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Effects of forest fragmentation on two sister genera of Amazonian rodents (*Myoprocta acouchy* and *Dasyprocta leporina*)

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ABSTRACT

Because agoutis (*Dasyprocta* sp.) and acouchies (*Myoprocta* sp.) are the most important dispersers of several large-seeded Amazonian trees, knowing their responses to forest fragmentation is essential and urgent. But until now, there was no study showing their population trends in Amazonian land forest fragments. The present study was conducted at the Biological Dynamics of Forest Fragments Project, Central Amazon, Brazil. Eleven sites (three fragments of 1 ha, three of 10 ha, two of 100 ha and three sites of continuous forest) were surveyed between 2003 and 2005. Agoutis and acouchies were systematically counted at each site through standard transect censuses and their densities were estimated with DISTANCE 4.1. Overall, I walked 100 km, and encountered 136 acouchies and 35 agoutis. Fragmentation had a significant negative effect on acouchies and a significant positive effect on agouti densities. Acouchy density was 0.64 ± 0.09 inds./ha $(\overline{X} \pm \mathrm{SE}, N = 3)$ in continuous forests and 0.07 ± 0.07 inds./ha in 1-ha fragments. On the other hand, agouti density was 0.16 ± 0.05 inds./ha in continuous forests and 0.71 ± 0.24 inds./ha in 1-ha fragments. This study is consistent with the idea that in fragments, larger species of mammals are initially less affected by forest fragmentation than smaller ones. More critical to conservation is the fact that acouchies, which were negatively affected by fragmentation, are restricted to the core region of the Amazonian rainforests. Continued fragmentation of Amazonian forests should have vast negative consequences for the genus.

1. Introduction

The Amazon Basin holds the largest tract of continuous forest in the Tropical world (FAO, 2005), but it is now experiencing the greatest rate of deforestation as well (INPE, 2002). At current rates, Amazonian forests will be completely fragmented in few decades (Laurance et al., 2001). Ground-dwelling mammals play key roles in Amazonian forest dynamics as seed dispersers, and seed and seedling predators (Smythe, 1986). In particular, acouchies (*Myoprocta* sp., Dasyproctidae, Rodentia) and agoutis (*Dasyprocta* sp., Dasyproctidae, Rodentia) constitute the most important dispersal agents of several large-seeded Amazonian trees (Forget, 1990, 1992, 1996; Peres and Baider, 1997; Salm, 2006). Knowing their responses to forest

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fragmentation is essential both for predicting their own fate and for understanding the fate of trees that depend on them for seed dissemination.

So far there has been no study to report effects of forest fragmentation on acouchies. As for agoutis, previous studies have shown that they are negatively affected by forest fragmentation in island fragments (Asquith et al., 1997 – Panama; Terborgh et al., 1997 – Venezuela) and in land fragments in the Atlantic forest (Chiarello, 1999). In the present study, I compared the trends of acouchy and agouti populations in Amazonian land forest fragments. My objective was threefold: (1) to report for the first time, the effects of forest fragmentation on populations of acouchies; (2) to compare the responses of agoutis to fragmentation with responses from other regions with other fragmentation contexts; and (3) to compare the responses of agoutis and acouchies to forest fragmentation in light of their body size differences.

The presence of a species in a forest patch depends on its population dynamics within the patch (which is greatly influenced by patch size) but also on the individuals' ability to migrate between patches. In ground-dwelling mammals, both aspects of population dynamics (within patch and between patches) may be influenced by body size. Within patches, larger animals should be more negatively affected. Larger animals are naturally found at lower densities and tend to have lower growth rates (Damuth, 1981). These characteristics should increase sensitivity to forest fragmentation because populations with fewer individuals are more susceptible to negative stochastic effects and slow-growing populations are more difficult to recover from population crashes. In support to this view Heaney (1984) and Asquith and colleagues (1997) showed a negative correlation between abundance and fragment area related to body size in fragments surrounded by water.

On the other hand, between patches, larger animals may have greater dispersal ability due to their greater mobility, greater perceptual range, and lower susceptibility to predation (Zollner, 2000). Consequently, negative effects between patches should be stronger in smaller animals. Indeed, evidence on land patches has shown that body size has either no effect on abundance (Laurance, 1991; de Castro and Fernandez, 2004) or a positive one (Gehring and Swihart, 2003).

