

Land fauna composition of small mammals of a fragment of Atlantic Forest in the State of São Paulo, Brazil

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ABSTRACT. The Atlantic Forest small mammal land fauna, except bats, and the abiotic factors that might have an influence on its composition, were studied in the Itapevi County, State of São Paulo, a forested region, partly altered by antropic action, from January, 1995 to June, 1996. The trapping effort consisted of 2,888 trap-nights, resulting in a 4.6% trapping success and consisted of monthly trappings, for five consecutive days. During this period, 134 specimens were captured, of which 46.3% were Didelphimorphia and 53.7% were Rodentia. Eleven species were registered: two Didelphimorphia: *Didelphis marsupialis* (Linnaeus, 1758) and *Marmosops incanus* (Lund, 1841), and nine Rodentia: *Akodon cursor* (Winge, 1887), *Bolomys lasiurus* (Lund, 1841), *Oxymycterus hispidus* Pictet, 1843, *Oxymycterus nasutus* (Waterhouse, 1837), *Oligoryzomys nigripes* (Olfers, 1818), *Oryzomys angouya* (Fischer, 1814), *Rattus norvegicus* (Berkenhout, 1769), *Euryzgomatomys spinosus* (G. Fischer, 1814) and *Cavia aperea* Erxleben, 1777. The relative density indices were correlated with meteorological data by Spearman and Pearson coefficients. For marsupials these correlations were not significant. For rodents, the correlations were significant and directly related to lower temperature and rainfall indices ($p < 0.05$). During the dry season the occurrence of small mammals was 50% greater than during the wet season, probably due to foraging strategies in the studied fragment of Atlantic Forest.

KEY WORDS. Small mammals, marsupial, rodent, Atlantic Forest

Growing economic development has destroyed the Atlantic Forest, especially in Southeastern Brazil, where gradual deforestation has generated mosaics with isolated fragments in different stages of secondary regeneration. Only 5% of the Atlantic forest remains, with less than 1% of the original vegetation (MITTERMEIER *et al.* 1982; FONSECA 1985). Except bats, in this ecosystem there are 80 species of

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small mammals described, 23 marsupials and 57 rodents. Of these, 9 opossums and 30 rodents are endemic, and could be threatened by environmental destruction (FONSECA & KIERULFF 1989). This environmental complexity provides more potential niches than structurally simpler habitats, increasing species diversity (KLOPFER & MACARTHUR 1960). A small patch of tropical forest can be extremely complex but homogeneous. On the other hand, potential niches are vertically distributed in complex habitats and, horizontally and vertically distributed in patchy habitats (AUGUST 1983). These habitats provide a variety of resources that favor fauna biodiversity growth (PAGLIA *et al.* 1995). Although rich and endemic, this small mammal fauna is poorly known when compared to other Brazilian biomes (FONSECA & KIERULFF 1989).

In Neotropical region studies (DAVIS 1945; DIETZ 1983; STALLINGS 1989; O'CONNELL 1989; OLMOS 1991; CERQUEIRA *et al.* 1993; BERGALLO 1994), the capture success of small mammals was related to seasonal fluctuation, with an increase in captures during the dry season. A pronounced peak in the total number of captures could be attributed to the paucity of food resources during this period of the year. Nevertheless, FONSECA & KIERULFF (1989) stated that the capture increase begins in the late wet season, on the western slopes of the Atlantic Forest, when juveniles are recruited into the population.

The purpose of the present study was to determine the composition of the small land mammal population, except bats, and to verify the abiotic factors influence in a disturbed Atlantic Forest fragment.

MATERIAL AND METHODS

Study Area

Itapevi County, State of São Paulo (23°32'45"S and 46°56'05"W) is located in the Atlantic Forest region. Certain parts have been altered by antropic action such as plantations, fields and built up areas, characterizing a mosaic type formation linked by corridors of vegetation. The Planalto Paulistano, where the county is located, comprises an area of 5,000 km², with heights ranging from 715 m to 900 m (PONÇANO *et al.* 1981). According to Köppen's classification, the climate type is Cwb (mesothermic with dry winter and cool summer), with an annual rainfall ranging from 1,300 to 1,500 mm³, and an annual mean temperature ranging from 20 to 22°C (SETZER 1949).

