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Ecology of a Small Mammal Community in an Atlantic Forest Area in Southeastern Brazil

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During a 14 month mark-and-release project in an Atlantic forest area (Juréia Ecological Station), I studied the population ecology of 8 species of small mammals (3 marsupials and 5 rodents). In a 4,307 trap nights, 182 individuals were captured 650 times. The rodents were caught 73% of the total capture and the marsupials 27%. *Oryzomys nitidus* was the commonest species in the grid followed by *Proechimys iheringi* and *Metachirus nudicaudatus*. The marsupials showed a seasonal pattern of reproduction. As a consequence, the population densities had a peak during the wet months with the entrance of the youngs. The rodents, *P. iheringi* and *O. nitidus* bred throughout the year, although the former one had a peak in the dry months. Density of *O. nitidus* was fairly constant, whereas that of *P. iheringi* was higher during the recruitment time. Rodents and marsupials contributed with the same biomass in Juréia small mammal community.

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Introduction

Atlantic forest is one of the tropical rain forests most threatened in the world. From its original 1,000,000 km^2 (12 % of the national territory) along the Brazilian coast, only 5% was retained (Lino, 1992). Biological diversity in this area is high, resulting from different climatic conditions, altitude and latitude along a continuous strip of woodland. But unfortunately, 171 of 202 Brazilian animal species at the verge of extinction are from the Atlantic forest (Lino, 1992). Furthermore, this region sustains more than 50 % (about 80 millions) of the Brazilian human population (Lino, 1992).

From 129 species of known non-volant mammals in the Atlantic forest ecosystem, about 40 % are endemic (Fonseca & Kierulff, 1989). Basic information concerning the mammalian species in this environment remain poorly known, as well as, the functional roles played by such species in their ecosystems (Fleming, 1975). After the pioneer work of Davis (1945), recent studies have begun to provide information on the population ecology of small mammals in Atlantic forest (Carvalho, 1965, Fonseca & Kierulff, 1989, Stallings, 1989; Olmos, 1991).

However, our understanding of Atlantic forest small mammals are still quite limited.

During a 14 month mark-and-release project in an undisturbed Atlantic forest area in Southeastern Brazil, I studied the population ecology of a small mammal community. The purpose of this study was to determine the reproductive pattern, the population density and home range size of the species from Juréia-Itatins Ecological Station. Other information as sex ratio, biometric parameters and biomass were also gathered.

Methods

Study area. The study was carried out at the Juréia-Itatins Ecological Station (24° 32′ S; 47° 15′ W) in São Paulo State, southeastern Brazil. The 80,000 ha station comprise one of the latest remaining areas of undisturbed Atlantic Forest. The climate of the area is subtropical with a high annual rainfall (3,000 - 4,000 mm). Most rain falls in the summer months (December to March), although during this study a high proportion occurred in what would normally be the dry season (Fig. 1). Mean annual temperature varies between 18.3 and 25.6° C with the coldest days occurring during the dry season. For the purpose of analysis, the wet season was considered from December to May and the dry season from June to November (Fig. 1). Long-term meteorological data were obtained from the VII Distrito de Meteorologia, Iguape Station (Nascimento & Pereira, 1988) and weather data for the study period was obtained from Juréia Station, close to the study area.

The vegetation of the station changes accordingly with the altitude, that ranges from the sea level up to 800 m. In the plains occur "restingas" that are salt sand substrate habitats covered with herbaceous and shrubby vegetation (Suguio & Tessler, 1984). Still in the plains, mangroves border the rivers that are under tide influences. The hillside of the mountains are covered by Atlantic forest and the canopy varies from 20 to 30 m in height. Characteristically, the trees support a rich flora of epiphytes on these areas (Por & Imperatriz-Fonseca, 1984). The altitude fields cover the high portions of the massifs (500 to 800 m).

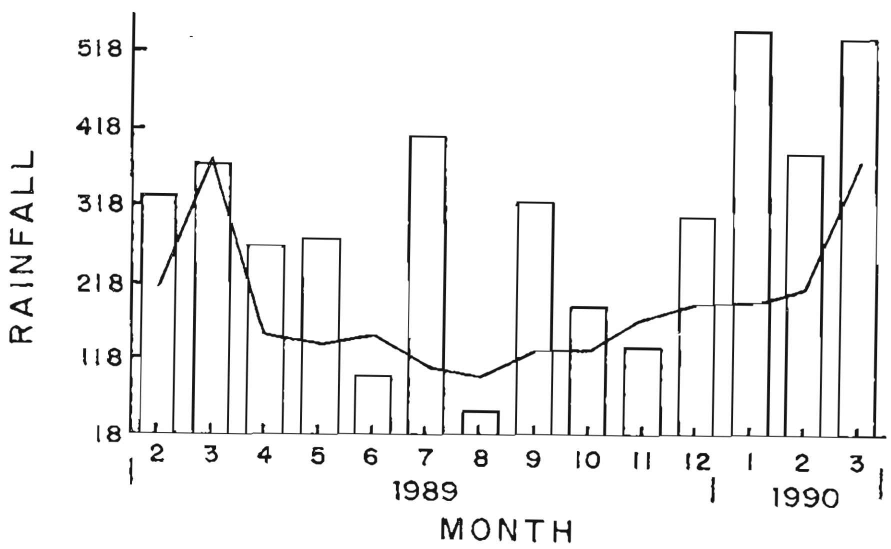

Fig. 1. Long-term average, 1977-1986 (line) and observed monthly, 1989-1990 (bar) rainfall (mm)

Trapping. Small mammal trapping was conducted on the hillside of the Massif of Juréia in a grid of 5.0 ha. Fourteen transects with 200 or 240 m of extension were established 20 m apart from each other. During three consecutive nights, 112 traps were opened on the ground every month from February 1989 to March 1990. Wire-cage traps were baited alternately with banana or with manioc and peanut butter.

Mammals were marked with an ear-code on first capture, sexed, weighed, measured (head-body HB, tail TA, hind-foot HF and ear E length) and released. Pouches of marsupial females were checked for the presence of neonates. Female rats were checked for condition of their vagina (imperforate or perforate) and palped to determine pregnancy.

Sex ratio, sexual dimorphism and growth. Sex ratio was estimated based on the first capture of the specimens and tested by the Chi-square test (Zar, 1984). This test was also used to compare the recapture rate with the sex ratio at first capture.

The sexual dimorphism in the biometric parameters (head-body, tail, hind-foot, ear and weight) for adults of each species was tested using Mann-Whitney U-test (Zar, 1984).

Specific growth rates were estimated by dividing the biometric parameter change (weight or head-body length) of recaptured individuals by the time interval between captures. Linear regression analysis was used to examine the relationship between growth rate and the biometric parameter. Size-age curves were constructed by integrating the differential form of the Von Bertalanffy model using the method described by Webb et al. (1978).

Persistence time and home range. The species persistence time at the grid was estimated based on recaptures. Data of specimens captured in the external lines of the grid were not considered. The differences in male and female mean persistence time were tested by the Student t-test (Zar, 1984).

Home range size was estimated using the Minimum Convex Polygon Method (Southwood, 1966) for animals captured four or more times. The differences between home range sizes of males and females were compared by the Student t-test (Zar, 1984).

Population density and biomass. Population density and recruitment of the more abundant species were estimated by the Jolly-Seber open population model (Caughley, 1977) and by the Minimum Number Known Alive (Krebs, 1966) to the less abundant species. The biomass (g/ha) of the small mammal populations at the grid was estimated monthly by multiplying the mean density (ind/ha) of each species by the mean body weight (g).

