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Small mammal ecology in an urban Atlantic forest fragment in southeastern Brazil

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Abstract
We conducted a capture-mark-release study of small mammals in an urban forest fragment at the Parque das Mangabeiras, in the city of Belo Horizonte, southeastern Brazil. Four marsupials — *Didelphis albiventris* Lund, *Gracilinanus agilis* (Burmeister), *Marmosops incanus* (Lund), *Philander frenatus* (Olfers) — and four rodents — *Sciurus aestuans* Linnaeus, *Akodon montensis* Thomas, *Rhipidomys mastacalis* (Lund) and *Mus musculus* Linnaeus — were found between March 2003 and February 2004. The most abundant species were *M. incanus* and *S. aestuans*, representing respectively 50% and 20% of the individuals recorded. Terrestrial habits were detected for *A. montensis* and *D. albiventris*, scansorial habits for *G. agilis, M. incanus, P. frenatus,* and *S. aestuans,* while *R. mastacalis* was exclusively arboreal. There was positive correlation between rainfall and population abundance for *D. albiventris*, and positive correlation between recruitment rates and rainfall for *M. incanus*. Rapid turnover rates suggested short residence time for most species. Three reproductive patterns were identified: prolonged reproduction during both seasons in *R. mastacalis*, reproduction during the dry season in *G. agilis*, and reproduction during the wet season in the remaining species. Only individuals of *D. albiventris, M. incanus, R. mastacalis,* and *S. aestuans* were detected across the paved road that runs through the fragment, suggesting that the road may be a barrier to the other species.

Keywords: small mammals, secondary forest, community ecology, population dynamics, seasonality.

Introduction

Small mammals have long been the focus of ecological studies, being recognized by various authors as the easiest mammal group to determine population parameters to (Fleming, 1972; O'Connell, 1989; Mares & Ernest, 1995). Their small body mass, wide distribution, and short life span generate rapid turnover rates in natural populations, making them ideal models for population ecology. However, basic ecological and life history traits are still very poorly known for a great number of small-mammal communities in many regions of the globe, particularly the Neotropics. Ecological studies at population and community level, are crucial in determining which factors influence species composition at a given habitat through time, such as: abundance, reproductive period, residence time, movement patterns (immigration and emigration), recruitment, and survivorship rates. Such factors are in turn shaped by other variables, both abiotic (e.g., temperature and rainfall) and biotic (predation, competition, and food availability) (Leigh, 1982).

The influence of physical barriers such as roads in the spatial dynamics and dispersal rates of animal populations was well studied in some mammal communities (Noss et al., 1996; Barratt, 1997; Bias & Morrison, 1999; Vaughan & Hawkins, 1999; Alexander & Waters, 2000; Tigas et al., 2002; Brock & Kelt, 2004). The ability to overcome those barriers depends on many factors, such as the specie's life-history traits (e.g., home range, dispersal capacity, mode of locomotion) and the size or proportion of a given structure. The presence of large barriers may promote population subdivision under certain circumstances due to the isolation of individuals, which drastically restrict their dispersal and movement abilities.

This study was designed to determine and quantify the following ecological parameters for a small mammal community: species composition, population abundances through wet and dry seasons, residence time, age structure (for marsupial

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species), recruitment and survivorship rates, and reproductive periods for the species occurring in the area. Our second goal was to determine the movement patterns of individuals, to verify their ability to cross the road located within the forest fragment. In addition, we compared the results obtained in this study with another survey done in the same area (Câmara & Lessa, 1994).

Material and Methods

The present study was carried out during a twelve-month period in an Atlantic forest fragment at the Parque das Mangabeiras (235 ha), in the southern border of the city of Belo Horizonte, southeastern Brazil (19º56'S, 43º53'W; elevation 1,000-1,300 meters). The area presents well defined dry (April to September) and wet (October to March) seasons. Rainfall values obtained in the past 62 years (1941 to 2003) revealed an annual average of 1,871 mm with a minimum of 560.4 mm in 1963 and a maximum of 3,084.6 mm in 1945. The total rainfall during the study period was 1,838.8 mm. The vegetation is heterogeneous, varying from semi-deciduous and gallery forests to high elevation grasslands.

We trapped small mammals in a secondary semi-deciduous forest fragment within the park boundary. The canopy averages ten meters in height and due to the relatively young age of the forest, the connectivity at the canopy is lower when compared to other forests in later succession stages. There is a 3-meter wide paved road running through the forest fragment. This road runs mostly along a hillside and, therefore, steep road cuts flank both sides. These cuts are usually tall (ca. two meters high), potentially obstructing animal movements across the road. Traffic in the area is restricted to occasional authorized vehicles and a tour bus, which runs every hour from 08:00 to 18:00.

