

# Small mammals in a fragment and adjacent matrix in southeastern Brazil

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(With 1 figure)

## Abstract

Between May 2002 and May 2003, we studied a small mammal community from an Atlantic forest fragment surrounded by a coffee plantation in the municipality of Santa Teresa, Espírito Santo state, Brazil. We obtained a total of 300 captures of 114 individuals belonging to 11 mammal species. Seventy three percent of the species captured in the forest also used the coffee plantation, mainly males (90%) and young (80%) individuals of *Marmosops incanus*. The exceptionally low recapture rate in the coffee plantation suggests that it functions as a corridor between fragments, rather than as a habitat for these species. Understanding the role of matrix habitat use in fragmented landscapes is an important factor in small mammal conservation, as it asymmetrically affects the rate and mode of individual movements of different species.

*Keywords:* Atlantic Forest, coffee plantation, landscape, fragmentation, conservation.

## Pequenos mamíferos em fragmentos e matriz adjacente no sudeste do Brasil

### Resumo

Entre março de 2002 e abril de 2003, estudamos uma comunidade de pequenos mamíferos em um fragmento de Floresta Atlântica cercado por plantação de café no município de Santa Teresa, estado do Espírito Santo, Brasil. Obtivemos um total de 300 capturas de 114 indivíduos pertencentes a 11 espécies de mamíferos. Setenta e três por cento das espécies capturadas na floresta também usaram a plantação de café, principalmente indivíduos machos (90%) e jovens (80%) de *Marmosops incanus*. A taxa de recaptura excepcionalmente baixa na plantação de café sugere que este possa funcionar como um corredor entre os fragmentos, e não como habitats para as espécies. Entender como é o uso da matriz de habitats em paisagens fragmentadas é um importante fator na conservação de pequenos mamíferos, uma vez que ele afeta assimetricamente a taxa e o modo de movimento de indivíduos de diferentes espécies.

*Palavras-chave:* Floresta Atlântica, plantação de café, paisagem, fragmentação, conservação.

### 1. Introduction

While the effect of forest fragmentation on the abundance and richness of small mammals has been studied by several authors, consistent and generalizable effects of fragment size on these community parameters remains elusive in fragmented Neotropical forest landscapes (Malcolm, 1991; Gascon and Lovejoy, 1998; Pardini, 2004; Passamani 2003). Species richness and abundance in a forest fragment are modulated not just by fragment size, but also fragment shape, degree of isolation and connectivity (Andrén, 1994; Passamani, 2003; Pardini, 2004; Pardini et al., 2005; Ewers and Didham, 2006). There is a considerable inconsistency across the results of studies evaluating these relationships (Debinski and Holt, 2000).

Many small mammal species depend fundamentally on forest for their survival, but the deforestation of the Brazilian Atlantic Forest has severely fragmented the ecosystem - causing the extinction of several species (Viveiros de Castro and Fernandez, 2004). Other species have benefited; increasing their abundance in new created anthropogenic habitats (Fernandez et al., 1998; Fonseca and Kierulff, 1989; Feliciano et al., 2002; Laurance et al., 2002; Viveiros de Castro and Fernandez, 2004; Pardini, 2004; Umetsu, 2005). The ability to tolerate or utilize matrix habitats is frequently associated with a species' ability to persist in fragmented landscapes (Laurance, 1991). Specialist species in forest habitats without the

ability to cross or to use the matrix often demonstrate reduced abundance in forest fragments (Gascon et al., 1999; Passamani, 2003).

The Atlantic Forest is regarded as one of the world's five most important biodiversity hotspots (Myers et al., 2000). Originally the Atlantic Forest covered almost the entire Brazilian coast, but is presently relegated to a series of small fragments (Galindo-Leal and Camara, 2003), some embedded within highly urbanized areas. One of the main consequences of the fragmentation process is the isolation of the forest remnants, but the isolation of the animal populations can be avoided through movement of some individuals among the fragments (Pires et al., 2002). The movement among forest fragments does not depend only on the characteristics of the surrounding vegetation but also on the biological attributes and behavior of the species involved (Passamani, 2003; Dayle et al., 2003; Pires et al., 2002; Ewers and Didham, 2006). If a species is incapable of moving across the areas surrounding a fragment, they are restricted to a small and isolated portion of the total area (Kozakiewicz, 1993), which can generate local extinctions.