Results

I collected eight species of small mammals throughout the 14 months of study: *Didelphis marsupialis, Metachirus nudicaudatus, Philander opossum* (Marsupialia, Didelphidae), *Proechimys iheringi* (Rodentia, Echimyidae), *Oryzomys nitidus, Nectomys squamipes, Oxymycterus* sp. (Rodentia, Cricetidae) and *Dasyprocta agouti* (Rodentia, Dasyproctidae). Although these species are known to be mainly terrestrial, the marsupials (Miles et al., 1981, Nowak & Paradiso, 1983; Fonseca & Kierulff, 1989) and the rats *O. nitidus* (pers. obs.) and *N. squamipes* (Fonseca & Kierulff, 1989) can also climb on shrubs and trees. *D. aguti* was the only species caught with diurnal habits. Other six species of non-volant small mammals (< 5 kg) were observed in the grid, but they were not trapped: *Chironectes minimus* (Marsupialia, Didelphidae), *Sciurus ingrami* (Rodentia, Sciuridae), *Coendou* sp. (Rodentia, Erethizontidae), *Eira barbara* (Carnivora, Mustelidae), *Nasua nasua* (Carnivora, Procyonidae) and *Cebus apella* (Primates, Cebidae).

During the study 182 individuals were caught 650 times (Table 1). The rodents were caught 72.8 % of the total capture and the marsupials 27.2 %. The mean trapping success was 15.1 % in 4307 trap nights.

Species accounts

Didelphis marsupialis. The black-eared opossum was the fourth most common mammal species in the grid (Table 1). The sex ratio at first capture did not deviate from 1:1 (0.92 : 1, $X^2 = 0.04$; $p > 0.05$). However, females were more recaptured than males ($X^2 = 5.51$; $p = 0.02$, df = 1) (Table 1). Based upon recaptures the persistence time in the grid of the males (x ± SD, 1.0 ±1.4 months; N = 4) did not differ significantly from that of females (2.0 ± 2.9 months; N = 7) ($t = 0.56$; $p > 0.05$; df = 9). But, the longest persistence time in the grid was of a female (7 months). The sexes differed only in weight (Appendix 1a), being the males (1311 ± 191 g) heavier than females (1011 ± 128 g).

The growth rate (GR) in head-body length (HB) decreased with increasing size in female *D. marsupialis* ($R^2 = 0.366$; $F_{1,10} = 5.774$; $p = 0.037$; N = 12; GR = 0.306 - 0.007xHB). The mean growth rate of juvenile was of 0.1189 ± 0.0408 cm/day (N = 5), whereas that of adults was of 0.0191 ± 0.0194 cm/day (N = 5). The predictive equation of age (days) from head-body length of female *D. marsupialis* is: t = 142.86 x ln (42.71) / (43.71 - HB) (Fig. 2). It was not possible to estimate growth rate for male *D. marsupialis*, because there were not enough recaptures.

The opossums were captured in the grid in all months but in May. Population recruitment and density varied throughout the year with peaks in November and December, respectively (Fig. 3). Recruitment correlated positively and significantly with one month time-lag of density ($R^2 = 0.66$; $p = 0.003$; N = 11). The mean density (± SD) of *D. marsupialis* in the area was of 0.54 ± 0.38 ind/ha. The

Table 1. Capture results in the grid during 14 months from February 1989 to March 1990 in Juréia Ecological Station. M = male and F = female.

Species	Number of first captures			Total number of captures		
	M	:	F	M	:	F
D. marsupialis	11	:	12	20	:	50
M. nudicaudatus	21	:	09	58	:	24
P. opossum	05	:	—	25	:	—
P. iheringi	24	:	15	104	:	92
O. nitidus	43	:	28	164	:	88
N. squamipes	09	:	01	16	:	04
Oxymycterus sp.	01	:	—	01	:	—
D. aguti		03 *			04 *	
Total		182			650	

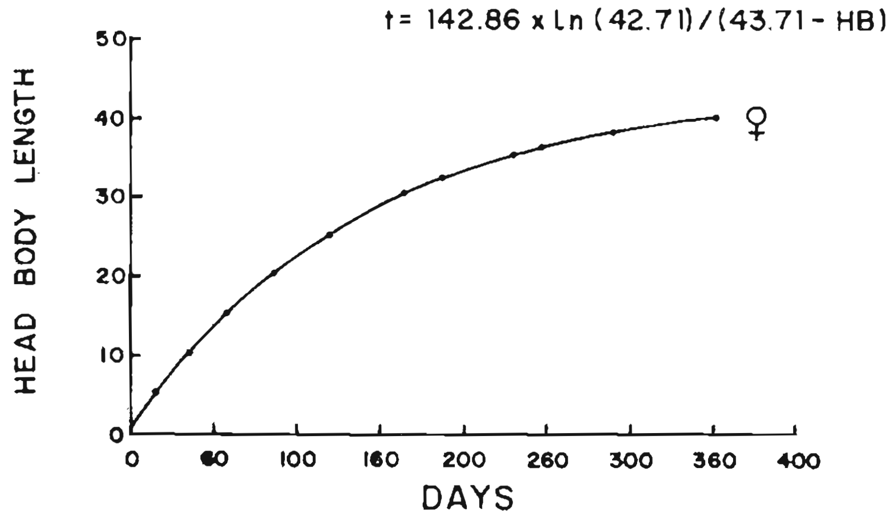

Fig. 2. Size-age curve for female *Didelphis marsupialis*. t = 142.86 x ln (43.71 - 1.0) / (43.71 - HB). Time (t) in days and head-body length (HB) in centimeters.

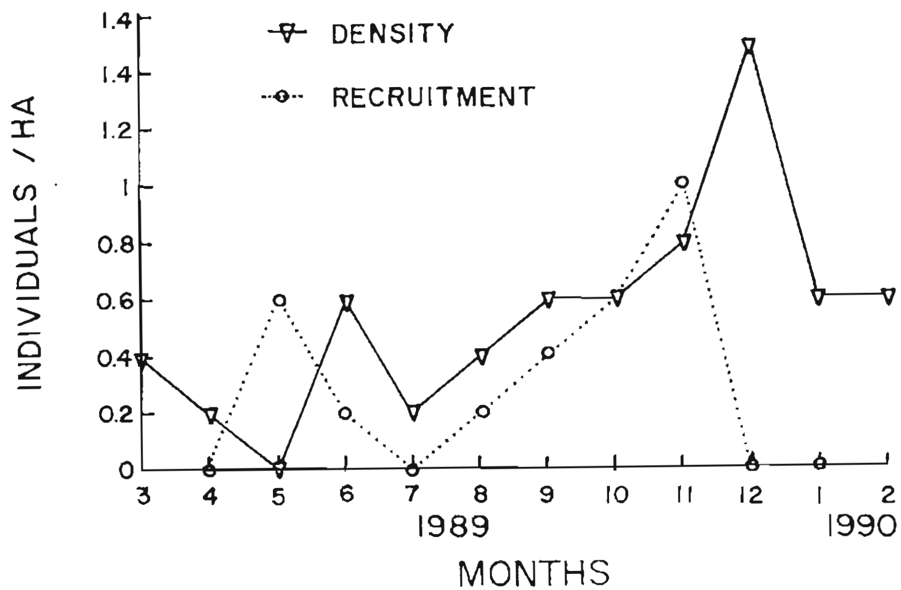

Fig. 3. Density (triangles) and recruitment (circles) (ind/ha) of *Didelphis marsupialis* from March

total biomass estimated during 12 months was 5,640 g/ha, with a monthly average (± SD) of 470.0 ± 289.0 g/ha.