We set traps along four parallel 210-meter long transects, 100 meters apart. Transects were also parallel to the road, with two of them on one side and two on the other side. There were 15 trapping stations along each transect, 15 meters apart. We used two wire live traps (32 cm x 15 cm x 15 cm) per station, one on the ground and the other on tree branches or lianas in the understorey (between one and two meters in height). We trapped for five consecutive nights, every month, using pineapple and peanut butter as baits. We marked animals with numbered ear-tags (National Band and Tag, Co., Newport, Kentucky, USA), releasing them after taking body measurements (head and body, tail, ear, and hind foot length), weight, and determining the sex and breeding condition. We classified male marsupials according to testis condition — inactive young males had small, furry, and dull-colored testis and active adults had naked, large, and blue-colored testis. For female marsupials, we inferred breeding condition by the presence/absence of lactation and pouch young. In the case of rodents, we determined male breeding activity by testis position — abdominal testis indicated absence of breeding activity and scrotal testis indicated breeding activity. For female rodents, we inferred breeding activity by the presence/absence of lactation and later stages of pregnancy, which can be detected by touching the abdomen. We also determined age classes for marsupials, following the patterns of pre-molar replacement and molar eruption (Tyndale-Biscoe & Mackenzie, 1976; D'Andrea et al., 1994). We established three age classes: (1) juvenile – deciduous third pre-molar and fourth molar absent; (2) sub-adult – both permanent third pre-molar and fourth molar absent; (3) adult – both permanent third pre-molar and fourth molar present. We collected voucher specimens, now deposited in the Mammal Collection at the Department of Zoology, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil.

We used the software BioEstat 3.0, Ayres et al. (2003) for statistical analyses. The chi-square test was used to check for differences in the vertical space used by different species. We compared monthly abundance values for each species with rainfall values, using the Spearman rank correlation coefficient. We calculated survivorship (ϕ), recruitment (B), and population size (N) for the two most abundant species, using the Jolly-Seber method designed for open populations (Begon, 1979). We also checked possible correlation of these three variables with rainfall for the two most abundant species *(M. incanus and S. aestuans)* using the Spearman coefficient.

Results

We trapped 163 individuals 389 times between March 2003 and February 2004 (Tab. 1). Our trapping effort was 7,115 trap-nights, and the average trapping success was 5.51%. We found eight species of small mammals – four marsupials and four rodents. The marsupials recorded were the white-eared opossum *Didelphis albiventris* Lund, 1840, the agile gracile mouse-opossum *Gracilinanus agilis* (Burmeister, 1854), the gray slender mouse-opossum *Marmosops incanus* (Lund, 1840), and the gray four-eyed opossum *Philander frenatus* (Olfers, 1818). The rodents trapped were the Guianan squirrel *Sciurus aestuans* Linnaeus, 1766, the grass mouse *Akodon montensis* (Thomas, 1913), the climbing rat *Rhipidomys mastacalis* (Lund, 1840), and the exotic, invasive house mouse, *Mus musculus* Linnaeus, 1758. *Marmosops incanus* was the most abundant species in the area, corresponding to 59.2% of the captures, followed by *S. aestuans*, with 15.6% of the captures. The remaining species corresponded to 25.2% of the total captures (Tab. 1).

The presence of coatis *Nasua nasua* (Linnaeus, 1766) in the area (see Alves-Costa, 2004) influenced trappability. Individuals of this species disturbed traps and ate baits during the study, decreasing trapping success, except in March, April, July, November, and January.

We found terrestrial habits for *A. montensis* and *D. albiventris* (both trapped only on the ground), scansorial habits for *G. agilis* (χ^2 = 0.72; p = 0.3961), *M. incanus* (χ^2 = 0.1394; p = 0.7089), *P. frenatus* (χ^2= 0.168; p = 0.6819), and *S. aestuans* (χ^2 = 0.166; p = 0.6837), while *R. mastacalis* was exclusively arboreal (no captures on the ground) (Tab. 1). Regarding the ability to cross the road, individuals of *A. montensis, G. agilis,* and *P. frenatus* were always trapped on the same side of the road, whereas some *D. albiventris, M. incanus, R. mastacalis,* and *S. aestuans* were able to cross the road during the study period, being trapped on both sides.

We found a positive correlation between rainfall and abundance for *D. albiventris* (r_s = 0.7898, p = 0.0022). This opossum was recorded only during the wet season and the first month of the dry season (Fig. 1a). We detected short residence times for most animals, denoting rapid turnover rates. Eighty (59.7%) out of 134 individuals analyzed were trapped only during one month, and most of the remaining stayed for only two consecutive months. A few *M. incanus* and *S. aestuans* were

Table 1 - Number of individuals and captures in two forest layers at the Parque das Mangabeiras, Belo Horizonte, Brazil, between March 2003 and February 2004.

