RELATION BETWEEN SMALL-MAMMAL SPECIES COMPOSITION AND ANTHROPIC VARIABLES IN THE BRAZILIAN ATLANTIC FOREST

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(With 1 figure)

ABSTRACT

Anthropic activities are frequently related in many ways to forest fragmentation and alteration of natural communities. In this study, we correlate the presence of hunting, tourism activity, agriculture/pasturing, and the distance of the study sites to the nearest human residences with the species composition of small Atlantic forest mammals. To do this, we utilize a multiple regression analysis of similarity matrices. The presence of both agriculture/pasturing and human residences near the study sites proved to be determinant factors in species composition of small mammals of the studied areas. Working with socioeconomic variables related directly with the study site could be a reliable and a direct way to predict the influence of human presence and entailed activity on small mammal communities.

Key words: species composition, small mammals, habitat disturbance, fragmentation, human activities.

RESUMO

Relação entre a composição de espécies de pequenos mamíferos e as variáveis antrópicas na Floresta Atlântica Brasileira

Atividades antrópicas estão freqüentemente associadas à fragmentação da paisagem e alteram as comunidades naturais de diversas maneiras. Neste estudo, a presença de caça, turismo, agricultura/pastagens e a distância até as residências mais próximas foram relacionadas à composição de espécies de pequenos mamíferos na Mata Atlântica por meio de uma análise de regressão múltipla de matrizes de similaridade. Verificamos que a presença de agricultura/pastagens, bem como de residências próximas aos locais de estudo, foram determinantes para a composição das espécies de pequenos mamíferos das áreas estudadas. Trabalhar com variáveis socioeconômicas diretamente relacionadas à área de estudo pode ser uma forma direta e confiável de predizer a influência da presença humana e de suas atividades relacionadas às comunidades de pequenos mamíferos.

Palavras-chave: composição de espécies, pequenos mamíferos, perturbação do habitat, fragmentação, atividades humanas.

INTRODUCTION

The effect of human activities in mammal communities takes many forms. Habitat fragmentation and deforestation are considered the main processes responsible for biodiversity loss in tropical forests (Laurance & Bierregaard Jr., 1997; Laurance, 1999). Moreover, tourism practices, hunting, agriculture, and cattle raising are frequently related to these processes, affecting the demography, population structure, and spatial range of individuals and species, leading to changes in the community structure (McLaughlin & Mineau, 1995; Forman & Alexander, 1998; Cullen *et al.,* 2000; Cullen *et al*., 2001).

The Atlantic Forest is a biodiversity hotspot due to its species richness, number of endemic species, and degree of threat (Mittermeier *et al*., 1998). One of the most disturbed tropical biomes in Brazil, it presents the largest number of threatened species per unit area (Fonseca *et al*., 1994; Bergallo *et al*., 2000; Myers *et al*., 2000). Habitat fragmentation and degradation related to human activity have been occurring for hundreds of years in this biome, of which 93% is now damaged (SOS Mata Atlântica, INPE and ISA, 1998). Given their trophic position and large habitat requirements, medium- to large-sized mammals in the Atlantic Forest are extremely threatened due to overhunting and habitat disturbance (Fonseca *et al*., 1994; Cullen *et al*., 2000; Cullen *et al*., 2001). In some localities they have been completely eliminated, causing changes in ecological interactions (Cullen *et al*., 2001) and probably increasing the abundance of some generalist small-mammal species, such as *Didelphis aurita* (Fonseca & Robinson, 1990). In these areas, the study of the influence of human activities on small mammal communities would be very valuable in making decisions relative to management and conservation actions.

The aim of this paper is to associate the species composition of small mammals with different kinds of human activities in remaining Atlantic forest areas in Rio de Janeiro State, Brazil. In addition, an effort was made to identify significant anthropic variables possibly influencing small mammal communities at a local scale.

METHODS

Study areas

This study was carried out on seven sites located at Serra dos Órgãos and its surroundings, in Rio de Janeiro State. The Serra dos Órgãos is a mountain chain covered by pluvial montane Atlantic forest, which runs through many municipalities, all of which have mild-humid mesothermal climates (Nimer, 1989).