Juvenile *D. marsupialis* (21.9 ± 2.1 cm, N = 13) were captured in February, March and December 1989 and January and March 1990. Adults were trapped in the dry months and from then on. The largest head-body lengths were observed during the dry months (Fig. 4). There were significant differences between the mean head-body lengths of the dry (37.9 ± 3.9 cm, range 33.0 - 43.5 cm) and wet months (28.0 ± 4.1 cm, range 22.7 - 35.5 cm) (ANOVA, $F_{1,11}$ = 19.42; p = 0.001) (Fig. 4). Lactant females were observed in October, December and January 1990. The smallest lactant female had 36.0 cm HB and the largest 38.0 cm HB. The size-age curve (Fig. 2) predicts that female *D. marsupialis* begins to breed at about 8 months, with a length of 36.0 cm. The number of youngs in the pouch varied from 5 to 9 with a mean (± SD) of 7.3 ± 2.1 youngs (N = 3). Two different litters, one in October and the other in December were observed for the same female. Another female who was lactant in January presented swollen teats that had milk two months afterwards, suggesting a second litter. The reproductive activity of females was coincident with the density peak observed to the population during the wet months (Fig. 3).

The mean home range size (± SD) of *D. marsupialis* was of 1.10 ± 0.43 ha (Table 2).

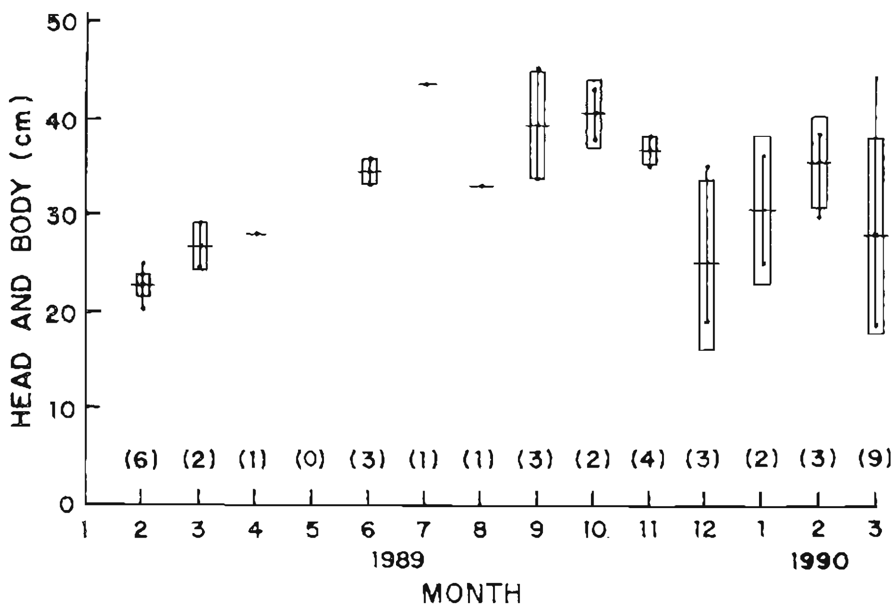

Fig. 4. Monthly variation in head-body lengths (cm) of *Didelphis marsupialis*. The horizontal, vertical lines and vertical bars represent the mean, the range and the standard deviation, respec-

Table 2. Home range size (in hectare) for the species in Juréia Ecological Station.

Species	Mean home size ± SD	Minimum size	Maximum size	N
D. marsupialis	1 10 ± 0.43	0.40	1.64	6
Male	1.20			
Female	1.09 ± 0.48	0.40	1.64	5
M. nudicaudatus	0.74 ± 0.54	0.14	1.72	10
Male	0.83 ± 0.57	0.14	1.72	7
Female	0.53 ± 0.48	0.18	1.08	3
P. opossum				
Male	0.39 ± 0.35	0.14	0.64	2
P. iheringi ~	1.06 ± 0.29	0.80	1.44	5
Male	1.37 ± 0.10	1.30	1.44	2
* Female	0.86 ± 0.05	0.80	0.90	3
O. nitidus ~	0.46 ± 0.31	0.16	1.12	13
Male	0.46 ± 0.39	0.16	1.12	8
Female	0.45 ± 0.15	0.32	0.66	5
N. squamipes				
Male	0.48			1

~ Bergallo (submitted)
* Significant difference between sexes - p < 0.05

Metachirus nudicaudatus. The brown four-eyed opossum was the most common marsupial trapped in the present study (Table 1). The sex ratio for first capture was biased to males (2.33 : 1; X^2 = 4.80; p < 0.05) and the proportion of total captures of each sex did not differ from the sex ratio for first capture (X^2 = 0.01; p = 0.92; df = 1) (Table 1). Male (2.0 ± 2.6 months; N = 11) and female (1.2 ± 2.2 months; N = 5) persistence time in the grid did not differ significantly (X^2 = 0.46; p > 0.05; df = 14), but the longest persistence time (8 months) was observed for a male. *M. nudicaudatus* has sexual dimorphism, being the males significantly largest in HB and HF length and heavier than females (Appendix Ib).

The brown four-eyed opossum were trapped during the 14 months of study but the density varied throughout the year with a peak in the wet season (Fig. 5). The recruitment followed the same tendency (Fig. 5) and was positively and significantly correlated with the population density with one month time-lag (R^2 = 0.92; $F_{1,9}$ = 100.4; p < 0.001). The mean density of *M. nudicaudatus* (± SD) was of 1.76 ± 1.53 ind/ha. The brown four-eyed opossum was the second species that more contributed with the annual biomass (6,430 g/ha), with an average per month of 535.9 ± 414.3 g/ha.

The only lactant female observed (25.0 cm HB) was trapped in October and had nine pouch youngs (7 males and 2 females). The sex ratio of such litter did not deviate from the observed in the population (X^2 = 0.18; p > 0.05). Juveniles

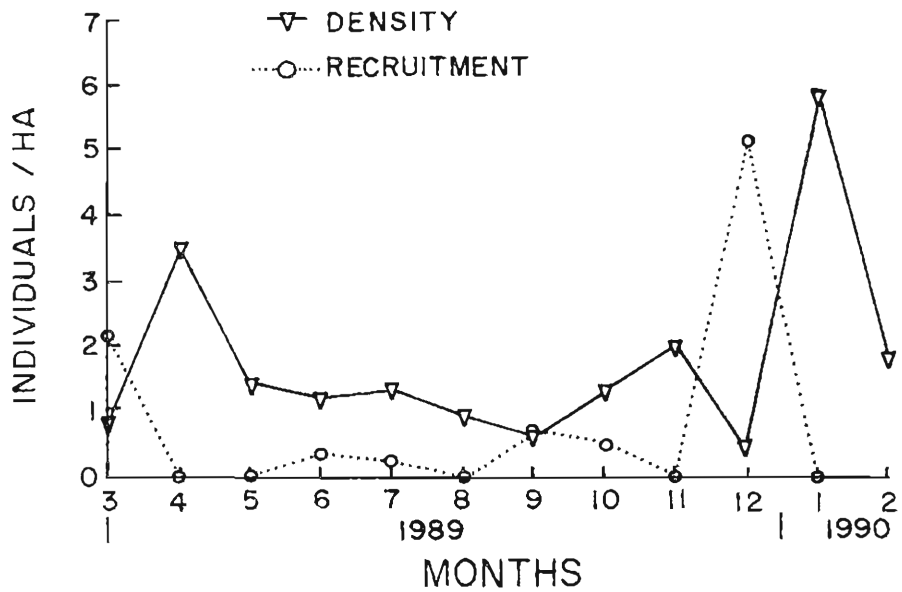

Fig. 5. Density (triangles) and recruitment (circles) (ind/ha) of *Metachirus nudicaudatus* from March 1989 to February 1990.

1990 (Fig. 6). Adult *M. nudicaudatus* were observed throughout the year (Fig. 6). The largest mean head-body lengths were observed in the end of the dry season (Fig. 6), but the differences between the dry (24.1 ± 1.4 cm; range 22.6 - 26.5 cm) and wet months (22.7 ± 1.2 cm; range 21.2 - 24.3 cm) were not significant (anova, $F_{1,12} = 4.47$; $p = 0.057$).

Male (0.83 ± 0.57 ha) and female (0.53 ± 0.48 ha) home range sizes did not differ significantly ($F_{1,8} = 0.622$; $p = 0.453$) (Table 2).