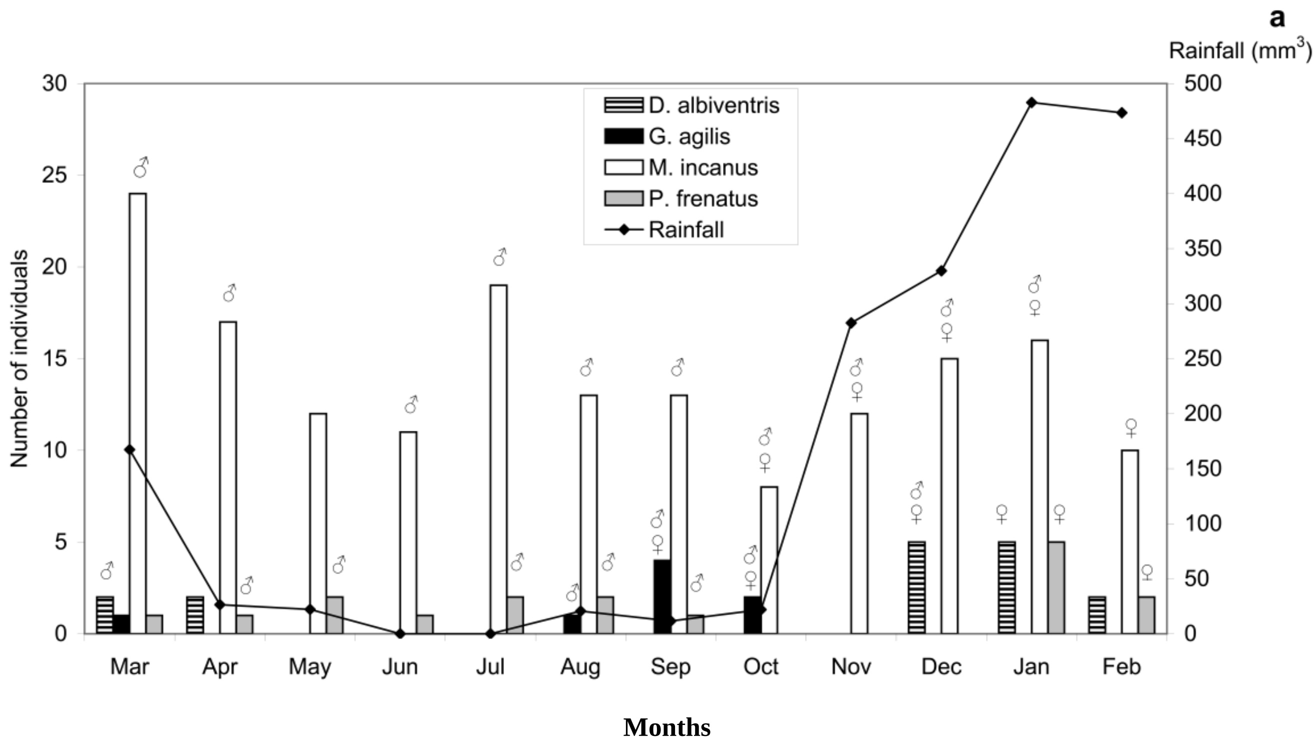
Taxa	Number of individuals	Number of captures		
		Ground	Understorey	Total
DIDELPHIMORPHIA				
Didelphidae				
Didelphis albiventris Lund, 1840	12	26 (100%)	0 (0%)	26
Gracilinanus agilis (Burmeister, 1854)	8	2 (20%)	8 (80%)	10
Marmosops incanus (Lund, 1840)	81	146 (63%)	85 (37%)	231
Philander frenatus (Olfers, 1818)	9	20 (64%)	11 (36%)	31
RODENTIA				
Sciuridae				
Sciurus aestuans Linnaeus, 1766	32	21 (36%)	38 (64%)	59
Cricetidae				
Akodon montensis Thomas, 1913	10	15 (100%)	0 (0%)	15
Rhipidomys mastacalis (Lund, 1840)	10	0 (0%)	16 (100%)	16
Muridae				
Mus musculus Linnaeus, 1758	1	1 (100%)	0 (0%)	1
TOTAL	**163**	**231 (59%)**	**158 (41%)**	**389**

trapped up to nine months after their first capture. Two *P. frenatus* were trapped during four months and one *R. mastacalis* was trapped for five consecutive months. *Akodon montensis, D. albiventris,* and *G. agilis* presented the shortest residence times, with maximum periods of two months for *A. montensis* and only one month for *D. albiventris* and *G. agilis*. Avoiding traps following the first capture is a behavior usually associated with stress during animal handling and may decrease chances of successive captures of the same individual.

Most marsupials recorded were adult and sub-adult individuals, with only one juvenile *M. incanus* captured in December (Fig. 2a), period of increasing recruitment for this species (Tab. 2). New individuals of *D. albiventris* occurred in March, April, December, January, and February, with higher recruitment in December. We trapped sub-adults of this species mostly during the wet season (December to February). Recruitment of *G. agilis* occurred in March, August, September, and October, with higher adult recruitment in September and October, and of sub-adults in March and August. Higher recruitment rates for *M. incanus* occurred during the beginning of the dry season (April and May) and during the wet season (December and January) (Tab. 2). Adults of *M. incanus* were

Table 2 - Rates of survivorship (ϕ), recruitment (B), and population size (N) of the two most abundant species, the marsupial *Marmosops incanus* and the rodent *Sciurus aestuans*. Periods of heavieset rainfall are boldfaced.