The main goal of this study was to evaluate which small mammal species were able to utilize a matrix habitat of coffee plantation.

## 2. Materials and Methods

The study was carried out in the municipality of Santa Teresa, in the state of Espírito Santo, Brazil (19° 58' S; and 40° 35' W), which has native vegetation of the Atlantic Forest.

The fragment sampled has approximately 7.6 ha of secondary and mature forest with many epiphytes and liana, and a very thick sub-canopy at ca 20 m. This fragment is surrounded by a coffee plantation and other forest fragments, at distances between 100 and 300 m (Passamani, 2003).

We surveyed small mammals in two distinct areas: in the interior of the forest fragment and in the neighboring coffee plantation (approximately four years old) over five consecutive nights every month from May 2002 to May 2003. The forest was sampled with three parallel transects set 50 m apart and 5 capture point at 15 m intervals in each transect, sampling a 0.6 ha of area. At each point we placed one trap on the ground (lower strata) and another in tree branches at one to two meters above the ground (middle strata) ( $n = 30$ ). In the coffee plantation, we placed five parallel transects, 25 m apart, that extended from the border of the fragment toward the coffee plantation, sampling a total area of 0.6 ha too. We placed five traps in each transect at 15 m intervals ( $n = 25$ ). Large (42 x 21 x 21 cm) and medium (30 x 10 x 10 cm) Sherman and wire mesh traps baited with banana and codfish oil were used in both locations. Captured individuals were identified and marked with numbered ears-tags for identification. Only marsupials were classified by sex, reproductive condition and age accord-

ing to Tyndale-Biscoe and Mackenzie (1976). Vouchers specimens were added to the collection of the Museu de Biologia Prof. Mello Leitão, Santa Teresa, ES.

Capture success rate was calculated by multiplying the total number of individuals captured by 100 and dividing the results by the capture effort (number of trap nights). In both areas we used a Spearman correlation to verify the relationship between the abundance of species and the  $\chi^2$  test (Yates correction) to verify differences in sexual ratio and age (Zar, 1984).

## 3. Results

With a capture effort of 3575 traps/nights, eleven species of small mammals were captured (Table 1). A total of 114 individuals were captured in 300 capture events (Table 1), corresponding a capture success of 8.33%. A porcupine (*Sphiggurus insidiosus* Lichtenstein, 1818) individual captured in the coffee plantation was excluded from analysis.

In the forest fragment, 99 individuals were captured 271 times across 1950 trap/nights, corresponding to a capture success rate of approximately 14% (Table 1). *Marmosops incanus* Lund (1840) was the most abundant species, accounting for approximately 36% of total captures (Figure 1).

In the coffee plantation area, a capture effort of 1625 traps/nights resulted in 29 captures, (capture success rate ca 2%) (Table 1). *Marmosops incanus* and *Oligoryzomys nigripes* Olfers 1818 were the most abundant species captured, representing 33.3% and 25% of the total captures. Other species captured were *Guerlinguetus aestuans* Linnaeus 1766, *Rhipidomys mastacalis* Lund 1840, *Micoureus paraguayanus* Tate 1831, *Didelphis aurita* Wied-Neuwied 1826, *Euryoryzomys russatus* Wagner, 1848 and *Gracilinanus microtarsus* Wagner 1842, together accounting for less than 30% of the total number of individuals (Figure 1). Among the *M. incanus* specimens captured in the coffee plantation, only one was recaptured.