Philander opossum. Only five individuals, all males, of the gray four-eyed opossum were captured in the grid (Table 1). The mean persistence time (± SD) was of 2.0 ± 2.0 months (range 0 - 4 months). Biometric data on *P. opossum* of Juréia are presented in Appendix 1c.

The captures of the gray four-eyed opossum occurred only from March to November 1989 in the grid. The mean density (± SD) was of 0.27 ± 0.18 ind/ha and was fairly constant during the time that the species was captured (Fig. 7). The total contribution of *P. opossum* to the biomass during 12 months were less than 1 kg/ha (805.8 g/ha), with an average per month of 67.2 ± 55.4 g/ha. Juveniles were trapped in March and May, and adults from July to November (Fig. 8). The mean home range size (± SD) obtained for two males was of 0.39 ± 0.35 ha (Table 2).

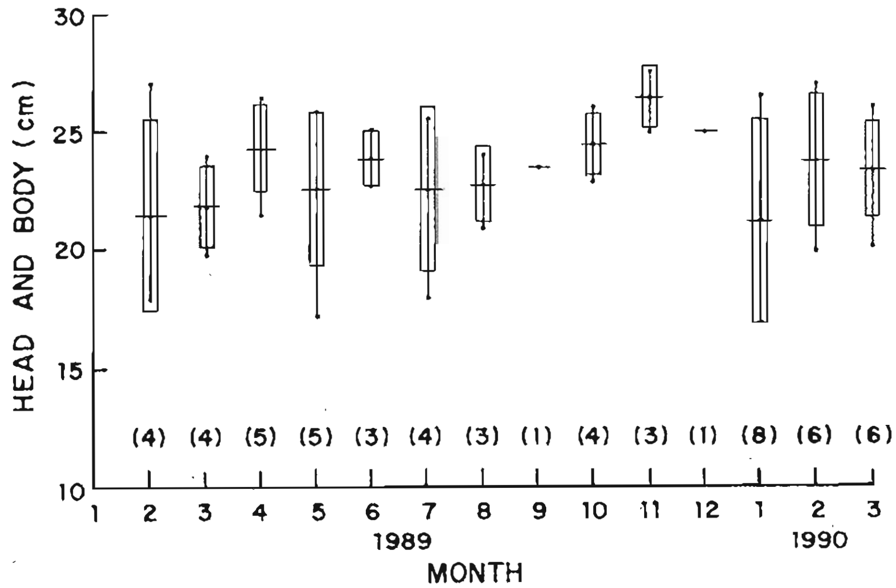

Fig. 6. Monthly variation in head-body lengths (cm) of *Metachirus nudicaudatus*. The horizontal, vertical lines and vertical bars represent the mean, the range and the standard deviation, respectively. Sample size in parenthesis.

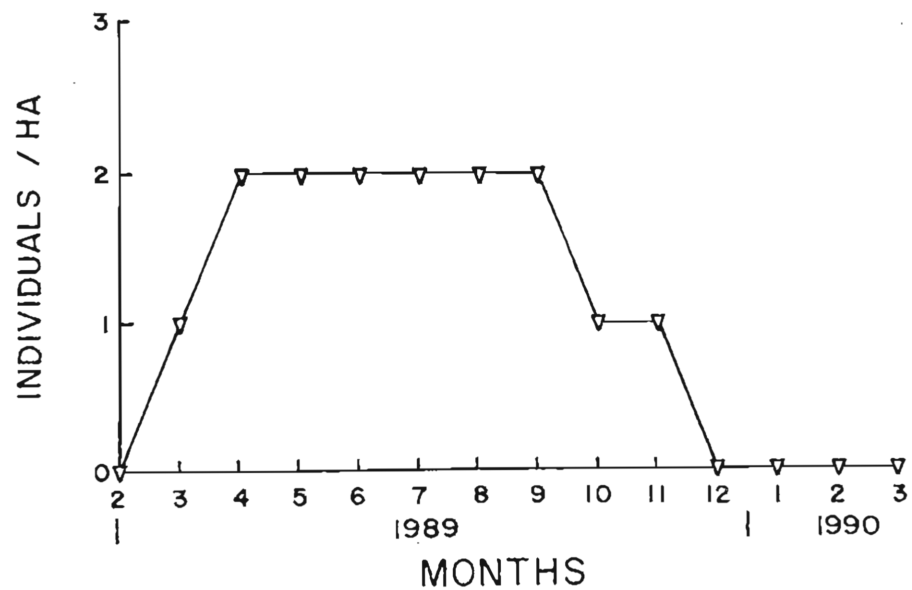

Fig. 7. Minimum number known to be alive (MNA) of *Philander opossum* through the study in Juréia.

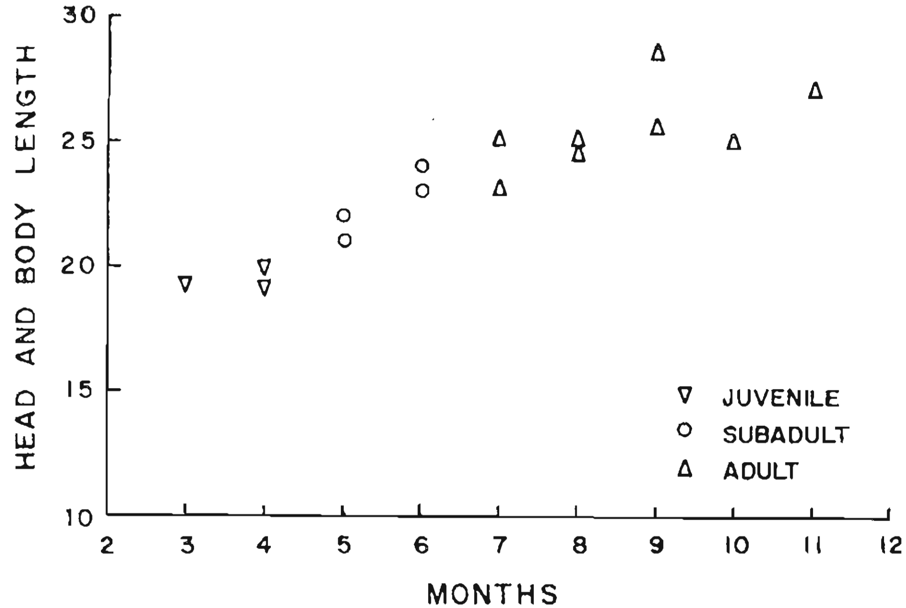

Fig. 8. Monthly observations in head-body lengths (cm) of *Philander opossum* in Juréia.

Proechimys iheringi. The spiny rat was very common in the grid. Twenty-four males and 15 females were trapped 196 times (Table 1). Sex ratio did not differ significantly between males and females for first capture ($X^2 = 2.08$, $p > 0.05$), as well as, for total captures ($X^2 = 2.87$, $p > 0.05$) (Table 1). This species had the highest persistence time in the grid with an average of 11.6 ± 5.0 months (and a maximum of 21 months, considering preliminary captures before the beginning of the study). Male and female *P. iheringi* had sexual dimorphism in hind-foot length and weight (Appendix 1d).

The spiny rat could be classed as residents or transients (Bergallo, submitted). Resident individuals were captured at least 7 months consecutively. Two males and three females were considered residents in the grid. The density of the residents was relatively constant with an average of 0.9 ± 0.1 ind/ha. However, transient density varied throughout the year (4.4 ± 3.8 ind/ha) with peaks in August and November (Bergallo, submitted). Considering transients and residents together, the population density of *P. iheringi* followed the transient tendencies (Fig. 9). Recruitment varied throughout the year (Fig. 9) correlating positively and significantly with one month time-lag of density ($R^2 = 0.88$; $F_{1,9} = 64.99$; $p = 0.000$). The spiny rat contributed with the highest biomass in the grid (8,468 g/ha) with an average of 705.6 ± 250.5 g/ha per month.