Period	*Marmosops incanus*			*Sciurus aestuans*		
	ϕ	B	N	ϕ	B	N
Mar/Apr	0.52	–	29.14	0.62	–	18
Apr/May	0.54	12.27	28.00	0.21	2.94	0
May/Jun	0.83	1.20	24.44	0	0	0
Jun/Jul	0.95	3.38	26.60	0	12.00	12.00
Jul/Aug	0.55	1.64	16.27	0.70	6.40	8.50
Aug/Sep	0.81	4.97	17.33	0.57	1.27	3.00
Sep/Oct	0.65	2.57	13.83	0	0	0
Oct/Nov	0.85	3.76	14.66	0	0	8
Nov/Dec	0.64	5.62	15.00	0.60	3.30	4.50
Dec/Jan	0.14	14.40	16.00	0.95	3.48	6.33



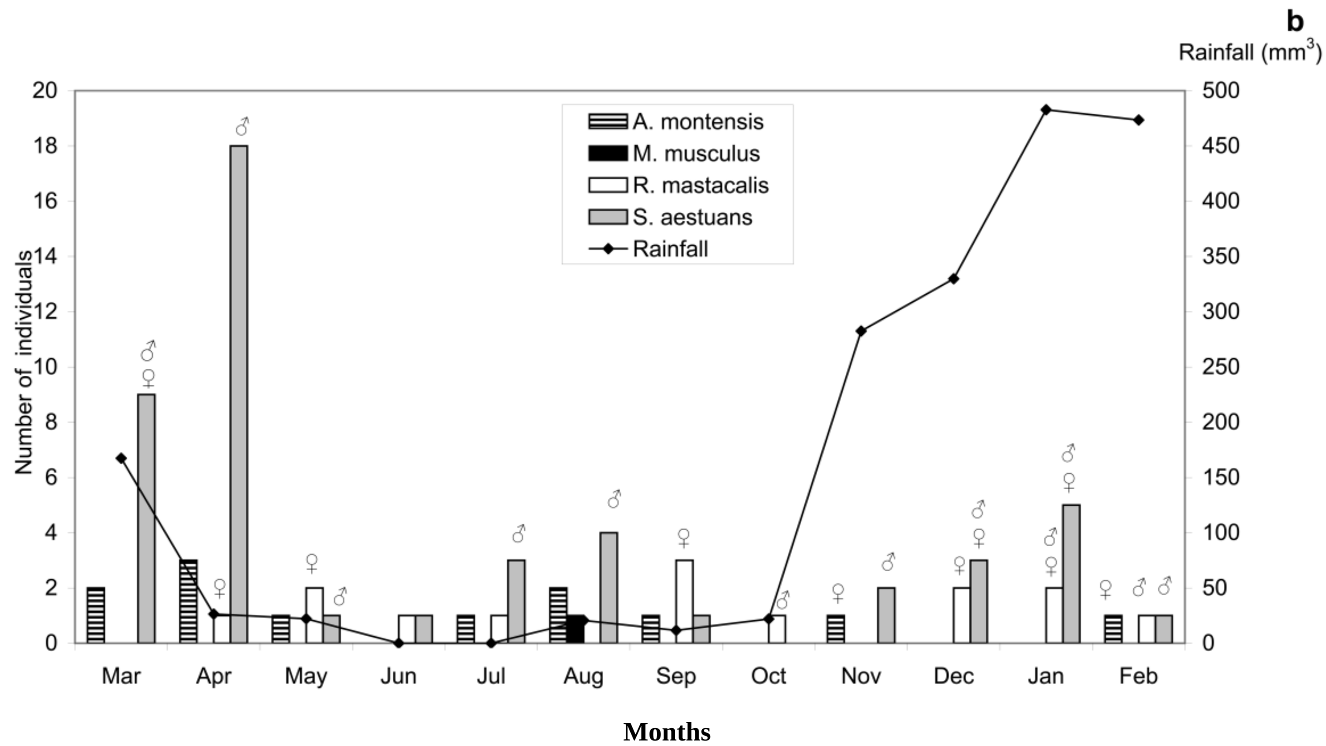


Figure 1 - Patterns of relative abundance (left column) and rainfall values (right column) along the study period for (a) marsupials and (b) rodents. Symbols above bars represent presence of reproductive activity for males (♂) and females (♀) during each month.

