Acta Theriologica 50: 551-560, 2005.
PL ISSN 0001–7051

Age, season, and arboreal movements of the opossum *Didelphis aurita* in an Atlantic rain forest of Brazil

André A. CUNHA and Marcus V. VIEIRA

Cunha A. A. and Vieira M. V. 2005. Age, season, and arboreal movements of the opossum *Didelphis aurita* in an Atlantic rain forest of Brazil. Acta Theriologica 50: 000–000.

The common opossum of the Atlantic forest, *Didelphis aurita* Wied-Neuwied, 1826 is predominantly terrestrial, but uses the vertical space of the forest regularly. It is the didelphid that most frequently uses large supports in vertical movements. Here we test the influence of age and seasonality in fruit production on the vertical movements of *D. aurita*. Animals were trapped in Serra dos Órgãos, state of Rio de Janeiro, and equipped with a spool-and-line device before release. The paths were tracked, and variables related to support incline, diameter, distances and heights moved above ground were measured and compared between age classes and seasons. There were no significant differences between seasons. Individuals of all ages used the vertical space of the forest but the young opossums did it more intensively along their paths.

Laboratório de Vertebrados, Departamento de Ecologia, Instituto de Biologia, Universidade Federal do Rio de Janeiro, CP 68020, Rio de Janeiro, RJ, Cep 21941-590, Brazil, email: cunha@biologia.ufrj.br (AAC, MVV)

Key words: marsupials, spool-and-line, seasonality, body size, small mammals, vertical stratification, canopy use

Introduction

The common opossum of the Atlantic forest of Brazil, *Didelphis aurita* Wied-Neuwied, 1826, is considered a habitat and diet generalist (Cerqueira 1985). It is predominantly terrestrial but often moves in the arboreal habitat (Fonseca and Kieruff 1989, Stallings 1989, Passamani 1995, Leite *et al.* 1996, Vieira 1998, Cunha and Vieira 2002, Grelle 2003). When moving above ground it reaches the canopy more frequently than arboreal species such as *Marmosops incanus* (Lund, 1840) (Cunha and Vieira 2002). However, the factors that influence these movements are not clear.

Fruit availability could influence vertical movements of this didelphid. Miles *et al.* (1981), Hume (1982) and Fonseca and Kieruff (1989) stated that individuals of *Didelphis* climb chiefly to forage. The common opossum of the Atlantic forest feeds on vertebrates, litter invertebrates, and fruits (Perissé and Cerqueira 1988, Santori *et al.* 1995a, Santori *et al.* 1995b, Leite *et al.* 1996, Freitas *et al.* 1997, Astúa de Moraes *et al.* 2003). Indeed, fruits of Solanaceae, Cecropiaceae, Rosaceae, Myrtaceae, Moraceae, Rhamnaceae, Cucurbitaceae, Flacourtiaceae, Passifloraceae, Piperaceae and Araceae are consumed and effectively dispersed by *D. aurita* (Cáceres *et al.* 1999, Grelle and Garcia 1999, Cáceres *et al.* 2000). Vieira and Izar (1999) and Cáceres *et al.* (1999) report opportunistic fruit consumption by *D. aurita,* as observed for *D. marsupialis* by Atramentowicz (1988), Julien-Laferrière and Atramentowicz (1990), and Fleck and Harder (1995).

In Neotropical forests, the production of fleshy fruits is higher in the wet season (Charles-Dominique *et al.* 1981, Jackson 1981, Peres 1994, Morellato *et al*. 2000). Thus, in the wet season *D. aurita* is more likely to use the upper strata to consume fruits that are more available during this period.

Age is another factor that could influence vertical movements by common opossums. Mortality is higher during the weaning age of the Virginia opossum (*D. virginiana* (Hossler *et al.* 1994), and in the common opossum of the Atlantic forest (Rademaker 2001). Young individuals could take advantage of their small size to use the upper strata of the forest as an escape route from terrestrial predators. Indeed, Fonseca and Kieruff (1989) and Stallings (1989) noted that juveniles tend to climb more than adults. Diameter of support used for climbing also could be related to age or body size, as observed by Cunha and Vieira (2002) in a comparison between four didelphid species.