Three of the sampling sites are situated in Guapimirim County in the town of Garrafão (22º28'S and 43º00'W). This area is typical of hillside forest; it has several cottages, dirt roads, and streams, and is located near a federal highway. With respect to one another, the sites were placed at altitudes of approximately 750 m (Grid A), 650 m (Grid B), and 520 m (Grid C).

Caneca Fina (Guapimirim County; 22º2'S and 42º59'W) is an old semi-abandoned farm situated exactly at the base of Serra dos Órgãos on the south slope of the forest at an altitude of roughly 100 m. The abiotic environment (vegetation, topography, and soil) is generally the same as that of Garrafão. There are some open areas, streams, and an artificial lake.

Santa Margarida Farm (Magé, Suruí County; 22º40'S and 43º07') and Relógio do Sol Farm (Cachoeira de Macacu; 22º28'S and 42º39'W) are typical rural areas, consisting of disturbed small forest fragments, pasture lands, and small vegetable plantations. They are located in the southern surroundings of Serra dos Órgãos, below 100 m of altitude. Most of these farms present open vegetation with pasture, grass, and bamboo. An open midstorey is present on the fragments. Several streams are located on Santa Margarida Farm, and flooded areas occur.

Pamparrão (Sumidouro County; 22º02'S and 42º42'W) is also characterized by small rural properties, but it is situated on the northern slope of Serra dos Órgãos, at 400 m above sea level. It presents small vegetable gardens, few pasture lands, and a low number of small Atlantic Forest fragments. Several streams, irrigation channels and some flooded areas are found throughout the locality.

Field methods

Small mammal samples were collected using mark-recapture and removal methods with Sherman and Tomahawk live-traps. These were placed in grids or transects and were baited with meat and bacon or a mixture of peanut butter, bananas, oats, and bacon. Animals of uncertain species were removed and cariotyped.

We considered in this analysis only terrestrial species and scansorial ones that are predominantly terrestrial in the sampled sites, i.e., those that were captured more frequently on the ground. Trappings were made between 1996 and 1998, and the number of trap nights varied between 800 and 1,000 in all sampled areas. In Relógio do Sol, Santa Margarida, and Pamparrão, transects were made inside the fragments, in pasture lands, and near the vegetable gardens. In Caneca Fina Farm, transects were placed inside the forested areas and along their edges. Mammal collections were licensed by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA).

Data analysis

Sampled areas were characterized by socioeconomic variables and land use indicators (Table 1), data obtained by field visits and maps.

Using a multiple regression model of similarity matrices (Legendre & Legendre, 1998), which is an extension of the Mantel test (Mantel, 1967), we investigated the influence of anthropic variables in species composition. The dependent variable was species composition and anthropic variables were the independent variables. A positive association between the species composition similarity matrix and the anthropic similarity matrices implies that localities more similar in anthropic variables tend to be more similar in species composition.

The similarity matrices used in the multiple regression analysis were obtained by computing for each variable analyzed pair-wise similarity indexes between all areas. The Jaccard index was used to calculate species composition similarity between areas (Magurran, 1988). The partial similarity index of Gower was used to compute the similarity between areas in relation to quantitative anthropic data (Legendre & Legendre, 1998). We utilized a symmetrical binary coefficient (Legendre & Legendre, 1998) to calculate the similarity between areas in relation to each qualitative variable. Multiple regression was performed using the program Permute! (Casgrain, 2001). The probability (*P*-values) of the regression coefficients and the associated R^2 (multiple determination coefficient) were obtained through a permutation method (999 randomizations), as described in Legendre *et al.* (1994). The variables included in the regression analysis were tested for independence and were not significantly correlated with each other. We performed a cluster analysis with the distance matrix of species composition, using the unweighted pair-group average method of linkage (Legendre & Legendre, 1998). The distance matrix was built using the formulae (D = 1 – J), where D is the distance measure and J is the Jaccard similarity index.