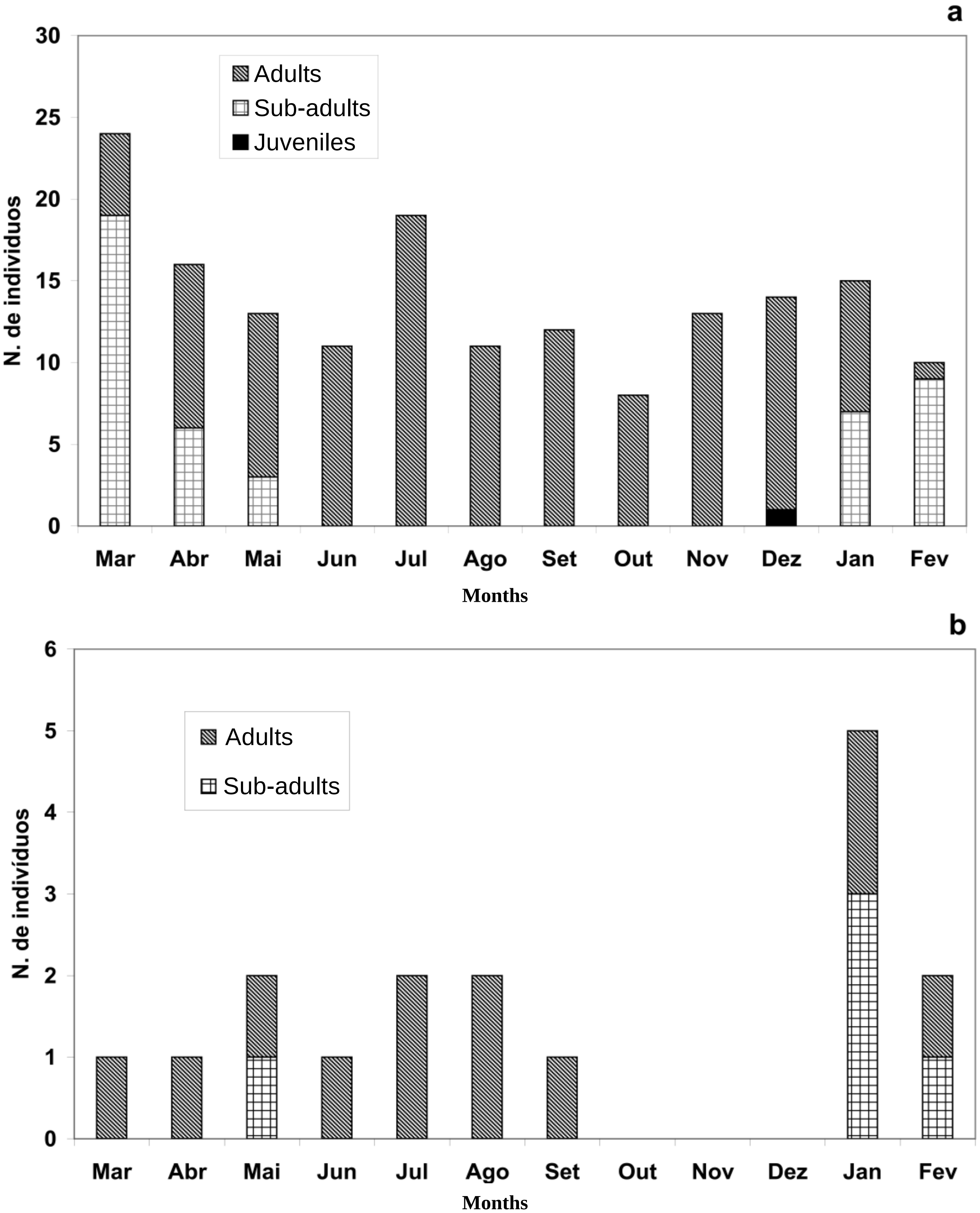


Figure 2 - Diagram of age structure for the two most abundant marsupial species, (a) *M. incanus* and (b) *P. frenatus*, based on patterns of pre-molar replacement and molar eruption.

trapped during the entire dry season and part of the wet season: April to December (Fig. 2a). We found a positive correlation between recruitment rates and the respective rainfall indices for *M. incanus* (r_s = 0.75; p = 0.01; see also Tab. 2). Adult *P. frenatus* were captured at the end of the wet season and during the entire dry season (March to September), with greater proportion of sub-adults at the end of the wet season: January and February (Fig. 2b). Recruitment rates for this species were relatively constant in both seasons, except for a peak in January. Most rodent species had constant recruitment rates in both seasons, except for *S. aestuans*, with the highest rate during the dry season (Tab. 2).

We found three reproductive patterns among species during the study period: (1) prolonged reproduction during both seasons; (2) seasonal reproduction during the dry season; and (3) seasonal reproduction during the wet season (Fig. 1). The first pattern applies only to *R. mastacalis*, which pregnant and lactating females were captured on both seasons. Only *G. agilis* fits the second pattern. However, due to the short residence time for this species in the area and the small number of captures, data on its reproductive condition were scarce. We found reproductively active individuals of both sexes between August and October. The remaining species fit the third reproductive pattern, with active females occurring during the wet season only (October to February). There was a positive correlation between the beginning of the rainy season and the beginning of reproductive activity for females of *A. montensis* and *S. aestuans*. Male *S. aestuans* reproduced in both seasons (Fig. 1). Individuals of *A. montensis* were captured mainly during the dry season, which possibly explains the predominance of inactive individuals of both sexes. Only two lactating females were captured in the wet season. Reproducing *D. albiventris* were trapped throughout most of the months in which this species occurred in the area. Lactating and pouched young females were captured in December and January, and active males were captured in March and December. Active males of *M. incanus, P. frenatus,* and *S. aestuans* occurred in both seasons, while active females were captured only during the wet season (October to February). We did not find females of *M. incanus* carrying pouch young, only lactating.

Discussion

The species richness found at the Mangabeiras Park is relatively low when compared to other sites with similar vegetation (Fonseca, 1989; Barros-Battesti et al., 2000). This may be related to the location and degree of isolation of the forest fragment. The park is isolated within a large urban area, and adjacent to extensive bare lands (iron mines) in the Serra do Curral range. Rocky areas in the range possibly constitute additional obstacles to immigration of forest dwellers from other fragments, such as the Jambreiro forest.