Acouchies and agoutis are very similar morphologically and behaviorally, with their size being the main the difference between them (agoutis weigh in average 2–3 times more than acouchies: 3–6 kg. vs. 0.5–1 kg.). Due to their size differences, agoutis have larger home ranges: 5–10 ha (Silvius and Fragoso, 2003; Jorge and Peres, 2005) versus 1–2 ha for acouchies (Dubost, 1988). Considering their size differences, if within patch dynamics is the main factor affecting their abundances, agoutis should be more sensitive to a decrease in forest size. On the other hand, if the main factor is the ability to move across fragments, by having larger bodies, agoutis may be better dispersers through the matrix, and acouchies should be more sensitive to forest fragmentation.

2. Study site

The study was conducted at the Biological Dynamics of Forest Fragments Project (hereafter referred as BDFFP), located 80 km north of Manaus, the capital of Amazonas State, in Central Amazon, Brazil. The forest of the region is upland mature forest, not subjected to flooding (*Floresta de Terra Firme*) with annual precipitation of approximately 2600 mm (Bierregaard et al., 2001). Fragments were 20–25 years old during data collection (2003–2005). They are surrounded by matrices composed by pasture and secondary vegetation. In the matrix habitat subjected to frequent burning, the secondary vegetation is dominated by *Vismia* sp. In the matrix not subjected to burning, secondary vegetation is dominated by *Cecropia* sp. Both matrix types are found in several stages of regeneration, depending on the last period of cutting and burning (Table 1). Fragments are spread among three cattle ranches (Fig. 1). The ranches are approximately 10 km apart from each other, and each is surrounded by large tracts of mature forest, where control sites were established. For the present study, a total of eight fragments (three of 1 ha, three of ten, and two of 100) and three sites of continuous forest were surveyed.

Table 1 – Physical characteristics of the fragments of Biological Dynamics of Forest Fragments Project, Manaus, Brazil (Bierregaard et al., 2001)

Ranch name	BDFFP reserve code	Size (ha)	Topography and other remarks	Shortest distance to 2ary forest with closed canopy or 1ary forest (m)	Composition and age of 100-m band around fragment
Dimona	2107	1	Deep valley cuts the reserve towards the west; no stream	150	Vismia 2–7 years
	2206	10	Strong topography with presence of two streams	225	Vismia 2–7 years
	2303	100	Rugged landscape with small streams. Soil with more sand than the other reserves	150	Vismia 2–7 years
Porto Alegre	3114	1	Gentle slope; no streams	200	Pasture
	3209	10	Gentle slope; no streams; indication of coal in the soil	100	Cecropia 2–7 years
	3304	100	Undulated terrain. Three small streams cut the reserve	<100	Cecropia > 14 years
Colosso	1104	1	Completely flat; no streams	<100	Vismia > 14 years
	1202	10	Gentle slope; no streams	700	Pasture

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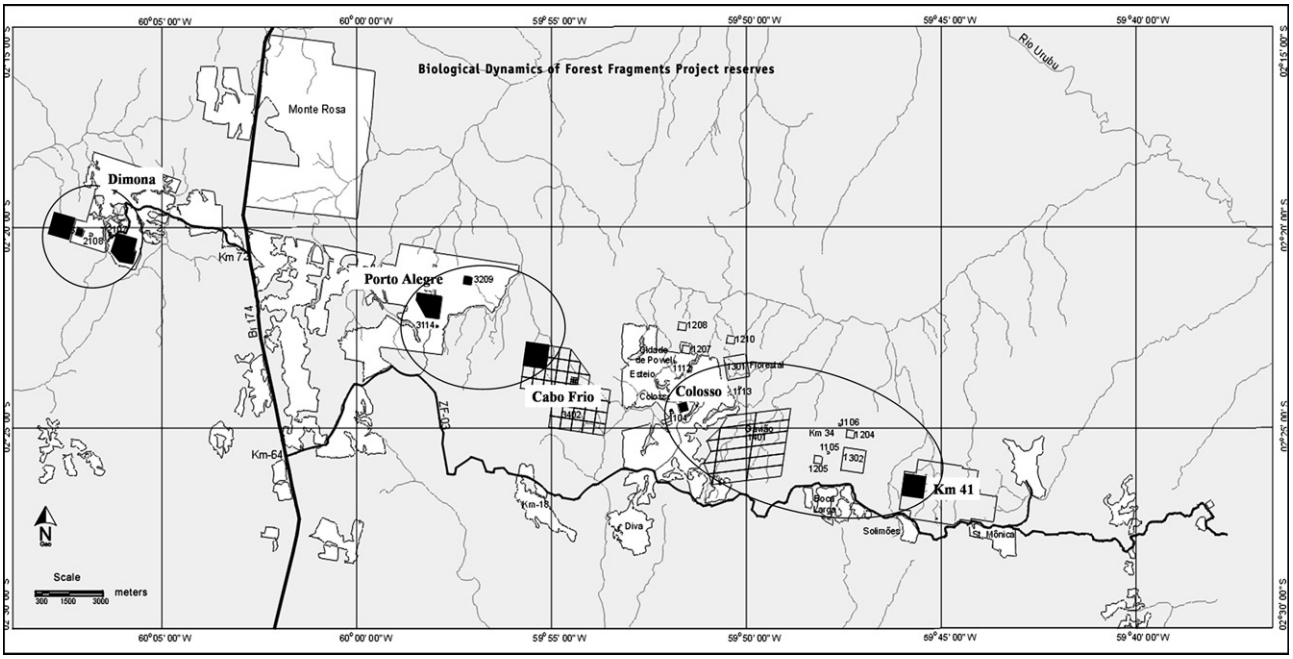