Juveniles were recorded in all months except in July, December and January 1990. The relationship between frequency of births (based on size-age curves, Bergallo, submitted) and rainfall was not significant ($R^2 = 0.10$, F... = 1.27, p =

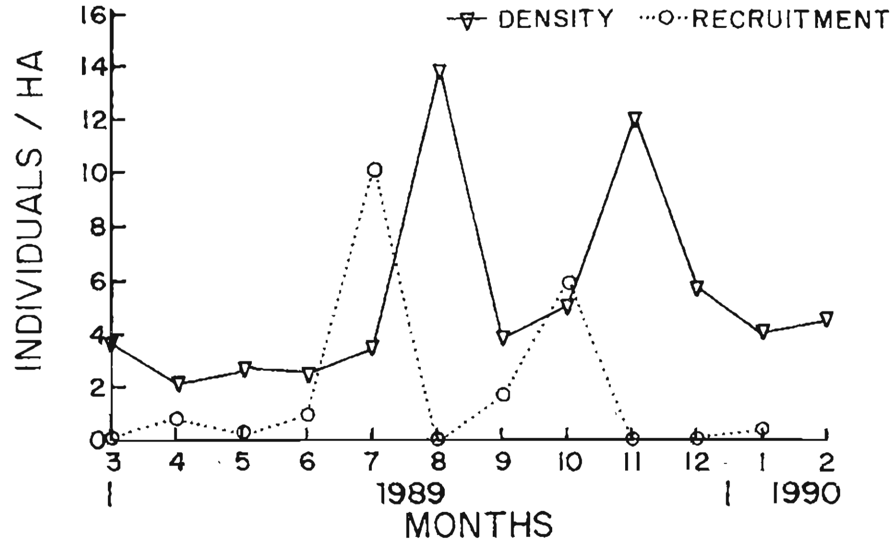

Fig. 9. Density (triangles) and recruitment (circles) (ind/ha) of *Proechimys iheringi* from March 1989 to February 1990. Data of transients and residents were plotted together.

0.281), suggesting that this species does not have a season of reproduction (Fig. 10). However, looking the Figure 10 one could see that birth frequencies are higher in the dry months, except for one point (the black one). This point corresponds with an atypical rain during what would normally be the dry season (Fig. 1). The relationship between frequency of births and rainfall became significant when this point was taken out ($R^2 = 0.52$, $F_{1,11} = 11.87$; $p = 0.005$). Hence, the spiny rat reproduction seems to peak in the winter, what is in agreement with the observation that pregnant females occurred mainly in the dry months (Bergallo, 1991). The smallest perforate and pregnant females weighed 180 g and 191 g, respectively. The age of first breeding of female *P. iheringi* was estimated as 249 days and a female can produce up to 4 litter p.a. (Bergallo, submitted).

The mean home range size for resident *P. iheringi* was of 1.06 ± 0.29 ha. Home range sizes of resident males and females differed significantly ($t = 5.1$, $p < 0.01$, $N = 5$; Bergallo, submitted) (Table 2).

Oryzomys nitidus. The rice rat was the most frequent species in the grid - 43 males and 28 females (Table 1). Sex ratio for first capture was unbiased (1.5:1.0; $X^2 = 3.17$, $p > 0.05$), as well as, for total captures ($X^2 = 1.10$, $p > 0.05$). Persistence time in the grid was of 5.0 ± 2.5 months (range from 2 to 10, N = 27). *O. nitidus* had sexual dimorphism for all biometric parameters, except ear length (Appendix 1e).

Population density of the rice rat (5.26 ± 1.02 ind/ha) was relatively stable throughout the study showing a slight increase in December (Fig. 11). As in the

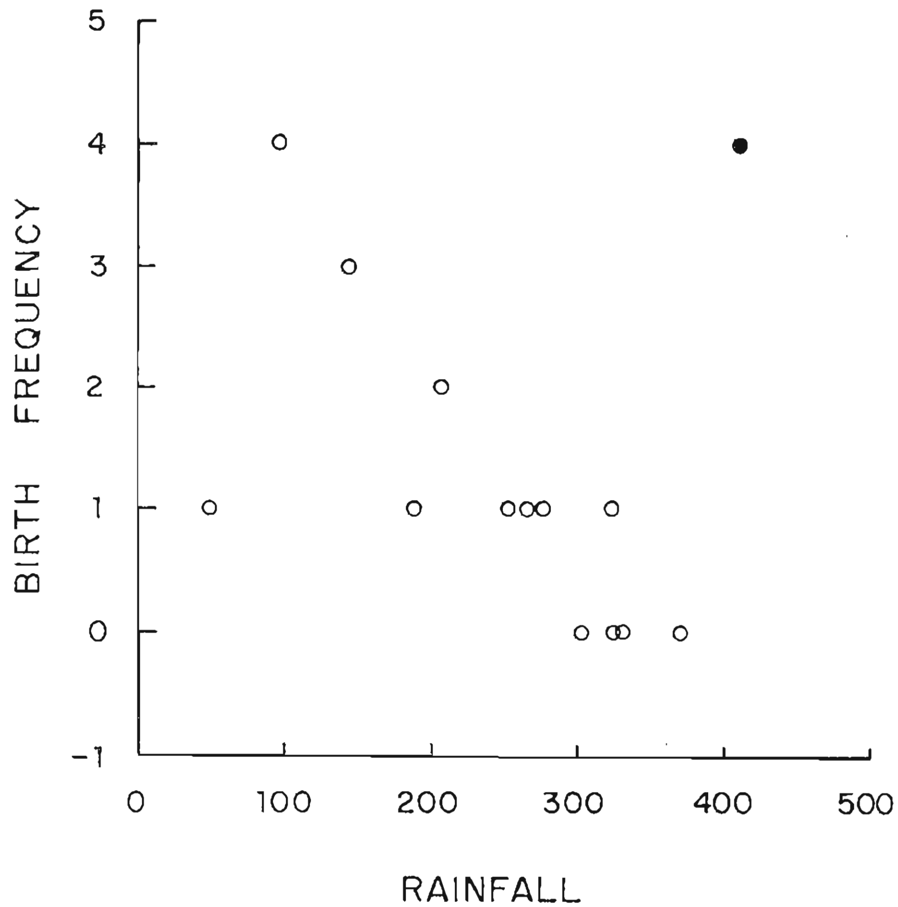

Fig. 10. Relationship between frequency of births of *Proechimys iheringi* and rainfall (mm) (R^2 = 0.10; $F_{1,12}$ = 1.27; p = 0.281). Black dot corresponds to an atypical rain during what would normally be the dry season.

other species, recruitment followed the same tendency of density (with one month time-lag - R^2 = 0 48; $F_{1,9}$ = 8.17; p = 0.019) (Fig. 11). Although very common in the grid, *O. nitidus* was the fourth species contributing with the annual biomass (5,007 g/ha), with an average per month of 417.3 ± 82.4 g/ha.

Juveniles were not captured in July, November and January. Pregnant females were recorded from March to July, in August and in October. Birth frequencies and rainfall were not significantly related (R^2 = 0.005, $F_{1,12}$ = 0.08, p = 0.788) (Fig. 12) and the rice rat apparently reproduces year-round with no clear peaks. Female *O. nitidus* can breed with approximately 115 days and produce up to 6 litters p.a. (Bergallo, submitted). The smallest perforate and pregnant females

Fig. 11. Density and recruitment (ind/ha) of *Oryzomys nitidus* from March 1989 to February 1990.

The mean home range size between male and female *O. nitidus* did not differ significantly (t = 0.05, p > 0.05, N = 13) (Table 2).