The dominance of one species in terms of number of individuals and biomass (such as *M. incanus* on this study) is a recurrent event in small mammal communities (Alho, 1985; Alho et al., 1986; Barros-Battesti et al., 2000). Such pattern generates low equitability, decreasing alpha diversity. Other studies also reported higher biomass of marsupials than rodents (Fonseca, 1989; Stallings, 1989; Gentile & Fernandez, 1999). The predominance of trees over herbs may be a factor influencing these results, given the preference of many marsupial species for trees (Gentile & Fernandez, 1999). Fonseca (1989) and Stallings (1989) documented higher biomass of marsupials (ca. 65%) than rodents in secondary Atlantic forest fragments, as we did in this study. According to Fonseca (1989), secondary forests favor marsupials due to higher food availability when compared to primary forests, considering that marsupials have broader diets than rodents. It is interesting to note that one individual of *Mus musculus* was the only invasive species detected during the present study, showing that even small city parks can be dominated by native small mammals, instead of commensal rodents, which dominate the urban surroundings.

Câmara & Lessa (1994) conducted the first small mammal survey of the Mangabeiras Park and here we document major changes in community composition. *D. albiventris* was the most abundant taxon then, followed by *A. montensis*, and *P. frenatus* (Câmara & Lessa, 1994). *M. incanus*, the most abundant species in the present study, was not even recorded by them. These differences suggest long-term fluctuations of small mammal populations and changes in community composition, as already recorded for other sites (e.g., Cerqueira et al., 1993). The decrease in the abundance of *D. albiventris* might be related to forest succession, considering that they prefer disturbed and secondary forests (Paglia et al., 1995). Câmara & Lessa (1994) collected two specimens of *Oligoryzomys* sp. in pitfalls (a method not employed in the present study) which we have not collected, either by chance or because of the methods employed.

Fleming (1972) and Cáceres (2000) also recorded a higher abundance of marsupials during the wet season as documented here (except for *G. agilis*). In both studies, increasing abundance was correlated with reproduction, leading to higher recruitment of young individuals, a pattern also noted here (see the results for *M. incanus* and Tab. 2). In contrast, other authors found higher abundances during the dry season (e.g., Dietz, 1983; Alho, 1985; Fonseca, 1989; O'Connell, 1989; Stallings, 1989; Barros-Battesti et al., 2000). These results can be somewhat misleading, considering that most of them occurred in highly seasonal habitats, generating distinct results regarding reproductive patterns. For example, Dietz (1983) and Alho (1985), studying small mammal communities in the Cerrado of Central Brazil, found higher abundances during the dry season, whereas the expected pattern for such a highly seasonal habitat should be higher values during the wet season. Fonseca (1989), O'Connell (1989), Stallings (1989), and Barros-Battesti et al. (2000) evaluated small mammal community structure in seasonal habitats, where the rainfall distribution is restricted to few months along the year. In these studies, rainfall increased food availability, which may have lead to higher abundance values. However, we should not consider the rainfall regime as the only factor influencing abundance, given the high seasonality recorded in the studies cited above. Various environmental factors other than rainfall may have influenced these results, such as temperature variation throughout the seasons, as well as photoperiod (see below). Another possible explanation for the increase in abundance during the dry season in seasonal habitats is the increase of birth rates during the wet season, generating greater recruitment rates during the dry season. Other ecological factors, such as competition and predation, may have influenced abundance as well. High mortality rates influenced the abundance of the squirrel *S. aestuans* in the area. This diurnal species does not tolerate long periods in traps, and 11 individuals died during the study period, mainly in the first two months.

The recruitment of marsupials is correlated with reproduction and associated with rainfall and food availability, leading to the capture of more juveniles and sub-adults during the wet season. The high mortality (Tab. 2) and dominance of sub-adults (Fig. 2a) of *M. incanus* during the wet season, indicates population turnover for this species in this season, with the replacement of adults by sub-adults. The short residence time of three to five months documented for *P. frenatus* is possibly related to dispersal (Fleming, 1972; Cerqueira et al., 1993; Gentile & Cerqueira, 1995), suggesting movements to other parts of the fragment or even between this and other nearby fragments (such as Mata da Baleia) *D. albiventris* probably moves among fragments as well. Considering its large body size and high energetic requirements, this species has relatively large home ranges (Mace & Harvey, 1983), making its dispersal to other sites likely. In fact, most white-eared opossums trapped were reproducing females during the wet season (Fig. 1a), suggesting that this species used the study area seasonally for reproduction.

The positive correlation between rainfall and marsupial reproduction is a common pattern in southeastern Brazil (Rigueira et al., 1987; Cerqueira et al., 1993; Gentile & Cerqueira, 1995), although a more intense activity during the dry season was documented in northern South America (Tyndale-Biscoe & Mackenzie, 1976; O'Connell, 1989; Julien-Laferriére & Atramentowicz, 1990), where differences between the dry and the rainy seasons are not so drastic. The increase in food availability during the rainy season is probably a triggering factor for reproduction. The correlation between rainfall and reproduction was stronger for females, which showed signs of reproductive activity mainly in the wet season, than for males, which were reproductive active in both seasons (Fig. 1). Photoperiod is considered an additional factor influencing the beginning of reproduction in marsupials (Cerqueira & Bergallo, 1993). In fact, three of the four species studied started reproduction in October, a month of increasing photoperiod.