The study of factors that influence vertical movements of *D.aurita* and small mammals in general requires methods different from trapping, because bait can alter the arboreal behavior of small mammals, such as the white footed mouse (*Peromyscus leucopus*) (Manville *et al.* 1992). The use of complementary techniques such as the fluorescent powder (Lemen and Freeman 1985, McShea and Gilles 1992) and a spool-and-line device (Miles *et al.* 1981, Boonstra and Craine 1986) avoid the problems associated with bait attraction, and allow a more detailed picture of the animal's path. The spool-and-line technique was used effectively to study movements of terrestrial and scansorial didelphids, initially by Miles *et al*. (1981), and later allowing a detailed mapping of their space use and vertical stratification (Cunha and Vieira 2002), more accurate estimates of densities based on capture-recapture in trapping grids (Mendel and Vieira 2003), detection of the effects of seasons on movements of males and females of *D. aurita* (Loretto and Vieira, in press), and detection of scale-dependent habitat selection by didelphids (Moura *et al*. 2005). However, it may be difficult to locate and follow the line of arboreal species, such as the Guianan squirrel *Sciurus aestuans* (A. A. Cunha, unpubl.).

The objective of our study was to determine if the vertical use of the forest by *D. aurita* differs between seasons and ages using a spool-and-line device. Our hypothesis are (1) that the frequency of vertical movements is higher during the rainy season, when the availability of fruits is higher, (2) that above ground movements are more frequent for young individuals, and (3) that differences in body size are positively related to differences in diameter of supports used by distinct age classes. Additionally, we also investigated whether the diameter of supports used differed between movements of climbing up, climbing down, and horizontal displacements above ground.

Material and methods

Study area

The study area is located in a subdivision of the Atlantic Forest Biome, the Coastal Forest of the Serra do Mar (Dinerstein *et al.* 1995), in the mountain range of Serra dos Órgãos, in the Parque Nacional da Serra dos Órgãos (PARNA/SO), municipality of Guapimirim, state of Rio de Janeiro, Brazil, locally known as Garrafão (22 28’S, 42 60’W). The forest of the region is part of one of the largest continuous stretch of Atlantic Forest remaining (SOS Mata Atlântica/INPE/ISA, 1998). Canopy reaches 20–25 meters, and diameter of trees varies from 40 to 60 cm, sometimes reaching one meter. A sub-canopy and understory are present, but generally it is not possible to distinguish them clearly. Lianas, palm trees, epiphytes, ferns, and bromeliads are frequent. Common tree species belong to *Sloanea*, *Ficus*, *Cedrela*, *Cariniana*, *Vochysia*, *Cecropia*, among others. Common species of the sub-canopy and understory include tree ferns of *Alsophila*, *Cyathea*, and *Hemitelia*, and the palm tree *Euterpe edulis* (Rizzini 1979: 70–73).

Trapping and handling

Animals were captured in bimonthly trapping sessions of five consecutive nights each, from January 1998 to April 2001, as part of a capture-recapture study of small mammal populations of the Laboratório de Vertebrados, Universidade Federal do Rio de Janeiro. We tracked 38 individuals of *Didelphis aurita*, 18 males and 20 females, all having more than 35 m of thread mapped. Three grids of 0.64 ha each were established in the area at different elevations (748, 652 and 522 m). Currently they are surrounded by holiday houses that could have some influence on the structure and composition of the forest (Freitas 1998). Each grid had 25 trapping stations placed 20 m apart, with two traps per station, one Tomahawk (41 14 14 cm) and one Sherman live trap (30.5 9.8 8 cm) both placed on the ground. After identification, animals were marked with ear-tags if necessary, and measured, and some equipped with a spool-and-line device based on Boonstra and Craine (1986). Individuals were released in the morning.