Fig. 1 – Biological Dynamics of Forest Fragments Project, Manaus, AM, Brazil. Fragments are distributed among three cattle ranches (*Dimona*, *Porto Alegre*, and *Colosso*). In each ranch, I sampled one fragment of 1, 10, and 100 ha, except for *Colosso*, which does not have a 100-ha fragment. Km 41 was used as control site for *Colosso*, and *Cabo Frio* as control site for *Porto Alegre*. Fragments are in black, secondary forest and pasture in lighter grey and primary forest in darker grey.

3. Study species

Agoutis (*Dasyprocta* sp.) and acouchies (*Myoprocta* sp.) are the sole extant representatives of Dasyproctidae, a rodent family restricted to the Neotropical region. The genus *Dasyprocta* has five to ten species, depending on the authority (Voss et al., 2001; Ximenes, 1999) and these are spread from Southern Mexico to Northern Argentina, east of the Andes. The species present near Manaus is *Dasyprocta leporina* (Voss and Emmons, 1996; Ximenes, 1999) and occurs from Central Amazon to Southeast Brazil. The genus *Myoprocta* is restricted to the core area of the Amazonian region, with two species, *Myoprocta acouchy* in Central and Central-East Amazon (and the one present near Manaus – Voss and Emmons, 1996) and *Myoprocta pratti* in Southwest Amazon.

Both genera are terrestrial and diurnal. They eat mainly fruits and seeds that fall on the forest floor (Dubost and Henry, 2006) and scatter-hoard seeds (Morris, 1962; Smythe, 1978) which they consume later when there is no fresh food available. They are very similar morphologically, but acouchies are, in average, half to three times smaller than agoutis. Ecologically, they show few differences, probably related to their size differences. Agoutis have larger home ranges: 5–10 ha (Silvius and Fragoso, 2003; Jorge and Peres, 2005) versus 1–2 ha for acouchies (Dubost, 1988). During periods of fruit scarcity, agoutis switch mostly to seeds whereas acouchies still include a fair amount of fruit pulps in their diet (Dubost and Henry, 2006). Finally, agoutis appear to be habitat generalist, while acouchies are restricted to mature forest (Dubost, 1988; Voss et al., 2001).

4. Methods

I used line-transect censuses to gather data for density estimates, following the protocol by Peres (1999). Particularly for this study, I walked on the trails during early morning (06:00–07:00 h) and late afternoon (17:00–18:00 h), which are peak activity periods for the two genera (Smythe, 1978; Dubost, 1988). Detections were visual and/or acoustic. Acoustic detections are possible because each species has a distinctive loud flee bark. Upon detection, I identified the species, determined the number of individuals present, and estimated the perpendicular distance (PD) between the trail and the animal(s).

In each of the eleven sites, there were three parallel transects. In the continuous forest and 100-ha fragments, transects were approximately 1000-m long, and 200 m apart from one another. In 10-ha fragments, they were approximately 350 m long, and 75 m apart from one another. In 1-ha fragments, they were approximately 100 m long, and 30 m apart from one another. In 2003, sites were sampled in February and March (peak of rainy season) and July and August (peak of the dry season). In 2004, sampling effort was continuous from February to August. For logistic reasons, 100-ha fragments were sampled in 2005 instead of 2004.