Nectomys squamipes. The water rats were always collected close to a stream that crossed the grid, but with a low frequency. Only ten specimens were trapped 20 times (Table 1). The sex ratio for first capture was strongly biased to males (9:1), as well as for total captures (4:1). Biometric parameters were not obtained for females, since only one was caught and it was a juvenile. Adult male *N. squamipes* can reach in average 180 mm in head-body length and 227 g in weight (Appendix 1f).

The maximum population density was reached in March and April 1989 (Fig. 13). Few individuals were recorded during the dry season (Fig. 13). Juveniles were trapped from February to April and in October. The mean density was of 0.23 ± 0.27 ind/ha.

Dasyprocta agouti (= *D. leporina*). The agoutis were frequently sighted in the grid during the day. However, only three specimens were trapped four times (Table 1). The animals captured in October and November were young and weight in average 527.7 g (range 409-670 g). The other animal trapped in January 1990 weighed 1400 g.

According to Emmons (1990), *D. agouti* distributes from Guianas and Brazil north of the Amazon to Rio de Janeiro State, the southermost limit of the range of the species. The occurrence of *D. agouti* in the Juréia-Itatins Ecological Station

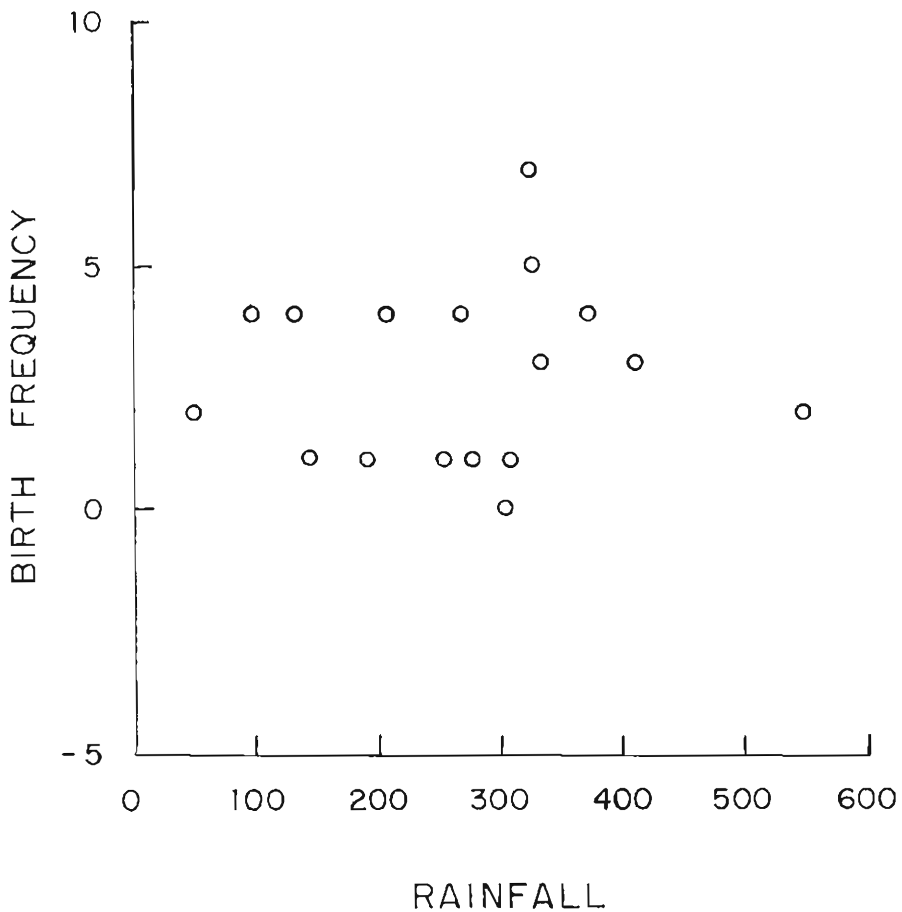

Fig. 12. Relationship between frequency of births of *Oryzomys nitidus* and rainfall (mm) ($R^2 = 0.005$; $F_{1,12} = 0.08$; $p = 0.788$).

Oxymycterus sp. This burrowing mice was only trapped once throughout the study (March 1990). The male measurements are as follows: HB 15.0 cm, TA 13.0 cm, HF 2.7 cm, E 1.9 cm and W 89 g. The average biomass obtained per month for the small mammal community of Juréia was of 2,228 ± 607 g/ha (range 1,323 - 3,240 g/ha), with a total biomass in one year of 26,731 g/ha. The average biomass did not differ between the wet and dry season (ANOVA, $F_{1,10} = 0.216$; $p = 0.652$). *P. iheringi* was the species that most contributed with biomass followed by *M. nudicaudatus*, *D. marsupialis*, *O. nitidus*, *P. opossum* and *N. squamipes* (Fig. 14). The total biomass of the rodents comprised 50.9 % and that of the marsupials 49.1 %.

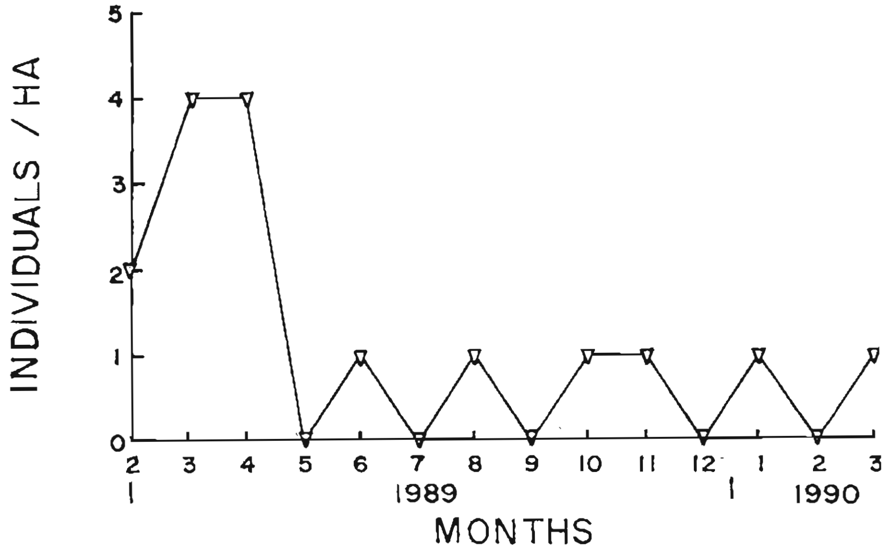

Fig. 13. Minimum number known to be alive (MNA) of *Nectomys squamipes* through the study in Juréia.

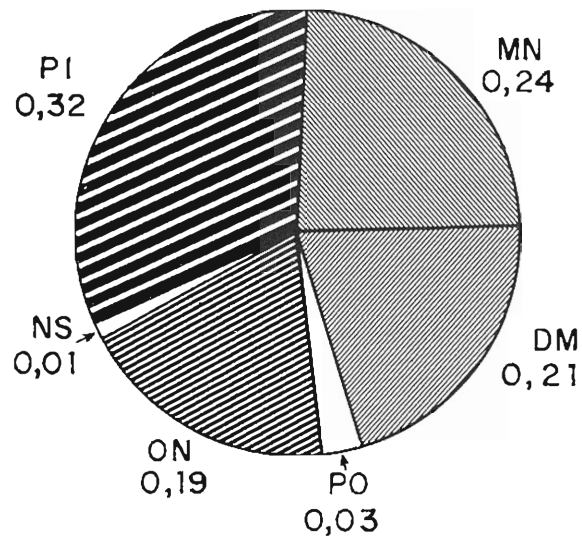

Fig. 14. Contribution (%) of each species to the total biomass in Juréia. Legend: PI *Proechimys iheringi*, MN *Metachirus nudicaudatus*, DM *Didelphis marsupialis*, ON *Oryzomys nitidus*,

Discussion

Although the small mammal community of Juréia-Itatins Ecological Station are under the same environmental conditions, rodents and marsupials differed in their population ecologies. The main difference seemed to be the reproductive pattern, which consequently, influenced other parameters.