TABLE 1

Anthropic variables obtained for each sampled site.

Anthropic variables	Grid A	Grid B	Grid C	Caneca Fina	Relógio do Sol	Santa Margarida	Pamparrão
Hunting[a]		x	x		x	x	
Tourism activity[a]		x					
Agriculture/pastures[a]					x	x	x
Distance from residences (m)[b]	100	200	250	500	150	100	150

[a]Qualitative data refers to the presence (x) or absence ( ) of the anthropic activity inside or at the vicinity of the sampled site. [b]Values were rounded to 50 meters of intervals.

RESULTS

Fig. 1 shows the species composition dendrogram. We divide the localities in two major groups: 1) the continuous forest areas of Garrafão, and Caneca Fina Farm; and 2) the rural areas of Relógio do Sol Farm, Santa Margarida Farm, and Pamparrão. The three grids of Garrafão and Caneca Fina Farm were more similar due to the presence of *Metachirus nudicaudatus*, *Oryzomys russatus*, and *Marmosops incanus* (Table 2). The rural areas were grouped by occurrence of *Akodon cursor, Oligoryzomys nigripes, Rattus rattus,* and *Nectomys squamipes*. *Didelphis aurita* and *Philander frenatus* were found in the great majority of these areas.

The multiple regression analysis of anthropic variables showed that agriculture practices, pasturing, and distance from residences were significant in species composition of the sampled areas (Table 3).

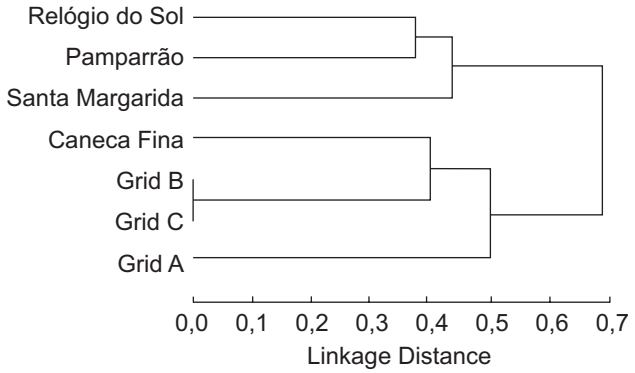

Fig. 1 — Dendrogram of species composition of the sampled sites.

TABLE 2
Small mammal species composition of the sampled sites.

Species	Grid A	Grid B	Grid C	Caneca Fina	Relógio do Sol	Santa Margarida	Pamparrão
Didelphis aurita	x	x	x	x	x	x	x
Metachirus nudicaudatus		x	x	x			
Philander frenatus	x	x	x	x	x	x	x
Marmosops incanus	x	x	x		x		
Oryzomys russatus	x			x			
Oligoryzomys nigripes					x		x
Nectomys squamipes					x	x	x
Akodon cursor	x				x	x	x
Bolomys lasiurus							x
Rattus rattus						x	x
Sylvilagus brasiliensis						x	

TABLE 3
Multiple regression analysis of species composition against local anthropic variables.

Variables	*b*
Hunting	0.193 (0.097)
Tourism activities	–0.098 (0.252)
Agriculture/pastures	0.775 (0.005)**
Distance from residences	0.272 (0.028)*
R^2	0.671 (0.007)**

b = partial regression coefficient; R^2 = multiple determination coefficient.
p-values are shown in parenthesis. *p < 0.05; **p < 0.01.

DISCUSSION

Many studies have shown that human presence and related activities in areas inhabited by, or in the vicinity of, small mammal communities, produce disturbing effects among these animals (McLaughlin & Mineau, 1995; Laurance & Bierregaard Jr., 1997; Malcolm, 1997; Forman & Alexander, 1998; Lopes & Ferrari, 2000; Rivard *et al*., 2000). In this study, the main differences in species composition between areas resulted from changes in habitat characteristics related to cattle raising and agriculture practices, both of which were present in all sites of the rural cluster, and also to human dwellings existing around the trapping areas. However, agriculture practices and the transformation of native forests into pastures result in habitats favorable to some generalist species. Species of the genus *Akodon* and *Oligoryzomys* are common in agrosystems (Mills *et al*., 1991). *Akodon cursor* and *Oligorizomys nigripes* frequently show high abundances at the edge of small forest fragments, grasslands, and in abandoned pastures (Paglia *et al*., 1995; Olifiers, 2002; Pires *et al*., 2002).