To avoid spatial autocorrelation, I ensured that the same transect was never sampled in the same day. Density estimates using transect census allow for repeated detections of the same animal in the same transect, as long as the detections are temporally independent, i.e., the animal has sufficient time between each of them to ensure random movements within its home range (Buckland et al., 1993).

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Temporal independence for agouti locations was empirically determined in a previous study to range from 60 to 270 min (Jorge, 2000). Therefore, it is safe to affirm that a 24 h interval was sufficient for independence between samplings (assuming that movement patterns between agoutis and acouchies are similar).

I also ensured that sampling effort for each fragment (and areas of continuous forest) was as spread as possible in time, in order to guarantee that all density estimates were representative of the entire sampling period. Fragments (and continuous forests) were sampled one to three times per month, every month, following a monthly rotational schedule of visits of the five field stations (refer to Fig. 1 for field station locations). Raining days and mornings in which the previous night had rained were not sampled to decrease detection error due to increase of background noise (water dropping in the forest).

In order to determine differences in animal abundances between fragment sizes, I estimated densities (number of individuals per hectare) for each site. For the density estimate, I used the number of individuals detected divided by two times the effective strip width (ESW). ESW was estimated as a function of the observed PDs with the software DISTANCE 4.1 (Thomas et al., 2003). This approach takes into account possible decays in detection with increased PD and fits a theoretical function that best describes the PD frequency distribution (Buckland et al., 1993).

Buckland and colleagues (1993) suggest a minimum of 60 to 80 detections for a robust ESW estimate. Those numbers were not achieved in any individual site for either of the two rodent species (Table 2). DISTANCE 4.1 allows for the estimation of one ESW for all sites for each species and then density estimation for each site using the same ESW. To pool all the data together for each species, I ensured that there were no significant differences on the frequency distribution of PDs and on the proportion of acoustic detections between fragment size, ranches and years (Table 3). Significant differences on the frequency distribution of PDs and on the proportion of acoustic detections would incur that there were detection differences between sites which could falsely imply density differences between sites.

Finally, I determined whether fragment size and ranch had an effect on densities for each of the rodents with a 1-way analysis of variance (ANOVA). Year comparisons were not considered because of the unbalanced effort between years. When significant differences were detected, least-square-differences (LSD) test of multiple comparisons was used to determine the origin of the differences. All statistical tests were conducted with SYSTAT 11.

5. Results

Over the course of the study, I walked approximately 100 km, encountering 136 acouchies and 35 agoutis (Table 2). Since no significant variation was detected for PD or detection type for either of the two species (Table 3), data was pooled together per species for density estimates. For a smoother PD frequency distribution, for acouchies, PDs were distributed in 5 m intervals, and for agoutis, PDs were distributed in 8 m intervals. Moreover, for acouchies, there was a correction factor of 0.85 for evasive behavior ($g(0) = 1/0.85$), which was not necessary for agoutis. DISTANCE assumes that detections at the transect line are equal to one ($g(0) = 1$) and calculates densities accordingly. For animals with evasive behavior (a characteristic that is detected *a posteriori* through the analysis of shape of PD frequency distribution) the program suggests the use of a correction factor to estimate densities more accurately. That evasive behavior was detected for acouchies and the correction factor was applied in the analysis. For both species, a half-normal function best fitted PD distributions, and ESW for acouchies was 14.34 ± 0.90 m, whereas for agoutis, it was 12.65 ± 1.54 m.

Table 2 – Sampling effort, number of detections, encounter rates and densities of Myoprocta acouchy and Dasyprocta leporina in 2003, 2004 and 2005, at the Biological Dynamics of Forest Fragment Project, North of Manaus, Amazonas, Brazil