Animals were not anaesthesized because they were handled quickly and without harm. Quilting cocoons no. 5 or no. 10 of nylon thread were used (Culver Textiles Corp., New York) weighing about 1.7 g (175 m) and 4.5 g (480 m), respectively. The size of the cocoon used depended on the size of animal: the small cocoon was used for all young individuals of *D. aurita*, whereas the large cocoon was used for subadults and adults. The spool used always weighted less than 1 % of the mass of the individual, to reduce the possibility of disturbing its usual behaviour. Cocoons were dyed with five different ink cloth pigments to facilitate the identification of threads of different individuals in the field. Colors also helped in case of thread breakage to find the other end of the thread. The cocoon was covered with PVC plastic film and wrapped with masking tape to form the spool. The spool was attached to the fur between the shoulders with Superbonder, an ester-cianocrilate based glue (“Loctite”, Manaus, Brazil). Any marks of cocoon or glue disappeared in animals recaptured one or two trapping sessions later.

Most paths of animals were tracked the next day after release, although some were tracked on the same day to locate their nest with certainty. In these cases, tracking began at least one hour after release of the animal to minimize interference, and continued the next day starting from the nest. The thread was tracked and collected separating movements on and above the ground. Movements on and above the ground were calculated by multiplying the weight (g) of thread collected by the ratio of total cocoon thread (m) to cocoon weight (g). The thread was weighted in a 10^{-3}g precision balance. Displacements were measured with a 3 m measuring tape. Movements above ground were measured by projecting on the ground the initial and final points and measuring the net displacement.

Data analyses

Nine out 47 individuals had less than 35 meters of thread tracked. The remaining 38 opossums had a total of 6063 meters (Mean = 160 m; SD = 88 m) of line tracked. Individuals did not bite or break the line. Some animals react from handling by running ca. 5 m meters after release, and returning to a slow speed thereafter. Line breakage was not frequent on the ground, but above the ground occurred frequently on windy days or when a line was not tracked after two or more days.

The use of the vertical strata was characterized by two sets of variables, both measured in each age class and season. One set comprised two variables related to the number of individuals with any record of (1) climbing up movement (NCLIMB), and of (2) horizontal movement aboveground (NABOVE). The other set comprised two variables as well, but related to the intensity or (1) number of events of climbing up per meter of thread tracked (ICLIMB), and (2) meters of horizontal movements above ground per meter of thread tracked (IABOVE).

The use of supports was measured by four complementary variables, measured along the paths of individuals (see definition, Table 1). The word "support" was used as a common term for tree trunks and limbs, and lianas. Diameter and incline were measured for each support used in a climbing up or down movement. An individual could use more than one support when climbing up or down, and could climb up and down more than once along its path.

To determine age classes, the first age was estimated for each animal by the formula of Motta (1988), based on head-and-body length, tail length, body mass, and tooth eruption. Animals were then placed in three age classes, young, subadults, and adults. The first class was composed of individuals less than 150 days of age, the end of weaning period (Motta 1988); the second class included individuals from 151 to 338 days of age, the average age in which animals reach the adult complete dentition; the third class was of adult individuals, with more than 339 days old.

Dry and wet seasons were defined based on precipitation data recorded from the metereological station of Nova Friburgo, of the Instituto Nacional de Metereologia – INMET. Dry months (less than 75 mm of rain) ranged from March to August 1998, from April to September 1999, from May to September 2000, and April 2001.

Table 1. Arboreal movements of opossums in three age classes showing the observed mean and the mean expected under the null hypothesis of no difference between age classes (in brackets). Asterisk indicates significant differences at the unicaudal 0.01 level. ICLIMB – Number of climb up movements/Total thread recovered (m); IABOVE – Meters of above ground movement approximately horizontal (m)/Total thread recovered (m); diamUP – Diameter of supports used for climbing up (cm); diamDOWN – Diameter of supports used for climbing down (cm); diamABOVE – Diameter of supports used for above-ground movements approximately horizontal (cm); MaxHT – Maximum height reached in a climbing up movement.