The study area consisted of a condominium located in the southwest of Itapevi, with an area of 124.58 ha. Of these, 62.07 ha are divided into lots, and 32.80 ha consist of green areas, with secondary forest in varying stages of regeneration.

The study area was divided into 4,000 m² squares. Using PEREIRA & BUSSAB's (1985) random numbers chart, one or more squares were chosen for each trapping stage.

Field Procedures

The study was conducted from January, 1995 to June, 1996. Monthly trappings were carried out for five consecutive days, always on the last week of the month. For marsupials, an average of 15 live traps, measuring 20x20x40 cm (10

mm mesh), were placed 8 to 10 meters apart. For rodents, 5 mm mesh traps, measuring 10x10x22 cm, were placed five meters apart. Twelve traps were used during the first seven months, later increasing to 27.

Traps were placed on the ground along transects, in the monthly selected squares. Sample areas for marsupials were defined as those around the houses and in forest environments; for rodents, forest borders and areas in the first stages of regeneration. The bait used was bacon for marsupials and corn for rodents. The small mammals registered during this study were restricted to ground dwelling fauna.

Captured animals were weighed, sexed and measured. All rodents were sacrificed for identification. The marsupials were identified, numbered with plastic necklaces and released. Reproductive conditions were observed for marsupials, verifying female pouch size, lactation and litter. The presence of embryos and/or litter was observed in female rodents. In males, a developed scrotum was observed.

Upper molars (KRAVETZ 1972) and skull sutures (LANGGUTH 1963) were used to determine rodents' age, establishing two age classes. Size and weight standards were considered for the marsupials' age determination.

Rodent and marsupial identification followed the nomenclature proposed by WILSON & REEDER (1993), GARDNER (1993) and MUSSER *et al.* (1998). Rodents' skin and skulls were deposited in the mastozoology collection of the Museu de História Natural Capão da Imbuia, State of Paraná. The Sanitation Company of the State of São Paulo (SABESP) Estação Morro Grande, Cotia, State of São Paulo, supplied the rainfall indices for each trapping stage. Temperatures were measured at the actual sampling sites.

Statistical Analysis

Due to the variation in the number of traps, the relative density index (RDI) (CRESPO 1966; KRAVETZ 1972) was calculated according to the formula: $RDI = [\text{number of captured specimens/trapping nights} \times \text{number of traps}] \times 100$. The Spearman coefficient was used to obtain the monthly correlation ratio of the number of captured animals and the meteorological data. The relative density indices were correlated monthly with the meteorological data using Pearson's coefficient (GLASS & STANLEY 1980). These calculations were obtained using the Stat Graf Program (version 5.0, Statistical Graphics System - STSC). The number of mammals, captured during dry and wet seasons, was analyzed by Fisher test, commonly used for low frequencies (ZAR 1974).

RESULTS

In 18 trapping months, 134 specimens were registered. Of these, 46,3% were Didelphimorphia and 53.7% were Rodentia. The trapping effort consisted of 2,888 trap-nights, resulting in a 4.6% trapping success in the sampled area.

Eleven species were registered among Didelphimorphia and Rodentia orders. The first order was represented by the Didelphidae family - *Didelphis marsupialis* (N=61; 45.6%) and *Marmosops incanus* (N=1; 0.7%). The Rodentia order was represented by three families: Muridae - *Akodon cursor* (N=30; 22.4%), *Bolomys lasiurus* (N=13; 9.7%), *Oligoryzomys nigripes* (N=13; 9.7%), *Oxymycte-*

rus hispidus (N=6; 4.5%), *Oxymycterus nasutus* (N=5; 3.8%), *Oryzomys angouya* (N=1; 0.7%), and *Rattus norvegicus* (N=1; 0.7%); Echimyidae: *Euryzomatomys spinosus* (N=2; 1.5%), and Caviidae: *Cavia aperea* (N=1; 0.7%).

The annual rainfall in this area during this study was 1,654.4 mm³. The annual average temperature was of 21°C, with two defined seasons: dry, from April to September, and wet, from October to March.

