al.* 1997).

Unlike rodents, marsupials do not have incisive teeth adapted to break hard seeds; therefore the presence of seeds in the samples from marsupials should reflect frugivory rather than granivory. In this study *M. demerarae* was found to be mostly insectivore, but having fruits as an important component of its diet as well. This result corroborates the findings of ROBINSON & REDFORD (1986) and FONSECA *et al.* (1996), who classified the species as insectivore-omnivore. *C. philander* also consumed insects more frequently than fruits. At first, this result seems contradictory with previous studies which pointed to fruits as the major component of *C. philander*'s diet, classifying it as frugivore-omnivore (ROBINSON & REDFORD 1986; ATRAMENTOWICZ 1988; EISENBERG 1989; JULIEN-LAFERRIÈRE & ATRAMENTOWICZ 1990; LEITE *et al.* 1994, 1996; FONSECA *et al.* 1996). For example, LEITE *et al.* (1996), working in the main forest block of Poço das Antas, found seeds in 94% of samples from *C. philander*. Nevertheless, our findings do not seem to be uncompatible with those, as fruits not only were found in a high proportion of samples (68%) but also were very abundant when present.

Sample sizes for the remaining marsupials were low, preventing a more detailed analysis of their diets. *P. frenata* is usually classified as insectivore-omnivore (FONSECA *et al.* 1996); SANTORI *et al.* (1997) recorded invertebrates as the major component of its diet, which included fruits and vertebrates as well as in the present study. Regarding *M. nudicaudatus*, Isoptera seems to be a particularly important group in the diet of this species, corroborating a pattern found previously for this species by EMMONS & FEER (1997) and SANTORI *et al.* (1995). The common opossum *D. aurita*, by its turn, is often classified as an omnivore, feeding on fruits, invertebrates and small vertebrates (PERISSÉ *et al.* 1988; SANTORI *et al.* 1995; EMMONS & FEER 1997; FREITAS *et al.* 1997). In the present study, only two samples were analysed, finding only invertebrates and seeds.

The rodent *A. cursor* is usually classified as insectivore-omnivore (FONSECA & KIERULFF 1989; STALLINGS 1989; FONSECA *et al.* 1996); according to EMMONS & FEER (1997) species from this genus are mostly insectivore. In the present study, indeed, insects were present in all samples analysed and seeds in only 47% of them (Table 1). However, one needs to keep in mind that as rodents have teeth well adapted to granivory, frequency of seeds in their diet can be underestimated precisely because they can grind seeds to pieces too small to be detected in the samples. It is also interesting to notice that *A. cursor* was the only species for which Arachnida was one of the two most frequent orders, which probably is related to *Akodon* being exclusively terrestrial and arachnids being especially abundant in the litter on the forest ground.

Two interesting points can be raised on the relationships between the diet of the small mammals, forest fragmentation and community composition. First, the vegetation of the communities in the fragments may affect the composition of the small mammal communities. It seems worth to notice that the most frequent and abundant seeds on the samples were from plants characteristic of secondary vegetation, like *Piper* sp., *Cecropia* sp., and species from the family Solanaceae. As it is well known that secondary plant species have increased abundances in small forest fragments (e.g. SAUNDERS *et al*., 1991), it is tempting to speculate that small mammal species for whom those secondary plants are the preferred foods may survive better in fragments as compared to mammals which do not rely so much on secondary plants. This reason may contribute to explain why some small mammals (e.g. *M. demerarae*) are so often abundant in fragments, whereas several other species are not. The second point is reciprocal to the first: small mammals affecting the composition of the plant communities in the fragments. Some small mammals are likely to be good seed dispersers, especially marsupials which do not grind the seeds as rodents do. Small seeds are ingested when the marsupials feed on fruit pulp, but pass intact through the digestive tract, whereas large seeds are usually rejected (CHARLES-DOMINIQUE *et al.* 1981; ATRAMENTOWICZ 1988). In the study area, individuals of several marsupial species move among fragments (PIRES & FERNANDEZ, 1999; FERNANDEZ & PIRES, *IN PRESS*), and in doing so they should disperse seeds from one fragment to another. This process may be important especially for the persistence of arboreal species in the fragments, as the low population densities so characterisitic of many tree species in Neotropical forests would condemn them to be represented by very small and otherwise isolated populations in each fragment. Knowing better the feeding ecology of small mammals in the fragments should help understanding better these and other processes which contribute to shape the biotic communities in forest fragments.

ACKNOWLEDGEMENTS

We thank IBAMA - Brazilian Institute of Environment and Renewable Natural Resources - especially through Whitson Júnior and Ivandy Castro Astor, for allowing us to work at Poço das Antas and providing facilities. We thank especially Jorge Luiz do Nascimento for his contribution in data analysis and discussions. We are also grateful to Benedito das Neves Costa and Leila M. Pessôa for identifying the seeds and the rodent remains respectively, to Diego Astúa de Moraes for reviewing the manuscript, and to the many colleagues who helped in the field work.

REFERENCES

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

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

CHARLES-DOMINIQUE, P.; M. ATRAMENTOWICZ; M. CHARLES-DOMINIQUE; H. GÉRARD; A. HLADIK; C.M. HLADIK & M.F. PRÉVOST. 1981. Les mammiferes frugivores arboricoles nocturnes d'une foret guyanaise: inter-relations plantes-animaux. **Rev. Ecol. (Terre et Vie), 35**: 341-435.

DEAN, W. 1996. **A ferro e fogo: a história e a devastação da Mata Atlântica brasileira**. São Paulo, Companhia das Letras, 484 pp.