Variable	Age class		
	Juvenile (n = 8)	Subadult (n = 19)	Adult (n = 11)
ICLIMB (no/100m)	1.8* (0.9)	0.8 (0.9)	0.4 (0.9)
IABOVE (m/100m)	3.7 (2.3)	2.2 (2.2)	2.7 (2.3)
Max. diamUP (cm)	18.7 (17.2)	17.9 (18.2)	22.2 (17.6)
Max. diamDOWN (cm)	5.7 (8.8)	10.5 (9.0)	9.9 (9.2)
Max. diamABOVE (cm)	5.8 (8.3)	8.6 (8.0)	9.3 (8.1)
Max. MaxHT (m)	8.5 (9.1)	9.1 (9.1)	7.0 (9.3)

The significance of differences in the frequency of individuals using the aboveground space was compared with chi-square tests between age classes or seasons (NCLIMB and NABOVE). Sample size did not allow testing the effects of age and season simultaneously, for example, in a two-factor log-linear analysis (Sokal and Rolf 1995). Only separate chi-squares for age and season were possible. Individuals were grouped in two seasons regardless of the year.

For ICLIMB and IABOVE, there was only one value per individual, but variables related to support use were measured more than once along the path of each animal (see Table 1). To obtain a single value per individual and to make variables comparable, the median and maximum values of each individual were used. When median and maximum were significantly correlated, the maximum was used in statistical tests. Significance of differences in the intensity of vertical movements and diameter of supports used between age classes or seasons were tested by a parametric bootstrap (Manly 1991, Crowley 1992). For each variable, all individuals were considered as coming from a single population, from which a random sample of individuals was taken, its mean calculated and stored. Sample size was the number of individuals in each age class or season. This procedure was repeated 1000 times for each sample size, generating a distribution of random means. According to the central limit theorem, a population of means has a normal distribution (Sokal and Rolf 1995). Thus, the mean and standard deviation of the distribution of 1000 random means were used to transform the observed mean to its z-score, and the probability of the observed mean was the proportion of the area under the normal distribution beyond its z-score (Manly 1991).

Results

Maximum and median values of the variables measured more than once along the path of each individual were highly correlated ($r_P > 0.82$ and $p < 0.087$ for diamUP, diamDOWN, and diamABOVE Bartlet $\chi^2 = 136.920$), except for MaxHT ($r_P = 0.376$, $p = 1.000$). Thus, maximum values of all variables were compared, except for MaxHT which median values were also compared. Head and body, tail length, and weight were positively correlated with age ($r_P > 0.728$, $p = 0.000$, Barllet $\chi^2 = 118.093$).

Arboreal movements of opossums did not differ between dry and wet seasons, neither for variables based on the frequency of individuals with any above ground movements (NCLIMB and NABOVE, both with $p > 0.88$, $\chi^2 < 0.0247$) nor for intensity of above ground movement (ICLIMB and IABOVE, both with $p > 0.37$ in the parametric bootstrap).

Individuals of all age classes used the vertical strata. The proportion of young individuals moving above ground at least once was higher than the frequency of subadults or adults (Fig. 1), but these differences were not significant.