The capture frequency of small mammals during the dry season (N=88, 66%; 35 marsupials and 53 rodents) was greater than during the wet season (N=46, 34%; 27 marsupials and 19 rodents). The difference was significant ($p=0.045$; $p<0.05$) according to the Fisher test.

The distribution of age classes for marsupials and rodents, during the dry and wet seasons, is shown on table I.

Table I. Age class distribution for the mammal species during wet and dry seasons in Itapevi, São Paulo. (M) Male, (F) female.

Species	Wet		Dry		Wet		Dry		Total
	Jan. to Mar., 1995		Apr. to Sep., 1995		Oct., 1995 to Mar., 1996		Apr. to Jun., 1996		
	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	Adults	Juveniles	
<i>D. marsupialis</i>	3M/8F	2M/1F	11M/12F	1M	3M/9F	1F	7M/4F	-	61(27M/34F)
<i>M. incanus</i>	-	-	-	-	1F	-	-	-	1(F)
Total marsupials	3M/8F	2M/1F	11M/12F	1M	3M/9F	1F	7M/4F	-	62(27M/35F)
<i>A. cursor</i>	-	-	8M/3F	2F	2M/5F	3M/1F	2F	4M	30(17M/13F)
<i>B. lasiurus</i>	-	-	1M/3F	3M/3F	1F	-	-	2M	13(6M/7F)
<i>C. aperea</i>	1F	-	-	-	-	-	-	-	1(F)
<i>E. spinosus</i>	-	-	-	-	-	-	1M/1F	-	2(1M/1F)
<i>O. hispidus</i>	1M	-	1F	-	1M/2F	1F	-	-	6(2M/4F)
<i>O. nasutus</i>	-	-	1M/2F	-	-	-	2M	-	5(3M/2F)
<i>O. nigripes</i>	-	-	6M/5F	1M	-	-	1M	-	13(8M/5F)
<i>O. angouya</i>	-	-	1M	-	-	-	-	-	1(M)
<i>R. norvegicus</i>	-	-	-	-	1M	-	-	-	1(M)
Total rodents	1M/1F	-	17M/14F	4M/5F	4M/8F	3M/2F	4M/3F	6M	72(39M/33F)
Total	4M/9F	2M/1F	28M/26F	5M/5F	7M/17F	3M/3F	11M/7F	6M	134(66M/68F)

The number of trapped adult specimens of *D. marsupialis* during the dry seasons (N=34) was greater than during the wet seasons (N=22); four juvenile specimens were trapped during the wet season, whereas only one during the dry season. In addition, 10 females with pouch litters and 8 lactant females of *D. marsupialis*, and a single breeding *M. incanus* female, were observed during the wet season.

A. cursor was more trapped than any other rodent species, with adults and juveniles occurring during both periods. For *B. lasiurus* the juveniles were more trapped than adults. Both juveniles and adults of *B. lasiurus* occurred mainly during the dry seasons. A single adult specimen was trapped during the wet season of 1996. Mainly adults of *O. hispidus* were trapped during the wet seasons, with only one juvenile female being registered. On the other hand, all specimens of *O. nasutus* were adults, and were trapped only during the dry seasons. Adults of *E. spinosus* and *O. angouya*, as well as adults and juveniles of *O. nigripes*, were trapped only during the dry seasons. A single adult *C. aperea* was trapped during the wet season.

Reproductive conditions were observed in 14 rodents: *A. cursor* (1 pregnant female and 2 males in April, 1995; 1 pregnant female and 1 nursing female in April, 1996 and June, 1996, respectively); *B. lasiurus* (1 pregnant female in May, 1 pregnant female and 1 male in June 1995, and 1 pregnant female in December, 1995); *E. spinosus* (1 pregnant female and 1 male in May, 1996); *O. nasutus* (1 nursing female in July, 1995) and *O. eliurus* (2 males in August, 1995).

The biometric data for small adult mammals, with the exception of those species represented by a single specimen or one specimen of each sex, is shown on table II.

Table II. Biometric data for adult mammals captured in Itapevi, São Paulo. (M) Male, (F) female, (N) number of specimens, (S) standard deviation.