The marsupials breed seasonally, with a peak during the wet months. The reproductive season of *Didelphis marsupialis* and *Metachirus nudicaudatus* initiated at about the same time at the end of the dry season (October) finishing at the end of the wet season (April). Female *D. marsupialis* and *M. nudicaudatus* are polyestrous being able to produce, at least, two litters per season. According to the size-age curve, female *D. marsupialis* who be born at the end of the reproductive season can breed at the beginning of the next reproductive season. Although not enough data were gathered to *Philander opossum*, probably, this species breeds at the same time of the other marsupial species, since juveniles were trapped at the wet season.

As a consequence of this seasonality in the reproduction, population densities of *D. marsupialis* and *M. nudicaudatus* showed a peak in the wet months with the entrance of the youngs. Hence, the head body lengths observed at that time decreased compared with those on the dry months

This seasonal reproduction in Neotropical marsupials has been reported in other studies (e.g. Davis, 1945; Fleming, 1973; Tyndale-Biscoe & Mackenzie, 1976; Fonseca & Kierulff, 1989; Bergallo & Cerqueira, 1994). For the marsupials, the critical time of the reproduction is the lactation, especially at final phase when the litter weight may exceed that of the mother (Tyndale-Biscoe, 1979). Hence, the best time to breed and rear the youngs would be on the most productive period (Bergallo & Cerqueira, 1994). Insects seems to be the principal food resource of didelphid marsupials (Nowak & Paradiso, 1983). Studies developed in Neotropical areas showed that insect population samples are larger in wet months (Janzen, 1973; Wolda, 1978), suggesting that the seasonality in marsupial reproduction is tied with food resources (Charles-Dominique, 1983).

The two most common species of rodents in Juréia, *Proechimys iheringi* and *Oryzomys nitidus*, showed different strategies in reproduction. *P. iheringi* and *O. nitidus* breed throughout the year, although the former one had a peak in the dry months. Consequently, *P. iheringi* density was higher from the middle of the dry season to the beginning of the wet season, because of a greater recruitment on that time. Density of *O. nitidus* was fairly constant, reflecting the aseasonal reproduction.

There are a great variation in the reproductive patterns of rodents. A large number of neotropical species shows a seasonal reproduction (Fleming, 1973, Murúa & Gonzalez, 1985; Meserve & Le Boulenge, 1987). However, species of the Echimyidae family breed throughout the year: *Proechimys semispinosus* (Fleming, 1971; Gliwicz, 1984), *P. guyanensis* (Everard & Tikasingh, 1973), *P. iheringi, P. setosus* (Davis, 1945) and *P. dimidiatus* (Fonseca & Kierulff, 1989). But even the species that breed throughout the year, can vary the reproductive intensity according to the conditions: *P. semispinosus* (Gliwicz, 1984) and *P. iheringi* (this study). Some species of *Oryzomys* can also have an aseasonal pattern of reproduction: *O. capito* (Fleming, 1970), *O. trinitatis, O. nigripes* (Fonseca & Kierulff, 1989) and *0. nitidus* (this study).

P. iheringi was the unique species that had sexual differences in home range sizes. Female *P. iheringi* are territorials, whereas the males do not defend a territory (Bergallo, submitted). The male home ranges are larger than that of females and overlapped with both sexes (Bergallo, submitted). Ostfeld (1990) suggested that females of species relying on foods that are relatively sparse, patchy and slowly renewed such as seeds, fruits and forbs will be territorial. Although there are no studies of the diet of *P. iheringi*, other species of the same genus feed mainly on seeds and fruits (Fleming, 1971; Emmons, 1982). These authors also reported little or no overlap in female ranges for *P. semispinosus* and *P. brevicauda*, respectively. The longest persistence time in the grid of *P. iheringi may* be in part explained by the territorial behavior of females. Being territorials, females compel males to stay close to them, allowing a higher rate of capture of both sexes.

The herbivore *P. iheringi* had the highest biomass in Juréia followed by the insectivorous/omnivorous *M. nudicaudatus, D. marsupialis* and *O. nitidus*. *Proechimys* species use to contribute with one of the highest biomass of non-volant mammals in the neotropics (Eisenberg et al., 1979). In a stomach content of a caiman, *Caiman latirostris*, captured close to Juréia, it was found fur of *P. iheringi* (pers. obs.). According to Hershkovitz (1969), *Proechimys* species are important resources for predators in the Brazilian subregion. Fleming (1971) in Panama estimated a biomass to *Proechimys semispinosus* (125 to 1099 g/ha) similar than that observed to *P. iheringi* (706 g/ha) in Juréia. However, *Oryzomys capito* (0 to 159 g/ha) in Panama (Fleming, 1971) had a lower biomass than that observed to *O. nitidus* (417 g/ha) in Juréia. In the Panamanian forests, the agouti, *Dasyprocta punctata*, account for a large portion of the total biomass together with *P. semispinosus* (Fleming, 1975). Although common sighted in Juréia, the population density of the agouti, *D. aguti*, was not assessed precluding the estimative of the biomass.

As observed in other neotropical small mammals studies, the number of rodents captured (72.8 %) in Juréia were higher than that of marsupials (27.2 %) (see Stallings, 1989). However, rodents and marsupials contributed with the same biomass (50.9 % and 49.1 %, respectively) in Juréia small mammal community. As expected in a mammalian fauna, herbivorous mammals represent the largest biomass followed by insectivorous and frugivorous, constituting the carnivores the smallest biomass component (Eisenberg, 1981).

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References

BERGALLO, H.G. (1991): Dinámica populacional, área de vida, parasitismo e mutualismo de pequenos mamíferos da Estação Ecológica da Juréia, SP. Ms. Thesis, Universidade Estadual de Campinas, Campinas, Brasil.

BERGALLO, H.G. (Submitted): Growth rate, life history and home range of two species of rats, *Proechimys iheringi* and *Oryzomys nitidus* in an Atlantic forest of Brazil.

BERGALLO, H.G. & R. CERQUEIRA (1994): Reproduction and growth of *Monodelphis domestica* in Northeastern Brazil. J. Zool. 232 (4): 551-563.

CARVALHO, C.T. (1965): Bionomia de pequenos mamíferos da Boracéia. *Rev. Biol. Trop.*, 13(2):239-257.

CAUGHLEY, G. (1977): Analysis of vertebrate populations. John Wiley & Sons Ltd., London.

CHARLES-DOMINIQUE, P. (1983): Ecology and social adaptations in didelphid marsupials: comparison with eutherians of similar ecology. In: *Advances in the study of mammalian behavior.* J.F. Eisenberg & D.G. Kleiman (eds.) 395-422. Amer. Soc. Mamm., Spec. Publ. 7.

DAVIS, D.E. (1945): The annual cycle of plants, mosquitoes, birds and mammals in two Brazilian forests. Ecol. Monogr., 15:244-295.

EISENBERG, J.F. (1981): The mammalian radiations. The University of Chicago Press, Chicago.

EISENBERG, J.F., M.A. O'CONNELL, & P.V. AUGUST (1979): Density, productivity and distribution of mammals in two Venezuelan habitats. In: Vertebrate ecology in the northern neotropics. J.F. Eisenberg (ed.). Smithsonian Inst. Press, Washington D.C.

EMMONS, L.H. (1982): Ecology of *Proechimys* (Rodentia, Echimyidae) in South-Eastern Peru. Trop. Ecol., 23(2):280-29O.

EMMONS, L.H. (1990): Neotropical rainforest mammals:.a field guide. University of Chicago Press, Chicago.

FLEMING, T.H. (1970): Notes on the rodent faunas of two Panamanian forests. J. Mamm., 51(3):473-490.

FLEMING, T.H. (1971): Population ecology of three species of Neotropical rodents. Misc. Publ. Mus. Zool., Univ. Michigan, 143:1-77.