Climbing up movements along the paths (ICLIMB) of young individuals were significantly more intensive than that of subadults or adults (Table 1, Fig. 1). Relative distances in approximately horizontal above ground movements (IABOVE) were also higher for young individuals (Table 1, Fig. 1). However, the probability of this difference being caused by chance was 0.12, higher than the usual significance level of 0.05. The maximum heights reached were fifteen, twenty and ten meters for these age classes. Diameters of supports used did not differ among age classes (Table 1). There was no significant difference (KW = 2.281, $p = 0.32$) between diameters of support used for climb up, down, and

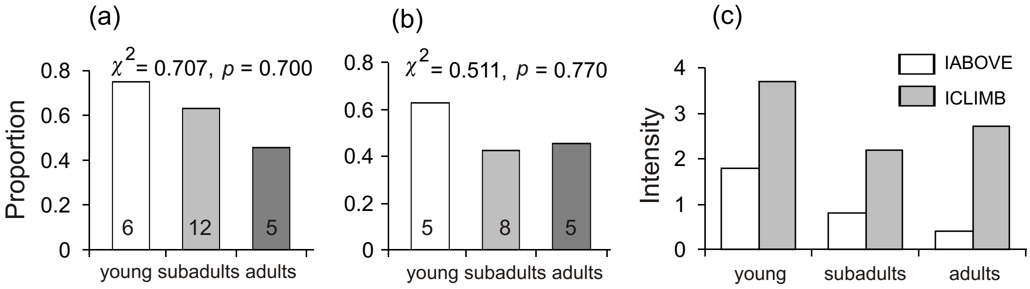

Fig. 1. Use of the vertical strata by opossums in each age class. (a) Proportion of individuals with climbing up movements (NCLIMB). (b) Proportion of individuals with horizontal above ground movements (NABOVE). (c) Intensity of climbing up movements, (ICLIMB, meters above ground per 100 m of line tracked), and of horizontal movements above ground, (IABOVE, number of events per 100 m of line tracked).

horizontal above ground movements, but supports used for climbing up tended to be larger than others (Table 1).

Discussion

Individuals of *D. aurita* used the above ground space at all ages, but the young used the vertical space slightly more than subadults and adults. Besides, young individuals climbed the vertical strata more frequently (Fig. 1) and twice as intensively as subadults, and these more frequently than adults (ICLIMB, Table 1, Fig. 1). Fonseca and Kieruff (1989) and Stallings (1989), captured young individuals more frequently above ground than adults. In our study, 45% of adults, 63% of subadults, and 75% of young individuals climbed at least once (Fig. 1). This inverse relationship between age and use of the vertical space cannot be disregarded. However, most differences tested were not significantly different. Sample size was relatively small considering the large variation in the vertical use of the forest within each age class, which must have affected the statistical results.

Predation and small size are the more likely hypotheses to explain the more intensive use of the vertical space by young individuals, as revealed by the significant differences in ICLIMB. Because of their small size, young individuals will not be as capable as adults of confronting enemies on the forest floor. However, a small size allows swift movements above ground (A. A. Cunha, unpubl.). Thus, the vertical space is likely to be a more effective escape route for young individuals than for adults.

Other factors can be important to avoid predation in the youngest age class. For example, dense herbaceous cover is positively associated with survival of young *D. virginiana* (Hossler *et al*. 1994), it is preferred by another didelphid, *Metachirus nudicaudatus* (Freitas *et al*. 1997), and by the rodent *Octodon degus* (Lagos *et al*. 1995). Additionally, the use of vertical space by the common opossum could also be influenced by other factors such as the use of holes in tree trunks as refuges, or to avoid terrestrial obstacles in flooded areas as reported by O'Connell (1989) and Leite *et al.* (1996).

Arboreal movements of *D. aurita* did not differ between dry and wet seasons, hence our first hypothesis was rejected, i.e., vertical movements would be higher during the wet season when availability of fruits is higher. An alternative explanation is that the opossum feeds on fruits mainly on the ground, as pointed out by Grelle and Garcia (1999) for *Cecropia* fruits. Also, *D. aurita* might not be climbing for fruits, but rather for eggs, a preferered item as indicated in laboratory experiments (Perissé and Cerqueira 1988 and Astúa de Moraes *et al.* 2003).