Mammals	Sex	N	Weight (g)		Body length (mm)		Tail length (mm)		Hind foot (mm)		Ear length (mm)	
			Mean	S	Mean	S	Mean	S	Mean	S	Mean	S
<i>D. marsupialis</i>	M	24	1328.4	434.5	397.1	38.6	339.3	23.9	57.5	4.3	47.8	4.2
	F	32	1098.3	369.7	367.8	33.8	330.0	22.7	54.0	3.4	45.3	4.3
<i>A. cursor</i>	M	10	44.6	3.5	118.1	6.9	87.6	5.6	22.5	1.5	17.8	1.2
	F	10	37.9	6.9	114.7	7.9	86.1	4.5	22.4	1.8	17.7	1.2
<i>B. lasiurus</i>	M	1	45.0	0.0	110.0	0.0	75.0	0.0	20.0	0.0	15.0	0.0
	F	4	40.5	13.9	107.3	19.2	74.5	8.0	20.0	3.4	15.0	0.8
<i>O. hispidus</i>	M	2	100.3	21.6	166.5	10.6	108.0	25.5	32.3	0.4	23.5	2.1
	F	3	81.2	7.2	164.0	4.0	115.0	5.0	31.0	1.0	23.3	1.5
<i>O. nasutus</i>	M	3	57.4	4.6	147.3	5.5	87.3	2.5	24.3	0.6	17.7	1.2
	F	2	50.0	14.1	132.0	2.8	79.0	5.7	23.5	0.7	16.0	0.0
<i>O. nigripes</i>	M	7	23.9	3.4	98.7	6.7	121.4	2.8	23.0	0.8	15.9	0.7
	F	5	20.3	2.8	93.8	8.5	118.6	9.4	21.6	1.3	16.2	1.1

Table III shows the total number of trapped specimens, the relative density indices for marsupials (MRDI) and rodents (RRDI), and the meteorological data. For marsupials, the highest MRDI was registered in March, 1995 (11.48%) and the lowest in February, 1996 (1.68%). For rodents, the highest RRDI was registered in June, 1995 (31.25%) and the lowest in December, 1995 (0.76%).

The correlation between captured mammals and meteorological data, obtained by Spearman and Pearson coefficients, is shown on table IV. Significant correlations ($p < 0.05$) are highlighted in bold face.

DISCUSSION

Over the study period, the small mammal capture during the dry season (April to September) was 50% greater than during the wet season (October to March) (Fisher test, $p = 0.045$; $p < 0.05$). This seasonal fluctuation, with an increase of captures during the dry season, has been commonly observed in other small mammal populational studies, in the Neotropical area (DIETZ 1983; FONSECA & KIERULFF 1989; STALLINGS 1989; O'CONNELL 1989).

The predominance of *D. marsupialis* amongst marsupials is probably due to the environment, altered by antropic action, confirming its characteristic as a bioindicator of disturbed areas (PAGLIA *et al.* 1995). According to age class, adult marsupials (92%) were more captured than juveniles (8%), and the sex proportion was 1:1 (Tab. I and II). Neither seasonal fluctuation, nor significant difference in the populational level for these species was observed during this study.

Table III. Mammals captured, marsupials' relative density index (MRDI), rodents' relative density index (RRDI) and meteorological data in Itapevi, State of São Paulo. (MAT) Monthly average temperature; (WAT) weekly average temperature; (MAR) monthly average rainfall; (WAR) weekly average rainfall; (AMR) accumulated monthly rainfall; (AWR) accumulated weekly rainfall.