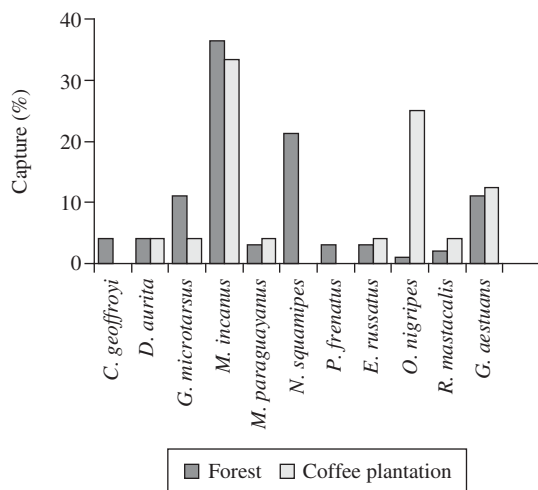
Despite the fact that *M. incanus* had been the most abundant species in both the coffee plantation and the forest, the abundance of this species was uncorrelated between the two areas (Spearman,  $r = -0.06$ ;  $p = 0.85$ ). Species captured both in the forest and the coffee plantation included *M. incanus*, *G. aestuans*, *M. paraguayanus*, *D. aurita*, *G. microtarsus*, *R. mastacalis*, *E. russatus* and *O. nigritus* (corresponding to 73% of the species). The exceptions were *Nectomys squamipes* Brants 1827, *Philander frenatus* Olfers 1818 and *Callithrix geoffroyi* Geoffroy in Humboldt 1812. Only one individual *O. nigritus* was captured in the forest fragment, while six were captured in the coffee plantation.

There was no significant difference in the relative abundance of males and females of *M. incanus* in the forest fragment (59% males versus 41% females;  $\chi^2 = 1.29$ ;  $p = 0.256$ ). The percentage of young and sub-adult individuals captured in the forest area was

**Table 1.** Number of captures of small mammals in a forest and coffee plantation in southeastern Brazil, including capture effort and success.

Species	Forest	Coffee plantation	Total
<b>DIDELPHIMORPHIA</b>			
<i>Didelphis aurita</i>	14 (4)	1 (1)	15 (4)
<i>Gracilinanus microtarsus</i>	30 (11)	1 (1)	31 (11)
<i>Marmosops incanus</i>	140 (36)	13 (8)	153 (40)
<i>Micoureus paraguayanus</i>	12 (3)	1 (1)	13 (3)
<i>Philander frenatus</i>	5 (3)	--	5 (3)
<b>PRIMATES</b>			
<i>Callithrix geoffroyi</i>	5 (4)	--	5 (4)
<b>RODENTIA</b>			
<i>Nectomys squamipes</i>	45 (21)	--	45 (21)
<i>Euryoryzomys russatus</i>	3 (3)	1 (1)	4 (4)
<i>Oligoryzomys nigripes</i>	1 (1)	6 (6)	7 (7)
<i>Rhipidomys mastacalis</i>	2 (2)	2 (2)	4 (4)
<i>Guerlinguetus aestuans</i>	14 (11)	3 (3)	17 (12)
Total of captures	271 (99)	29 (24)	300 (114)
Capture effort	1950	1625	3575
Capture success (%)	13.79	1.78	8.33

The number in brackets refers to the number of individuals captured.



**Figure 1.** Capture frequency (%) of species in the forest and the coffee plantation in southeastern Brazil

42.6%, with non-significant difference (Chi square,  $\chi^2 = 0.72$ ;  $p = 0.395$ ).

In the coffee plantation, the sex ratio of *M. incanus* differed significantly ( $c^2 = 34.06$ ;  $p = 0.001$ ) being 90% males versus 10% females. The differences in individuals' ages were also significantly in the coffee plantation ( $c^2 = 18.48$ ;  $p = 0.001$ ), being 80% young and sub-adult versus 20% adult. The capture of young and sub-adult marsupials in the coffee plantation occurred from January to June 2003.

#### 4. Discussion

The fact that some species were only captured in the forest fragment does not necessarily mean they do not use the coffee plantation for shelter or passage. *Nectomys squamipes*, for example, is a semi-aquatic species extremely well adapted to live in surrounding rivers and creeks (Ernest and Mares, 1986; Emmons and Feer, 1997) and it was not captured in the coffee plantation area probably because the traps had not been set near water. Among other species, a *P. frenatus* individual was followed by radio-tracking in these areas and it used both the forest and the coffee plantation for daytime shelter and passage, and a group of *C. geoffroyi* was also followed by radio and used both areas for passage too (Passamani unpub. data). Thus, it is possible that many species captured in the forest fragment may have some ability to exploit the coffee plantation. This ability may explain why many species persist in that fragment of the area, since it is possible for individuals to migrate from one fragment to another (Passamani, 2003), as verified in other studies in the Atlantic Forest (Pires and Fernandez, 1999; Pires et al. 2002).