Ranch	Fragment area (ha)	Sampling effort (m)	*Myoprocta acouchy*			*Dasyprocta leporina*		
			Number of detections[a]	Enc Rate (inds./km)	Density ± SE (inds./ha)[b]	Number of detections[a]	Enc rate (inds./km)	Density ± SE (inds./ha)[b]
Colosso	1	2100	1	0.48	0.21 ± 0.17	6	2.86	1.17 ± 0.53
Porto Alegre	1	2100	0	0.00	0.00	3	1.43	0.58 ± 0.38
Dimona	1	3200	0	0.00	0.00	3	0.94	0.38 ± 0.24
Colosso	10	6480	7	1.08	0.47 ± 0.15	3	0.46	0.19 ± 0.12
Porto Alegre	10	8280	17	2.05	0.89 ± 0.20	0	0	0
Dimona	10	6950	3	0.43	0.19 ± 0.11	1	0.14	0.06 ± 0.06
Porto Alegre	100	12,680	23	1.36	0.79 ± 0.18	5	0.39	0.16 ± 0.09
Dimona	100	16,900	23	1.81	0.59 ± 0.11	0	0	0
Km 41[c]	Continuous	27,700	40	1.44	0.63 ± 0.10	7	0.25	0.10 ± 0.04
Cabo Frio[d]	Continuous	7950	9	1.13	0.49 ± 0.17	5	0.63	0.26 ± 0.08
Dimona	Continuous	7000	13	1.86	0.81 ± 0.23	2	0.29	0.12 ± 0.07
	Total	101,340	136	–	–	35	–	–

a One detection is defined as one sight or hearing event. For *Myoprocta*, all events corresponded to a single individual. For *Dasyprocta*, there were two events (*Colosso* and *Porto Alegre*) with two individuals and one (*Colosso*) with three.
b Densities were estimated with DISTANCE 4.1. See detailed explanation in the text.
c Km 41 was used as control for *Colosso* fragments.
d Cabo Frio was used as control for *Porto Alegre* fragments.

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Table 3 – Statistical results of 1-way analysis of variance (perpendicular distance) and chi-square test (detection type)

Species	Factor	Perpendicular distances			Detection type (visual vs. acoustic)		
		F	d.f.	p	χ^2	d.f.	p
Myoprocta	Fragment size	0.146	2, 131	0.864	2.395	2	0.302
	Ranch	0.269	2, 131	0.765	2.632	2	0.268
	Year	0.639	2, 131	0.539	2.058	2	0.357
Dasyprocta	Fragment size	0.058	3, 31	0.981	3.080	3	0.379
	Ranch	2.723	2, 32	0.081	4.111	2	0.128
	year	1.125	1, 33	0.296	3.500	1	0.061

No significant differences were found between fragment sizes, ranches and years. Therefore, detection data was pooled together for each species for the density analysis with DISTANCE 4.1.