EISENBERG, J.F. 1989. **Mammals of the Neotropics, vol. 1. The northern Neotropics: Panama, Colombia, Venezuela, Guyana, Suriname, French Guiana**. Chicago and London, The University of Chicago Press, 449 pp.

EMMONS, L.H. & F. FEER. 1997. **Neotropical rainforest mammals: a field guide (Second edition)**. Chicago, The University of Chicago Press, XVI + 307p.

FERNANDEZ, F.A.S., & A.S. PIRES (in press). Perspectivas para a sobrevivência dos marsupiais brasileiros em fragmentos florestais: o que sabemos, e o que precisamos ainda aprender? *In*: **Marsupiais do Brasil: Avanços em Evolução, Biologia e Ecologia**. E.L.A. Monteiro-Filho & N.C. Caceres (Eds.). Curitiba, Editora da Universidade Federal do Paraná.

FERNANDEZ, F.A.S.; A.S. PIRES; D. FREITAS; F.S. ROCHA & T.B. QUENTAL. 1998. Respostas de pequenos mamíferos à fragmentação de habitats em remanescentes de Mata Atlântica. **Anais do IV Simpósio de Ecossistemas Brasileiros, 5**: 184-189.

FONSECA, G.A.B. & M.C.M. KIERULFF. 1989. Biology and natural history of brazilian Atlantic Forest small mammals. **Bull. Florida State Mus., Biol. Sci., 34**(3): 99-152.

FONSECA, G.A.B.; G. HERRMANN; Y.L.R. LEITE; R.A. MITTERMEIER; A.B. RYLANDS & J.L. PATTON. 1996. Lista Anotada dos Mamíferos do Brasil. **Occas. Papers Conserv. Biol., 4**: 1-38.

FREITAS, S.R.; D. ASTÚA DE MORAES; R.T. SANTORI & R. CERQUEIRA. 1997. Habitat preference and food use by *Metachirus nudicaudatus* and *Didelphis aurita* (Didelphimorphia, Didelphidae) in a restinga forest at Rio de Janeiro. **Rev. Brasil. Biol., 57**(1): 93-98.

JULIEN-LAFERRIÈRE, D. & M. ATRAMENTOWICZ. 1990. Feeding and reproduction of three didelphid marsupials in two neotropical forests (French Guiana). **Biotropica, 22**(4): 404-415.

LAURANCE, W.F. & R.O. BIERREGAARD, (EDS.). 1997. **Tropical forest remnants - ecology, management, and conservation of fragmented communities.** Chicago and London, University of Chicago Press. XV + 616 pp.

LEITE, Y.L.R.; J.R. STALLINGS & L.P. COSTA. 1994. Partição de recursos entre espécies simpátricas de marsupiais na Reserva Biológica de Poço das Antas, Rio de Janeiro. **Rev. Brasil. Biol., 54**: 525-536.

LEITE, Y.L.R.; L.P. COSTA & J.R. STALLINGS. 1996. Diet and vertical space use of three sympatric opossums in a Brazilian Atlantic forest reserve. **J. Trop. Ecol., 12**: 435-440.

LUDWIG, J.A. & J.F. REYNOLDS. 1988. **Statistical Ecology - a Primer on Methods and Computing**. New York, John Wiley & Sons, XVIII + 337p.

PERISSÉ, M.; R. CERQUEIRA & C.R. SORENSEN. 1988. A alimentação na separação de nicho entre *Philander opossum* e *Didelphis aurita* (Polyprotodontia, Didelphidae). **Anais dos Seminários Regionais de Ecologia, VI**: 283-294.

PIRES A.S. & F.A.S. FERNANDEZ. 1999. Use of space by the marsupial *Micoureus demerarae* in small Atlantic Forest fragments in southeastern Brazil. **J. Trop. Ecol. 15**: 279-290 .

REDFORD, K.H. & J.G. DOREA. 1984. The nutritional value of invertebrates with emphasis on ants and termites as food for mammals. **J. Zool., Lond., 203**: 385-395.

ROBINSON, J.G. & K.H. REDFORD. 1986. Body size, diet and population density of neotropical forest mammals. **Am. Nat., 128**: 665-680.

SANTORI, R.T. & D. ASTÚA DE MORAES. (in press). Alimentação, nutrição e adaptações alimentares de marsupiais brasileiros. In: **Marsupiais do Brasil: Avanços em Evolução, Biologia e Ecologia**. E.L.A. Monteiro-Filho & N.C. Caceres (Eds.). Curitiba, Editora da Universidade Federal do Paraná.

SANTORI, R.T.; D. ASTÚA DE MORAES & R. CERQUEIRA. 1995. Diet composition of *Metachirus nudicaudatus* and *Didelphis aurita* (Marsupialia, Didelphoidea) in Southeastern Brazil. **Mammalia, 59**(4): 511-516.

SANTORI, R.T.; D. ASTÚA DE MORAES; C.E.V. GRELLE & R. CERQUEIRA. 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.

SAUNDERS, D.A.; R.J. HOBBS & C.R. MARGULES. 1991. Biological consequences of ecosystem fragmentation: a review. **Conserv. Biol., 5**: 18-32.

STALLINGS, J.R. 1989. Small mammal inventories in an eastern Brazilian park. **Bull. Florida State Mus., Biol. Sci., 34**(4): 153-200.

ZAR, J.H. 1999. **Biostatistical Analysis (Fourth Edition)**. New Jersey, Prentice Hall. 929 pp.