Rural areas are frequently strongly modified by harvesting, grass-cutting, presence of vegetable gardens and cattle-raising, which may provide distinct habitats within each locality. In a long-term study carried out at Pamparrão (D'Andrea *et al*., 1999; Gentile & Fernandez, 1999; Gentile *et al*., 2000), the authors suggest that agrosystems can be more heterogeneous in horizontal space and in time, due to constant human interference and high rotation of vegetable cultivation. This favors a high population abundance of a few generalist species, as well as several opportunist species, particularly rodents, which occasionally occur. Mills *et al*. (1991) found a like result in an agricultural area in Argentina.

None of the anthropic activities affected the occurrence of *Didelphis aurita* and *Philander frenatus*, generalist species commonly found in disturbed areas. On the other hand, Fonseca & Robinson (1990) suggested that the abundance of *D. aurita* could be reduced in preserved forests owing to predation pressure by carnivorous mammals. Of the species occurring in the forest sites, half were also captured in rural areas, including *Metachirus nudicaudatus* (Olifiers, 2002). Only *Oryzomys russatus*, which was not present in any of the rural localities, seems to have been affected by anthropogenic disturbances, e.g., forest fragmentation (Olifiers, 2002).

The forest localities sampled in this study are not well preserved. Hunters and domestic pets were seen in the grids, and garbage dumps are located and tourism activities occur near or inside these areas. Nevertheless, since no great changes in habitat features have occurred, species – such as the frequently found *Oryzomys russatus* – continue to inhabit the continuous forests of Rio de Janeiro. Therefore, differences found within each major group (forest and rural) are more related to habitat fragmentation, which in turn are related to features of the local economy that are associated with the human occupation pattern. Other differences may be attributed to specific microhabitat elements, such as watercourses or ponds, which are determinant for the occurrence of *Nectomys squamipes* (Ernest & Mares, 1986).

Hunting practices mainly influence the abundance and species composition of medium- to large-sized mammals (Cullen *et al*., 2000; Cullen *et al*., 2001). Nevertheless, as a consequence of the extirpation of large mammal species in most of the study areas, local people usually hunt small mammal species, e.g., opossum (*Didelphis aurita*) and rabbit (*Sylvilagus brasiliensis*) for consumption. In spite of this, the effects of hunting and tourism activities on small mammal communities seemed to be either negligible or undetectable by the methods used.

The presence of human dwellings near natural habitats also influenced species composition of small mammals, which is certainly the case of *Rattus rattus* in the vicinity of sampling transects in two of the localities studied. *R. rattus* is an exotic species, whose occurrence is directly related to human settlements and is not captured inside primary forests in the Neotropics (Emmons & Feer, 1997). Human settlements entail not only habitat modification, but also intrusion by domestic pets and the existence of garbage dumps, which are additional forms of disturbance in natural communities (Aragona & Setz, 2001; Ruxton *et al*., 2002).

The types of land occupation or human activity in natural habitats and their surroundings is a determinant factor for small-mammal species presence. In natural habitats of Rio de Janeiro State, sampled areas represent a gradient of anthropic activities, including some of the most consequential kinds of human disturbance. Their levels relate directly to presence of some species, which can be considered as indicators of the preservation level of the sampled area.

Working with socioeconomic variables directly connected to study sites could be a reliable and a direct way to predict the influence of human presence and activities on small mammal communities. In addition, the results of associating anthropic variables with species composition in a given community can be used as a tool to evaluate the conservation status in specific areas, mainly those in which medium- to large-sized mammals have been eliminated.

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