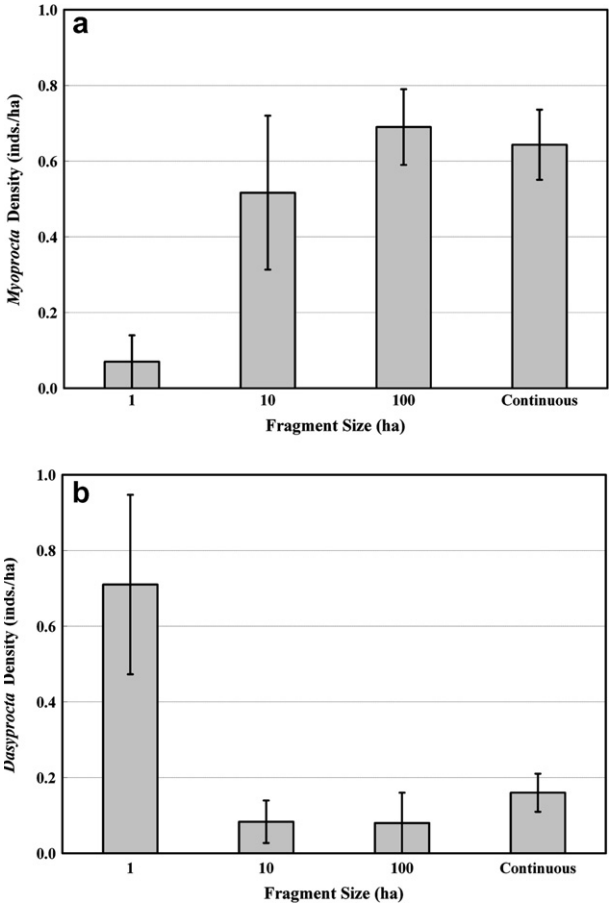

Fig. 2 – Differences in densities ($\overline{X} \pm SE$) of acouchies (*Myoprocta exilis*) and agoutis (*Dasyprocta leporina*) in fragments of 1 (N = 3), 10 (N = 3), 100 ha (N = 2) and continuous forest (N = 3) at the *Biological Dynamics of Forest Fragments Project*, Manaus, Brazil; (a) acouchies densities were similar in continuous forest (0.64 ± 0.09 inds./ha), in fragments of 100-ha (0.69 ± 0.10 inds./ha) and in fragments of 10-ha (0.52 ± 0.20 inds./ha), but significantly lower in fragments of 1-ha (0.07 ± 0.07 inds./ha; 1-way ANOVA: $F_{3,7} = 4.494$ $p = 0.046$); (b) agoutis densities were similar in continuous forest (0.16 ± 0.05 inds./ha), in fragments of 100-ha (0.08 ± 0.08 inds./ha) and in fragments of 10-ha (0.08 ± 0.06 inds./ha), but significantly higher in fragments of 1-ha (0.71 ± 0.24 inds./ha; 1-way ANOVA: $F_{3,7} = 4.819$; $p = 0.040$).

Densities were significantly affected by fragment size for both genera (1-way ANOVA, *Myoprocta*: $F_{3,7} = 4.494$, $p = 0.046$; *Dasyprocta*: $F_{3,7} = 4.819$, $p = 0.040$). Interestingly, trends were opposite. Densities of the smaller acouchies increased with fragment size (Fig. 2a), whereas densities of the larger agouti decreased (Fig. 2b). For acouchies, densities in 1-ha fragments were significantly smaller than in any other fragment size (LSD pairwise comparison with 10-ha = 0.044; with 100-ha = 0.019; with continuous forest = 0.016). For agoutis, densities in 1-ha fragments were significantly larger than any other fragment size (LSD pairwise comparison with 10-ha = 0.014; with 100-ha = 0.022; with continuous forest = 0.024). Ranch effects were not significant for either genus (*Myoprocta*: $F_{2,8} = 0.182$, $p = 0.837$; *Dasyprocta*: $F_{2,8} = 0.867$, $p = 0.456$).

The same positive relationship was found between acouchy encounter rate (inds./km) and fragment size (1-way ANOVA $F_{3,7} = 4.497$, $p = 0.046$) and a negative relationship between agouti encounter rate and fragment size (1-way ANOVA $F_{3,7} = 4.924$, $p = 0.038$).

6. Discussion

This study reveals that fragmenting the forest at BDFFP had opposite effects on populations of acouchies (*M. exilis*) and agoutis (*D. leporina*). Acouchies decreased in density as forest patch decreased in size, whereas agoutis' density increased (Fig. 2). The results are enlightening for three reasons. First, they are the first to show how destructive forest fragmentation is for populations of acouchies. Second, they show that the agouti's response to forest fragmentation is context-dependent. Third, they suggest that body size differences may be an important factor in determining the responses of these rodents to fragmentation.

Agoutis' positive response, and opposite of what previous studies had shown, seems to be the result of a less inhospitable environmental scenario at BDFFP. In Venezuela (Terborgh et al., 1997), fragments are approximately the same age (10–20 years) and the same sizes (1–100 ha) of those at BDFFP. But they are surrounded by water, a much more hostile matrix. Therefore, in Venezuela, agoutis were present in large and medium-sized fragments (>10 ha), but disappeared from small ones (<1 ha). In Panama (Asquith et al., 1997) fragments have a comparable size range as those from BDFFP, but are much older (more than 100 years old) and also surrounded by water. Similar to Venezuela, agoutis were present in large and medium-size fragments, but absent from small ones. In

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the Panama case, time of isolation and matrix type may be acting in tandem to negatively affect populations of agoutis. In Southeast Brazil (Chiarello, 1999), fragments are surrounded by a matrix of pasture, agricultural fields and *Eucalyptus* plantations. But they much older (more than 100 years) and have suffered from poaching and human intervention (e.g. fire and logging) for at least 150 years. Consequently, agoutis disappeared from much larger fragments (200 ha). In summary, in all three previous scenarios, levels of fragmentation are much worse than in BDFFP in several aspects. Fragments have been isolated for longer periods, the matrix is more inhospitable, and human intervention within the fragments has been more intense. As expected, in those contexts, agoutis were negatively affected. At BDFFP, forest fragmentation appears to have not yet been sufficiently intense to affect agouti population. In fact, it seems to be beneficial for the agoutis in its present levels. These comparisons reinforce the idea that species response to forest fragmentation is greatly influenced by the landscape structure and the time since the beginning of fragmentation.