Barros-Battesti et al. (2000) found males and females of *Akodon cursor* (Winge, 1887) reproducing only during the dry season in another area in southeastern Brazil with vegetation structure and rainfall regime similar to those prevailing in the Parque Mangabeiras. In contrast, we found females of *A. montensis* reproducing only during the wet season (Fig. 1b). Again, food availability may be a possible influencing factor, considering the similarity of rainfall distribution on both areas. O'Connell (1989) and Bergallo (1995) found a prolonged reproductive activity for most rodent species in tropical forests of Venezuela and in secondary Atlantic forest, respectively. Prolonged reproduction has been well documented for *R. mastacalis* in particular (O'Connell, 1989; Mares & Ernest, 1995). In fact, we found females of this species reproducing during both seasons (Fig. 1b), but small sample size precludes statistical inferences.

The ability to cross the paved road is related to the species' mode of locomotion. Arboreal and scansorial species have greater capacity to move across the road due to canopy connectivity. Marsupials and rodents presented different capacities to overcome the physical barrier. Thus, the potential for some species to transpose the road is compromised. The road cuts on both sides may be of greater influence for terrestrial species then the road itself, considering that they reach more than two meters in height in some parts and many of them are located near the transects. These road cuts potentially restrict the locomotion of strictly terrestrial species, especially small-bodied ones, such as *A. montensis.* These small species may be living in a fragmented habitat, isolated in two distinct sub-populations. Rodents tend to have small home ranges, varying from 0.016 ha in *Kannabateomys amblyonyx* (Wagner, 1845) (Stallings et al., 1994) to 1.30 ha in *Trinomys iheringi* (Thomas, 1911) (Bergallo, 1995), for example. There is usually little or no overlap of territories among individuals, making long distance dispersal unlikely. In addition, a high level of territoriality in defending environmental resources (Meserve, 1977; Bergallo, 1995) may be another factor influencing these results. Scansorial and arboreal species (*M. incanus*, *R. mastacalis*, and *S. aestuans*) presented a greater capacity to cross the road because there is a considerable connectivity in the canopy across the road. The low number of recaptures of *G. agilis* and *P. frenatus* may have prevented the detection of their movements across the road. Territoriality may be another factor influencing this result, considering that a previous study (Cáceres & Monteiro, 2001) found no overlap among territories of female *Didelphis aurita* (Wied-Neuwied, 1826) during the breeding season in an urban Atlantic forest fragment in southern Brazil. These results must be considered during conservation planning and management of protected areas, especially those having physical structures such as roads, fences, and buildings. In such cases, these structures must be constructed around forest patches, avoiding fragmentation of populations of species having low dispersal rates and small home ranges. In the case of the Mangabeiras Park, we suggest two measures to ensure long-term population viability through movements between forest patches: a) reduction of road cuts and construction of underground tunnels favoring terrestrial species, and b) maintenance of canopy connectivity across the road, favoring scansorial and arboreal species.

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References

Alexander, S. M. & Waters, N. M. 2000. The effects of highway transportation corridors on wildlife: a case study of Banff National Park. **Transportation Research Part C: Emerging Technologies, 8**: 307-320.

Alho, C. J. R. 1985. Population ecology of a cerrado rodent community in Central Brazil. **Revista Brasileira de Biologia, 45**: 597-607.

Alho, C. J. R.; Pereira, L. A. & Paula, A. C. 1986. Patterns of habitat utilization by small mammal populations in cerrado biome of central Brazil. **Mammalia, 50**: 447-460.

Alves-Costa, C. P.; Fonseca G. A. B. & Christofaro, C. 2004. Variation in the diet of the brown-nosed coati (*Nasua nasua*) in southeastern Brazil. **Journal of Mammalogy, 85**: 478-482.

Ayres, M.; Ayres, M. JR.; Ayres, D. L. & dos Santos, A. S. 2003. **BioEstat 3.0**: **Aplicações estatísticas nas áreas das ciências biológicas e médicas.** Manaus, Sociedade Civil Mamirauá, MCT/CNPq, Conservation International, 291 pp.

Barratt, D. G. 1997. Home range size, habitat utilisation and movement patterns of suburban and farm cats *Felis catus*. **Ecography, 20**: 271-280.

Barros-Battesti, D. M.; Martins, R.; Bertim, C. R.; Yoshinari, N. H.; Bonoldi, V. L. N.; Leon, E. P.; Miretzki, M.; Schumaker, T. T. S.; 2000: Land fauna composition of small mammals of a fragment of Atlantic Forest in the State of São Paulo, Brazil. **Revista Brasileira de Zoologia, 17**: 241-249.

Begon, M. 1979. **Investigating animal abundance**: **capture-recapture for biologists.** London, Edward Arnold. 335 pp.

Bergallo, H. G. 1995. Comparative life history chacteristics of two species of rats, *Proechimys iheringi* and *Oryzomys intermedius*, in an Atlantic forest of Brazil. **Mammalia, 59**: 51-64.

Bias, M. A. & Morrison, M. L. 1999. Movements and home range of salt marsh harvest mice. **Southwestern Naturalist, 44**: 348-353.

Brock, R. E. & Kelt, D. A. 2004. Influence of roads on the endangered Stephens' kangaroo rat (*Dipodomys stephensi*): are dirt and gravel roads different? **Biological Conservation, 118**: 633-640.