Months *	Marsupials			Rodents			Mammals	Meteorological data					
	Trap**	Captured	MRDI	Trap**	Captured	RRDI	Captured	MAT	WAT	MAR	WAR	AMR	AWR
Jan., 1995	12.6	2	3.17	12.0	0	0.00	2	24.6	25.2	7.96	2.20	246.9	11.00
Feb.	15.2	5	6.58	12.0	1	1.67	6	23.7	26.3	16.95	6.94	474.7	34.70
Mar.	12.2	7 (4)	11.48	11.2	1	1.79	8	22.8	21.8	4.79	9.66	148.6	48.30
Apr.	12.2	6	9.84	10.0	4	8.00	10	21.0	20.9	3.43	0.16	103.0	0.80
May	13.6	3 (2)	4.41	9.2	5	10.87	8	19.7	17.2	1.91	0.02	59.1	0.02
Jun.	12.8	5 (1)	7.81	6.4	10	31.25	15	17.6	15.9	1.04	2.98	31.1	14.90
Jul.	15.0	2 (1)	2.67	9.0	7	15.56	9	19.4	20.5	1.56	0.20	48.5	1.20
Aug.	12.8	3	4.69	22.8	8	7.02	11	21.2	21.1	0.84	0.12	26.2	0.60
Sep.	12.0	5	8.33	23.2	6	5.17	11	19.5	19.2	2.20	2.86	66.1	14.30
Oct.	14.8	2	2.70	23.6	6	5.08	8	20.0	22.8	6.18	0.06	191.7	0.30
Nov.	14.6	3 (1)	4.11	24.6	3	2.43	6	22.3	20.2	3.04	0.10	91.2	0.50
Dec.	14.0	2	2.86	26.4	1	0.76	3	22.8	21.1	5.40	7.40	167.3	37.00
Jan., 1996	12.6	3 (1)	4.76	25.4	3	2.36	6	24.6	26.0	6.18	4.76	191.6	23.80
Feb.	15.6	1	1.28	23.2	4	3.45	5	24.1	22.2	5.34	1.54	154.9	7.70
Mar.	14.6	2	2.74	26.0	0	0.00	2	23.2	24.2	6.78	0.60	210.2	3.00
Apr.	13.2	4	6.06	24.8	2	1.61	6	21.9	20.0	1.25	1.78	37.6	8.90
May	13.8	3	4.35	19.8	7	7.07	10	18.6	18.3	1.46	0.42	45.3	2.10
Jun.	14.4	4	5.56	22.0	4	3.64	8	17.8	20.9	1.50	0.02	45.1	0.10

(*) Five consecutive trapping days/month; (**) monthly average number of traps. In parenthesis marsupials recaptured.

Table IV. Pearson coefficient (r) and Spearman coefficient (r_s), in parenthesis, descriptive level (p) of the null hypothesis test association between meteorological data and number of mammals, and relative density index for marsupials (MRDI) and rodents (RRDI) in Itapevi, São Paulo. (MAT) Monthly average temperature; (WAT) weekly average temperature; (MAR) monthly average rainfall; (WAR) weekly average rainfall; (AMR) accumulated monthly rainfall; (AWR) accumulated weekly rainfall. The significant correlations are highlighted in bold face.

Meteorological data	Marsupials number (r_s)	MRDI (r)	Rodents Number (r_s)	RRDI (r)
MAT	-0.284 (0.241)	-0.189 (0.453)	-0.730 (0.005)	-0.625 (0.007)
WAT	-0.298 (0.220)	-0.216 (0.389)	-0.499 (0.053)	-0.646 (0.005)
AMR	-0.294 (0.226)	-0.075 (0.768)	-0.617 (0.017)	-0.402 (0.109)
AWR	0.228 (0.347)	0.414 (0.087)	-0.463 (0.073)	-0.217 (0.403)
WAR	-0.306 (0.206)	-0.091 (0.719)	-0.594 (0.022)	-0.420 (0.093)
MAR	0.228 (0.347)	0.414 (0.087)	-0.463 (0.073)	-0.217 (0.403)

The reproductive activity and breeding of *D. marsupialis* occurred during the wet season. This was also observed by BERGALLO (1994) in the Estação Ecológica Juréia/Itatins, an ecological Atlantic Forest reserve in the southeast of the State of São Paulo. Nevertheless, JULIEN LAFERRIÈRE & ATRAMENTOWICZ (1990) noted that *D. marsupialis* has seasonal reproductive strategies, through reproductive feedback mechanisms.

Adult rodents (72%) were more trapped than juveniles (28%) (Tab. I). The greater rodent richness occurred in July, 1995 and May, 1996. Three species occurred during both months: *B. lasiurus*, *O. nasutus* and *O. nigripes*. One specimen of *O. hispidus* was found only in July and two specimens of *E. spinosus* in May. The specimens of *O. nasutus* were found only during the dry season, while *O. hispidus* was found mainly during the wet season, with a single individual captured during the dry season. This distribution suggests a resource division in habitat use by both species. According to O'CONNELL (1989), the comparison of the responses of different species to these fluctuations provides an insight into the role of variable environments in shaping life-history strategies, and different species within a community may respond differently to the same environmental fluctuations.