Diameter of supports used did not differ significantly between age classes, but mean diameters used by young for climbing up and climbing above were narrower than subadults and adults, suggesting a positive relation between body size and diameter of supports used. Some individuals used large supports (> 60 cm diameter) in all age classes, indicating that individuals of all ages are capable of climbing trunks with the claws (claw climbing *sensu* Szalay 1994). This ability could be a consequence of the longer body length, broader foot, and longer foot claw of the common opossum, when compared with other didelphids such as *Philander frenatus* (Vieira 1997). Additionally, individuals seem to use larger supports for climbing up than for climbing down and for horizontal movements above ground. Opossums are capable of reversal of their hind feet to some degree, which allows them to climb up and down trunks using their claws (Jenkins and McClean 1984). However, it is possible that their ability of hindfoot reversal when climbing down does not permit the use of supports as large as in climbing up movements, or in horizontal movements above ground.

In conclusion, *D. aurita* used all strata of the forest at all ages, and similarly throughout the year. Although all individuals climbed to the canopy, young individuals tended to use the vertical space more intensively than subadults and adults.

Acknowledgements: We are especially grateful to A. Capparelli, A. Delciellos, D. Loretto, F. Pedreira, J. Macędo, M. Moura, M. Belarmino, R. Gentile, S. Mendel, V. Antunes and V. Rademaker. A. Marcondes and N. Pereira for their dedication in the office and laboratory work. R. Darigo, Dr R. Cerqueira, Dr C. E. Grelle, and anonymous reviewers made invaluable comments on earlier versions of this manuscript. This research was funded by PROBIO (MMA-GEF), CNPq (PIBIC, PIE, PRONEX), FUJB, FAPERJ and CAPES.

References

Astúa de Moraes D., Santori R. T., Finotti R. and Cerqueira R. 2003. Nutritional and fiber contents of laboratory-established diets of neotropical opossums (Didelphimorphia, Didelphidae). [In: Predators with pouches: The biology of carnivorous marsupials. M. Jones, C. Dickman and M. Archer, eds]. CSIRO Publishing: 229–237.

Atramentowicz M. 1988. La frugivorie opportuniste de trois marsupiaux didelphidés de guyane. Revue d'Ecologie (Terre et Vie) 43: 47–57.

Boonstra R. and Craine I. T. M. 1986. Natal nest location and small mammals tracking with a spool and line technique. Canadian Journal of Zoology 64: 1034–1036.

Cáceres N. C., Dittrich V. A. O. and Monteiro-Filho E. L. A. 1999. Fruit consumption, distance of seed dispersal and germination of solanaceous plants ingested by common opossum (*Didelphis aurita*) in southern Brazil. Revue d' Ecologie (Terre et Vie) 54: 225– 233.

Cáceres N. C. and Monteiro-Filho E. L. A. 2000. The common opossum, Didelphis aurita, as seed disperser of several plants in southern Brazil. Cięncia e Cultura 52: 41–44.

Cerqueira R. 1985. The distribution of *Didelphis* in south america (Polyprotodontia, Didelphidae). Journal of Biogeography 12: 135–145.

Charles-Dominique P., Atramentowicz M., Charles-Dominique M., Gérard H., Hladik A., Hladir C. M. and Prévost M. F. 1981. Les mammifères frugivores arboricols nocturnes d'une forêt guyanaise: Inter-relations plantes-animaux. Revue d' Ecologie (Terre et Vie) 35: 341–435.

Crowley P. H. 1992. Resampling methods for computation intensive analysis in ecology and evolution. Annual Review of Ecology and Systematics 23: 405– 447.

Cunha A. C. and Vieira M. V. 2002. Support diameter, incline, and vertical movements of four didelphid marsupials in the Atlantic forest of Brazil. Journal of Zoology 258: 419–426.

Dinerstein E., Oslon D. M., Graham D. J., Webster A. L., Primm S. A., Bookbinder M. P. and Ledec G. 1995. A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean. WWF & World Bank., Washington, DC: 00–00.