The presence of agoutis in 1-ha fragments of BDFFP seems to be the result of the ability of these animals to cross and use the matrices of secondary vegetation. It is unlikely that the animals present in the small fragments were remnants of pre-isolation times (BDFFP fragments were about 20 years old when surveyed for this study and maximum lifespan of *D. leporina* is approximately 15 and 18 years – http://genomics.senescence.info – accessed on August 1, 2007). Animals visiting these fragments are probably using them as part of their home ranges, where they can find better-quality food (e.g. larger seeds). The fragmented scenario of BDFFP may parallel what happens in the continuous forest. In continuous forests of Southeast Amazon, agoutis used their home range unevenly, exploring areas of greater food abundance for longer periods and more frequently (Jorge, 2000). At BDFFP, agoutis may be spending more time in 1-ha forest patches because of differences in food quality compared to the surrounding matrix.

Comparisons between 2003 and 2004 are consistent with this idea. In 2003, there were three times more agoutis seen in 1-ha fragments than in 2004 (1.67 agoutis/km vs. 0.5 agoutis/km). In parallel, T. Viscarra (unpublished data) reported that in 2003, fruit production in the secondary vegetation was significantly lower than in 2004. Agoutis may have been searching more intensively for food in small fragments in the first year due to lower resource availability in the surrounding areas.

The same fragmentation scenario that did not affect agoutis, negatively affected the smaller acouchies (Fig. 2a). When compared to other taxa in the same areas, acouchies responded similarly to understory birds (Bierregaard and Stouffer, 1997), but opposite to smaller mammals (Malcolm, 1997). Anti-predatory behavioral attributes could explain the different responses. Acouchies and understory birds are diurnal and probably depend on visual cues to avoid predation. Conversely, smaller mammals are nocturnal, and must depend mostly on auditory and olfactory cues to detect potential predators. An increase of light intensity due to greater canopy opening could negatively affect species that use visual anti-predatory cues, but not the ones that use other sensory cues.

The previous argument cannot be used to explain the divergent responses of acouchies and agoutis because both are diurnal and probably use visual cues to avoid predation. In this case, what seems to be dictating the divergence is the body size difference. Previous studies (Zollner, 2000; Gehring and Swihart, 2003) have shown that in terrestrial forest-dwelling mammalian groups, there is a positive correlation between body size and the ability to cross open habitats. Previous studies also report that acouchies are never seen outside of the mature forest, whereas agoutis can be found in a greater range of habitat types (Dubost, 1988; Voss et al., 2001). Consistent with those, in the present study, acouchies were never seen crossing or using the matrix, even considering the short distances between fragments and tracts of continuous forest (Table 1). Agoutis, on the other hand, were frequently seen and heard in forests at several levels of regeneration, forest edges adjacent to open vegetation, and even crossing dirt roads. The larger body size of agoutis may provide greater perceptual ability (*sensu* Zollner, 2000) allowing enhanced assessment of the heterogeneous landscape at greater distances and reduced vulnerability to predation. In this sense, my results are consistent with the body size hypothesis. At a broader level, the same explanation for the divergent responses of acouchies and agoutis to forest fragmentation at BDFFP could be used to explain the differences that exist in their geographic ranges, with agoutis more geographically widespread than acouchies.

In summary, this study enlightens the effects of forest fragmentation on agoutis and acouchies in two ways. The future of agoutis in Amazonian forest is unclear. It is somewhat encouraging to know that they may support mild levels of forest fragmentation, such as if large tracts of secondary forest are still present. Unfortunately this scenario is not the rule in Amazonian forests, with fragmentation levels only getting worse, fragments becoming smaller, more isolated, and with more inhospitable matrices (Laurance, 2001). Moreover, the fragmentation scenario at BDFFP needs to be seen with caution due to the young age of the fragments. In the Atlantic forest, Chiarello (1999) showed that with enough time of human intervention, agoutis disappeared from larger tracts of forest, and that may be a consequence of either continuous negative population effects overtime (e.g. inbreeding, negative stochastic events) or because of synergistic effects of fragmentation and hunting.

For acouchies, the perspectives are much worse. Acouchies rapidly disappear from young, not so isolated, small fragments. If Amazonian forests become completely fragmented with many small fragments, the disappearance of acouchies appears to be inevitable, even if the fragments are close together and surrounded by a matrix of secondary vegetation.

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