Among the trapped rodents, *A. cursor*, a species associated to edges and open areas, was the most common. Neither seasonal fluctuation nor significant differences in the populational level were observed for this species during this study. But, when there was a greater diversity of rodents in July, 1995 and May, 1996, *A. cursor* was absent, suggesting that there was a competitive exclusion possibly provoked by the resources and use of the habitat. Adults and juveniles of *O. nigripes*, were trapped only during the dry seasons. The specimens of *E. spinosus* (trapped in May, 1996) and *O. angouya* (trapped in May, 1995) were rare in the study area. Two specimens of *O. nigripes* were captured in July; six in August; four in September, 1995 and only one in May, 1996. OLMOS (1991), who studied the behavior of some rodent species in an Atlantic Forest state reserve in the Serra de Paranapiacaba, Southern São Paulo, also observed that *O. nigripes* appears suddenly in the dry season (between July and August) and then there is an absence of captures during the following months. For *O. angouya*, this author registered a maximum density in October.

Reproductive activity in rodents seems to occur mainly during the dry season and was only observed in 14 specimens. Although the data is incomplete, since the rodents were captured only once, they agree with those observed by OLMOS (1991) who found a general pattern of reproductive rest during winter.

The number of rodent trappings was greater than the marsupial ones during the dry seasons. The correlation with meteorological data was not significant ($p > 0.05$) neither for the number of captured marsupials nor for the MRDI. Nevertheless, it was significant ($p < 0.05$) for the number of captured rodents and negatively correlated with the monthly average temperature, monthly average rainfall and weekly average rainfall (Tab. IV). For RRDI, it was significant ($p < 0.05$) and negatively correlated with the monthly and weekly average temperatures.

For captured rodents, whose average body size and weight in adults ranged from 93.8 mm and 20.3 g (*O. nigripes*) to 166.5 mm and 100.3 g (*O. hispidus*), the capture chances of smaller individuals tend to increase during colder months (Tab. III). This fact could also illustrate the absence of seasonal fluctuation for marsupials due to their larger size and weight among small mammals (Tab. II). According to VICKERY & BIDER (1981), small rodents have difficulties in body temperature regulation. As the difference between body and environment temperatures increases, the metabolic rate increases to compensate the excessive heat loss.

When the number of captured mammals and the meteorological data were analysed monthly, it was observed that when the temperature and rainfall decrease, the total number of captures increases. The highest number of captured animals and the highest relative density indices were registered in March, 1995, for marsupials (MRDI) and in June, 1995, for rodents (RRDI) (Tab. III). It was observed that the highest number of captured rodents occurred when there was the smallest number of traps available. The smallest number of captured animals and MRDI occurred in February, 1996. No rodents were captured in January, 1995 and March, 1996.

Although CERQUEIRA *et al.* (1993) observed no correlation between population density and rainfall for rodents in a Brazilian coastal shrubby vegetation (Restinga) in the state of Rio de Janeiro. However some authors have linked rainfall with population fluctuations of Neotropical small mammals. A study about rodents population in an *Araucaria* forest (uplands sub-region in the State of Paraná, Southern Brazil) mentioned a significant and negative correlation between RRDI and the accumulated weekly rainfall (Carmen Zotz personal communication 1998). For lower temperatures the correlation was not significant. In our study, the correlation between the number of captured rodents and RRDI was significant when the temperature and rainfall indices were low, despite the small capture effort. The difference between our data and that obtained by FONSECA *et al.* (1993) in relation to rainfall, and with Zotz's study in relation to temperatures, could be due to the biome differences, or possibly a consequence of the availability (paucity) of resources and the pronounced drop in temperatures in the winter months, in the *Araucaria* forest. Nevertheless, in the portion of the Atlantic Forest which we studied, it was noted that the small land mammal fauna composition is being influenced by these climatic variations. However, further studies, involving canopy levels, will be necessary to determine the real composition of this area.

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