FLEMING, T.H. (1973): The reproductive cycles of three species of opossums and other mammals in the Panama Canal Zone. J. Mamm., 54(2):439-455.

FLEMING, T.H. (1975): The role of small mammals in tropical ecosystems. In: Small mammals: their productivity and population dynamics. F.B. Golley; K. Petrusewicz & L. Ryszkowski (eds.) 269-298. Cambridge Univ. Press, Cambridge.

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.

GLIWICZ, J. (1984): Population dynamics of the spiny rat *Proechimys* semispinosus on Orchid Island, Panama. Biotropica, 16(1):73-78.

HERSHKOVITZ, P. (1969): The evolution of mammals on southern continents. VI. The recent mammals of the neotropical region: a zoogeographical and ecological review. Quart. Rev. Biol. 44:1-70.

JANZEN, D.H. (1973): Sweep samples of tropical foliage insects: effects of seasons, vegetation types, elevation, time of day and insularity. Ecology, 54:687-708

KREBS, C.J. (1966): Demographic changes in fluctuating populations of *Microtus californicus.* Ecol. Monogr., 35:239-273.

LINO, C.F. (1992): Reserva da Biosfera da Mata Atlântica. Plano de açcao. Vol. 1: Referências basicas. Consórcio Mata Atlântica - Univ. Estadual de Campinas.

MESERVÉ, P.L & E. LE BOULEGÉ (1987): Population dynamics and ecology of small mammals in the Northern Chilean semiarid region. In: Studies in Neotropical mammalogy: Essay in honor of Philip Hershkovitz. B.D. Patterson & R.M. Timm (eds.). Fieldiana Zool. 39:413-431.

MILES, M.A., A.A. SOUZA, & M.M. POVOA (1981): Mammal tracking and nest location in Brazilian forest with an improved spool-and-line device. J. Zool., London, (195:331-347.

MURÚA, R. & L.A. GONZÁLEZ (1985): A cycling population of *Akodon olivaceus* (Rodentia: Cricetidae) in a Chilean temperate rainforest. Acta Zool. Fennica, 173:77-79.

NASCIMENTO, C.M. & M.A.M.G. PEREIRA (1988): Atlas climatológico do Estado de São Paulo (1977-1986). Fund. Cargill, Campinas.

NOWAK, R.M. & J.L. PARADISO, (1983): Walker's mammals of the world. John Hopkins Univ. Press, Baltimore.

OLMOS, F. (1991): Observations on the behavior and population dynamics of some Brazilian Atlantic forest rodents. Mammalia, 55(4):555-565.

OSTFELD, R.S. (1990): The ecology of territoriality in small mammals. T.R.E.E., 5:411-415.

POR, F.D. & V.L. IMPERATRIZ-FONSECA (1984): The Juréia Ecological Reserve, São Paulo, Brazil - facts and plans. Environ. Conserv., 11:67-70.

SOUTHWOOD, T.R.E. (1966): Ecological methods with particular reference to the study of insect populations. Methuen, London.

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

SUGUIO, K. & M.G. TESSLER (1984): Planícies de cordões litorâneos Quaternários do Brasil: origem e nomenclatura. In: Restingas: origem, estrutura, processos. L.D. Lacerda; D.S.D. Araújo, R. Cerqueira & B. Turcq (eds.), 15-25. Centro Editorial Univ. Federal Fluminense, Niterói.

TYNDALE-BISCOE, C.H. (1979): Ecology of small marsupials. In: Ecology of small mammals. D.M. Stoddart (ed.), 343-379. Chapman & Hall LTD., London.

TYNDALE-BISCOE, C.H. & R.B. MACKENZIE (1976): Reproduction in *Didelphis marsupialis* and *D. albiventris* in Colombia. J. Mamm., 57(2):249-265.

WEBB, G.J.W. H. MESSEL, J. CRAWFORD & M.J. YERBURY (1978): Growth rate of *Crocodilus porosus* (Reptilia: Crocodilia) from Arnhem Land, Northern Australia. Australian Wildl. Res., 5:385-399.

WOLDA, H. (1978): Seasonal fluctuations in rainfall, food and abundance of tropical insects. J. Anim. Ecol., 47:369-381.

ZAR, J H. (1984): Biostatistical analysis. Prentice-Hall, Englewood Cliffs.

Appendix 1

Sample size (N), mean (X), standard deviation (SD), minimum (MIN) and maximum measurements (MAX) of biometric parameters of small mammal species from Juréia-Itatins Ecological Station. Significant differences in measurements between sexes for each species are designated by * ($p < 0.05$) and ** ($p < 0.01$). Legend: head-body length (HB), tail length (TA), hind-foot length (HF), ear length (E) and weight (W). Weight is given in g and other body measurements in mm.

		N	X	SD	MIN	MAX
a) *Didelphis marsupialis*						
HB	Female	05	373.1	37.8	336.7	435.0
	Male	05	399.0	30.5	360.0	440.0
TA	Female	04	361.9	20.0	334.0	380.0
	Male	05	368.7	26.4	340.0	400.0
HF	Female	05	57.6	1.1	56.0	58.7
	Male	05	59.1	3.1	55.0	63.5
E	Female	05	43.9	3.2	40.0	48.5
	Male	05	43.0	5.8	33.0	48.0
W	Female	05	1011.0	127.9	844.0	1159.6
	Male	05	1310.6	190.7	1038.0	1500.0 **
b) *Metachirus nudicaudatus*						
HB	Female	06	223.4	17.2	202.0	245.0
	Male	14	254.9	10.2	235.0	270.0 **
TA	Female	06	307.1	13.7	290.0	322 5
	Male	14	309.9	14.8	276.0	333.3
HF	Female	06	42.6	1.7	40.0	45.0
	Male	14	45.1	2.0	41.3	48.0 *
E	Female	06	27.6	2.4	25.0	32.0
	Male	14	27.5	2.1	25.0	33.0
W	Female	06	254.0	42.0	199.0	312.0
	Male	14	409.5	66.1	311.0	506.0 **
c) *Philander opossum*						
HB	Male	04	255.9	20.0	240.0	285.0
TA	Male	04	285.6	10.9	270.0	295.0
HF	Male	04	36.9	1.7	35.0	38.6
E	Male	04	23.2	2.3	20.0	25.0
W	Male	04	323.9 9	59.5	266.5	386.0
d) *Proechimys iheringi*						
HB	Female	13	197.7	8.1	183.0	210.0
	Male	22	201.8	11.2	170.0	225.0
TA	Female	13	160.5	13.5	131.5	177.1
	Male	21	168.2	8.7	144.3	182.0
HF	Female	13	43.0	1.4	40.0	45.6
	Male	22	44.2	1.2	42.0	47.0 *
E	Female	13	21.2	1.8	17.0	24.0
	Male	22	20.9	1.7	16.0	22.3
W	Female	13	190.7	10.8	182.0	240.0
	Male	22	217.4	27.2	184.0	264.0 **
e) *Oryzomys nitidus*						
HB	Female	18	136.3	7.8	120.0	154.0
	Male	30	141.2	9.0	120.0	156.9 *
TA	Female	18	148.5	11.6	114.0	170.0
	Male	30	157.7	9 3	141.0	180.0 **
HF	Female	18	33.4	0.9	32.0	35.5
	Male	30	34.8	1.3	33.0	37.4 **
E	Female	18	18.8	1.7	16.0	22.0
	Male	30	18.9	1.0	17.0	20.5
W	Female	18	77.6	9.2	68.0	97.5
	Male	30	87.5	11.9	68.0	114.0 **
f) *Nectomys squamipes*						
HB	Male	04	180.0	29.1	145.5	210.0
TA	Male	04	208.2	22.7	185.0	238.0
HF	Male	04	46.4	3.1	43.5	50.0
E	Male	04	16.9	1.3	15.0	18.0
W	Male	04	227.3	73.2	147.0	305.0