Cáceres, N. C. 2000. Population ecology and reproduction of the white-eared opossum *Didelphis albiventris* (Mammalia, Marsupialia) in an urban environment of Brazil. **Ciência e Cultura, 52**: 171-174.

Cáceres, N. C.; Monteiro, E. L. A., 2001: Food habits, home range and activity of *Didelphis aurita* (Mammalia, Marsupialia) in a forest fragment of southern Brazil. **Studies on Neotropical Fauna and Environment 36 (2)**: 85-92.

Câmara, E. M. V. C. & Lessa, L. G. 1994. Inventário dos mamíferos do Parque das Mangabeiras, Belo Horizonte, Minas Gerais, Brasil. **Bios, 2**: 31-35.

Cerqueira, R. & Bergallo, H. G. 1993. A possible case of photoperiod controlling the reproduction of a South American marsupial. **Ciência e Cultura, 45**: 140-141.

Cerqueira, R.; Gentile, R. D; Fernandez, F. A. S. & D'Andrea, P. S. 1993. A five-year population study of an assemblage of small mammals in southeastern Brazil. **Mammalia, 57**: 507-517.

D'Andrea, P. S.; Cerqueira, R. & Hingst, E. D. 1994. Age estimation of the gray four eyed opossum, *Philander opossum* (Didelphimorphia, Didelphidae). **Mammalia, 58**: 283-291.

Dietz, J. M. 1983. Notes on the natural history of some small mammals in Central Brazil. **Journal of Mammalogy, 64**: 521-523.

Fleming, T. H. 1972. Aspects of the population dynamics of three species of opossums in the Panama Canal Zone. **Jounal of Mammalogy, 53**: 619-623.

Fonseca, G. A. B. 1989. Small mammal species diversity in Brazilian tropical primary and secondary forests of different sizes. **Revista Brasileira de Zoologia, 6**: 381-422.

Gentile, R. & Cerqueira, R. 1995. Movement patterns of five species of small mammals in a Brazilian restinga. **Journal of Tropical Ecology, 11**: 671-677.

Gentile, R. & Fernandez, F. A. S., 1999: Influence of habitat structure on a streamside small mammal community in a Brazilian rural area. **Mammalia, 63**: 29-40.

Julien-Laferriére, D. & Atramentowicz, M. 1990. Feeding and reproduction of three didelphid marsupials in two Neotropical forests (French Guiana). **Biotropica, 22**: 404-415.

Leigh, E. G. 1982. Introduction, *In:* Leigh, E. G., Rand, A. S. & Windsor, D. M. (eds.) **The Ecology of a Tropical Forest.** Washington, D. C, Smithsonian Institution Press. pp. 11-17.

Mace, G. M. & Harvey, P. H. 1983. Energetic constrains on home-range size. **American Naturalist, 121**: 120-132.

Mares, M. A. & Ernest, K. A. 1995. Population and community ecology of small mammals in a gallery forest of Central Brazil**. Journal of Mammalogy, 76**: 750-768.

Meserve, P. L. 1977. Three-dimensional home ranges of cricetid rodents. **Journal of Mammalogy, 58**: 549-558.

Noss, R. F.; Quigley, H. B.; Hornocker, M.G.; Merrill, T. & Paquet, P. C. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. **Conservation Biology, 10**: 949-963.

O'Connell, M. A. 1989. Population dynamics of Neotropical small mammals in seasonal habitats. **Journal of Mammalogy, 70**: 532-548.

Paglia, A. P.; de Marco Jr.; P., Costa, F. M.; Pereira, R. F. & Lessa, G. 1995. Heterogeneidade estutural e diversidade de pequenos mamíferos em um fragmento de mata secundária em Minas Gerais Brasil. **Revista Brasileira de Zoologia, 12**: 67-79.

Rigueira, S. E.; Valle, C. M. C.; Varejão, J. B. M.; Albuquerque, P. V. & Nogueira, J. C. 1987. Algumas observações sobre o ciclo reprodutivo anual de fêmeas do gambá *Didelphis albiventris* (Marsupialia, Didelphidae) em populações naturais no estado de Minas Gerais. **Revista Brasileira de Zoologia, 4**: 129-137.

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

Stallings, J. R.; Kierulff, M. C. M.; Silva, L. F. B. M., 1994: Use of space and activity patterns of Brazilian Bamboo Rats (*Kannabateomys amblyonyx*) in exotic habitat. **Journal of Tropical Ecology, 10**: 431-438.

Tigas, L. A.; Van Vuren, D. H.; Sauvajot, R. M. 2002. Behavioral responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. **Biological Conservation, 108**: 299-306.

Tyndale-Biscoe, C. H. & Mackenzie, R. B. 1976. Reproduction in *Didelphis marsupialis* and *D. albiventris* in Colombia. **Journal of Mammalogy, 57**: 249-265.

Vaughan, C. S. & Hawkins, L. F. 1999. Late dry season habitat use of common opossum, *Didelphis marsupialis* (Marsupialia: Didelphidae) in Neotropical lower montane agricultural areas. **Revista de Biologia Tropical, 47**: 263-269.