Fleck D. W. and Harder J. D. 1995. Ecology of marsupials in two Amazonian rain forest in northeastern Peru. Journal of Mammalogy 76: 809– 818.

Fonseca G. A. B. and Kierulff M. C. M. 1989. Biology and natural history of Brazilian Atlantic forest small mammals. Bulletin of the Florida State Museum, Biological Sciences 34: 99–152.

Freitas S. R. 1998. [Spatial and temporal variation in habitat structure, and microhabitat selection by small mammals in the Atlantic forest]. MSc thesis, National Museum of the Federal University of Rio de Janeiro, Rio de Janeiro: 1–168. [In Portuguese]

Freitas, S. R., Astúa de Moraes, D., Santori, R. T. and Cerqueira, R. 1997. Habitat preference and food use by *Metachirus nudicaudatus* and *Didelphis aurita* in a restinga forest at Rio de Janeiro. Revista Brasileira de Biologia 57: 93–98.

Grelle, C. E. V. 2003. Forest structure and vertical stratification of small mammals in southeast Brazil. Studies on Neotropical Fauna and Environment 38: 81–85.

Grelle C. E. V. and Garcia Q. S. 1999. Potential dispersal of *Cecropia hololeuca* by the common opossum (*Didelphis aurita*) in Atlantic forest, southeastern Brazil. Revue d' Ecologie (Terre et Vie) 54: 327– 332.

Hossler J. R., McAninch J. B. and Harder J. D. 1994. Maternal denning behavior and survival of juveniles in opossums in southeastern New York. Journal of Mammalogy 75: 60–70.

Howe H. F. 1993. Specialized and generalized dispersal systems: Where does 'the paradigm' stand? Vegetatio 107/108: 3–13.

Hume I. D. 1982. Digestive physiology of marsupials. Comparative Biochemistry and Physiology 71A: 1–10.

Jackson J. F. 1981. Seed size as a correlate of temporal and spatial patterns of seed fall in a neotropical forest. Biotropica 13: 121–130.

Janzen D. H. 1980. When is it coevolution? Evolution 34: 611–612.

Jenkins F. A. Jr and McClean D. 1984. Mechanisms of hindfoot reversal in climbing mammals. Journal of Morphology 182: 197–219.

Julien-Laferrière D. and Atramentowicz M. 1990. Feeding and reproduction of three didelphid marsupials in two neotropical forests (French Guiana). Biotropica 22: 404–415.

Lagos V. O., Contreras L. C., Menserve P. L., Gutiérrez J. R. and Jaksic F. M. 1995. Effects of predation risk on space use by small mammals: A field experiment with a neotropical rodent. Oikos 74: 259–264.

Leite Y. L. R., Costa L. P. and 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.

Lemen C. A. and Freeman P. W. 1985. Tracking mammals with fluorescent pigments: A new techinique. Journal of Mammalogy 66: 134–136.

Loretto D. and Vieira M.V. (in press). The effects of reproductive and climatic seasons on movements in the black-eared opossum (*Didelphis aurita* Wied-Neuwied, 1826). Journal of Mammalogy.

Manly B. J. F. 1997. Randomization, boostrap and Monte Carlo methods in biology. Second edition. Chapmam & Hall, New York. 34–67. 399 p.

Manville C. J., Barnum S. A. and Tester J. R. 1992. Influence of bait on arboreal behavior of *Peromyscus leucopus*. Journal of Mammalogy 73: 335–336.

McShea W. J. and Gilles A. B. 1992. A comparison of traps and fluorescent powder to describe foranging for mast by *Peromyscus leucopus*. Journal of Mammalogy 73: 218–222.

Mendell S. and Vieira M. V. 2003. Movement distances and density estimation of small mammals using the spool-and-line technique. Acta Theriologica 48: 289–300.

Miles M. A., Souza A. A. D. and Póvoa M. M. 1981. Mammal tracking and nest location in Brazilian forest with an improved spool-and-line device. Journal of Zoology, London 195: 331–347.