The capacity to occupy the matrix seems to be a good parameter to foresee the vulnerability of the species to fragmentation (Umetsu, 2005), since isolated populations in the small habitat remnants can be subject to higher risk of extinction (Wilcox and Murphy, 1985; Viveiros de Castro and Fernandez, 2004). In this study, the majority of the small mammal species use the coffee plantation, and the proximity of the forest fragments

(<400 m) can explain the facility of occupation of this matrix, since individuals were often detected moving among these fragments and crossing the coffee plantation (Passamani, 2003).

The occurrence of *G. aestuans* in the coffee plantation was likely a result of the presence of *Attalea* sp. (Arecaceae), one of their major sources of food (Souza, 2000), as most captures were made in areas close to that palm tree. In Costa Rica, some species, like squirrels, captured in coffee plantations may have been foraging rather than simply in transit between forest remnants (Dayle et al., 2003). The capture of *Sphiggurus insidiosus* in the coffee plantation was unusual, considering that it is a species that dwells in trees and is difficult to capture in traps. An individual of this species, however, was radio-tracked and used both the forest and the coffee plantation for daytime shelter and passage (Passamani unpub. data).

Except for *O. nigripes*, all species captured in the coffee plantation were more abundant in the forest fragment. Similar results were reported by Passamani (2003) and Viveiros de Castro and Fernandez (2004) for the Atlantic Forest, and by Malcolm (1991), Laurance and Bierregaard (1997) and Gascon et al. (1999), for Amazonian forest fragments, where small mammal communities that use the vegetation surrounding forest fragments are similar to those found within the fragments themselves, probably because of an intense edge effect.

The great majority of the marsupial specimens captured in the coffee plantation were male (90%). Among these, about 78% were sub-adult or young individuals who were captured mainly between January and April (2003), when the rainy season ends and the dry season begins, and food availability (fruit and insects) tends to decrease (Charles-Dominique, 1983; Stalling, 1989). This fact might be related to an increase in competition and agonistic interaction among individuals within the forest fragment (Passamani, 2003). Thus, it is probable that those individuals that use the coffee plantation area had lost their territory in the competition against older individuals in the forest, and moved into human-altered areas looking for other forest remnants to settle, or they are in the process of dispersion. The combination of the very small number of individuals recaptured and the unique capture of only sub-adult or young individuals in the coffee plantation supports the conjecture that these animals may be born in the forest fragment and later migrate to the coffee plantation.

Malcolm (1991) carried out a quantitative study of the effects of forest fragment size and isolation on mammal communities in the Amazon Forest. He concluded that fragmentation of the forest results in continuous alterations in diversity, abundance and biomass of small mammals, with a decrease in species diversity and increase in abundance of those species that utilize forest fragment edges. Small mammal richness may also increase or not suffer meaningful change with fragmentation because many times the species are associated with

the matrix areas surrounding the fragments (Paglia et al., 1995; Gascon et al., 1999; Passamani, 2003; Pardini, 2004). The use of the matrix can explain the variation in responses to habitat fragmentation (Laurance, 1991; Malcolm, 1991; Gascon et al., 1999; Pardini, 2004) and is critical in the dynamics and composition of small mammal communities in tropical forest remnants. As a consequence, understanding patterns of matrix use can provide empirical support for conservation and management strategies of fragmented landscapes.

It is important to mention that in our study sites, *M. incanus* is the most abundant species, but as no individuals were recaptured in the coffee plantation it remains unknown if *M. incanus* actually resides there. *Marmosops incanus* probably uses the coffee plantation to move between forest patches, permitting them to reach high abundances in some small forest patches (Passamani, 2003). In Costa Rica, mature coffee shrubs appear to provide cover and facilitate movements, connecting mammal populations into larger metapopulations and reducing local extinction (Dayle et al., 2003). As observed by Silva et al. (2005), the maintenance of small forest patches in close proximity is fundamental for the conservation of small mammals inhabiting agricultural landscapes in Canada, and the responses of some species will change as the surrounding landscape matrix is transformed (Lindenmayer et al., 2001). Hence, the type of vegetation that constitutes the surround of forest fragments in an Atlantic Forest is an important factor that influences the population dynamics of many species of small mammals, and the coffee plantation is permeable to the movement of them among fragments. This information can support our understanding of Neotropical fauna as well as conservation and management strategies within this biodiversity hotspot.

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