Morellato L. P. C., Talora D. C., Takahasi A., Bencke C. C., Romera E. C. and Zipparro V. B. 2000. Phenology of Atlantic rain forest trees: a comparative study. Biotropica 32: 811–823.

Motta M. F. D. 1988. [Study of the extra-uterine development of *Didelphis aurita*, Wied, 1826, in captivity: investigating criteria for age estimation]. MSc thesis, National Museum of the Federal University of Rio de Janeiro, Rio de Janeiro: 1–105. [In Portuguese]

Moura M. C., Caparelli A. C., Freitas S. R. and Vieira M. V. 2005. Scale-dependent habitat selection in three didelphid marsupials using the spool-and-line technique in the Atlantic forest of Brazil. Journal of Tropical Ecology 21:1–7.

O'Connell M. A. 1989. Population dynamics of neotropical small mammals in seasonal habitats. Journal of Mammalogy 70: 532–548.

Passamani M. 1995. Vertical stratification of small mammals in Atlantic hill forest. Mammalia 59: 276–279.

Peres C. 1994. Primate responses to phenological changes in an Amazonian terra firme forest. Biotropica 26: 98–112.

Perissé M. and Cerqueira R. 1988. Food habits on the niche segregation between Philander opossum and Didelphis aurita (Polyprotodontia, Didelphidae). Annual Seminar of Regional Ecology, Săo Carlos 6: 283–294. [In Portuguese with English summary]

Rademaker V. 2001. [Population ecology and reproduction of Didelphis, with special emphasis in *D. aurita* in a disturbed area of Atlantic Forest in the Serra dos Órgăos, Guapimirim, RJ]. MSc thesis, Graduate Program in Wildlife Management and Conservation, Belo Horizonte: 1–46. [In Portuguese]

Rizzini C. T. 1979. [Treatise of phytogeography of Brazil: sociological and floristic aspects]. Hucitec Ltda. and University of Săo Paulo Press, Săo Paulo: 1–374. [In Portuguese]

Santori R. T., Astúa de Moraes D. and Cerqueira R. 1995. Diet composition of *Metachirus nudicaudatus* and *Didelphis aurita* (Marsupialia, Didelphidea) in southeastern Brazil. Mammalia 59: 511–516.

Santori R. T., Cerqueira R. and Kleske C. C. 1995. Digestive anatomy and efficienty of *Didelphis aurita* and *Philander opossum* (Didelphimorphia, Didelphidae) in relation to food habits. Revista Brasileira de Biologia 55: 323–329. [In Portuguese with English summary]

Sokal R. R. and Rohlf F. J. 1995. Biometry: the principles and practice of statistics in biological research. 3rd. W. H. Freeman and Company, New York: 1–887.

SOS Mata Atlântica/INPE/ISA. 1998. [Atlas of the evolution of forest remnants and ecosystems associated with the Atlantic Forest Domain in the 1990–95 period]. SOS Mata Atlântica/INPE/ISA, Săo Paulo: 1–54. [In Portuguese]

Stallings J. R. 1989. Small mammal inventories in an eastern Brazilian park. Bulletin of the Florida State Museum, Biological Sciences 34: 159–200.

Szalay F. S. 1994. Evolutionary history of the marsupials and an analysis of osteological characters. Cambridge University Press, Cambridge: 1–481.

Vieira E. M. 1998. A technique for trapping small mammals in the forest canopy. Mammalia 62: 306–310.

Vieira E. M. and Izar P. 1999. Interactions between aroids and arboreal mammals in the Brazilian Atlantic rainforest. Plant Ecology 145: 75–82.

Vieira M. V. 1997. Body size and form in two neotropical marsupials, *Didelphis aurita* and *Philander opossum* (Marsupialia, Didelphidae). Mammalia 61: 245–254.

Received 28 May 2004, accepted 14 January 2005.

Associate Editor was Joseph F. Merritt.