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Bird species richness in natural forest patches in southeast Brazil

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Abstract

Studies of populations in fragmented habitats have become essential tools in biodiversity conservation. This study was conducted at 14 natural forest patches ("capões") in the Serra da Canastra National Park, with the purpose of evaluating bird species richness of these patches in relation to patch area and distance to other patches. In this study, area and isolation did not explain much of the variation in bird richness and abundance when all species were considered. However, when only forest-dependent species were considered, both area and isolation were significantly related to patch richness, suggesting that the distribution of these birds is highly related to forest patch area and is limited by dispersal ability of the species through the matrix. But, some individuals of some forest-dependent species (*Thamnophilus caerulescens*, and *Basileuterus leucophrys*) were also found in the very small (0.05 ha) or most isolated (430 to 700 m) patches. This fact may be related to an adaptation of these species to the naturally fragmented landscape, since this is a landscape which have not been altered considerably in the last two centuries. Our results showed that this natural landscape of small and isolated forest patches imbedded in a grassland matrix may support populations of several forest-dependent species of birds, increasing the regional biodiversity.

Keywords: Birds, Brazil, Forest patches, Fragmentation

Introduction

The number of species on an island is influenced by the island's size, internal environmental heterogeneity, age, and distance from a species source (MacArthur & Wilson, 1967; Vuilleumeier, 1970; Galli *et al.*, 1976; Connor & McCoy, 1979; Coleman *et al.*, 1982; Nores, 1995). When we compare studies about fragmented habitats, one must take into account how and when these habitat patches were created. Bierregaard & Lovejoy (1989) and Turner & Corlett (1996) asserted that habitats recently fragmented by humans need some time to reach equilibrium after being saturated by individuals and species of the surrounding destroyed habitat. Some studies have shown that the loss of species in fragmented areas continues for decades (Kattan *et al.*, 1994; Aleixo & Vielliard, 1995). However, studies dealing with natural habitat patches, such as mountain tops (Vuilleumeier, 1970; Brown & Gibson, 1983; Nores, 1995), may bring new insights into the interpretation of the effects of habitat fragmentation, since natural habitat patches are probably in equilibrium and are used by species better adapted to this patchy landscape. Equally interesting are the natural forest patches imbedded in a grassland matrix that occur in central and southeast Brazil (Rizzini, 1979, Meguro *et al.*, 1996). They represent a natural 'fragmented' landscape in which it is supposed that animals have had time to adapt to a mosaic landscape.

Our objective here was to study the bird community of natural forest patches of southeast Brazil, evaluating the relationship between species richness and abundance and forest patch area and isolation.

Methods

Study Area

The study was conducted at the Serra da Canastra National Park (PNSC) (46º15'-47º00'W; 20º00'-23º30'S) located at southwest Minas Gerais state, southeast Brazil (Figure 1). PNSC has 71,525 ha, with a perimeter of 173.4 Km, between 1,033 and 1,493 m above sea level (MMA, 1993). The predominant vegetation of the park is cerrado *sensu lato* (mostly grasslands) with portions of rocky fields (*campo rupestre*), cerrado *sensu stricto* (shrublands) and natural patches of gallery forests (locally called *capões*) (forest patches herein). We assume these forest patches are natural based on the fact that Saint-Hilarie described the region as it is during his visit to Serra da Canastra in 1816-1819 (Saint-Hilaire, 1975). Also, since most of Serra da Canastra plateau is very high, cool, windy, and dry, the presence of forests outside the wet, richer valleys seems unlikely.

The forest patches had trees usually between 5 and 15 m tall, with a closed canopy and an understorey. The smaller patches were shorter with a denser understorey. The relief is

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undulated, with streams in the valleys. The climate is strongly seasonal, with a marked warm rainy season between September and February and a cool dry season between March and August (IBDF, 1981).

Figure 1 - Location of Serra da Canastra National Park, Minas Gerais state, Brazil.

Data collection was conducted in 12 forest patches inside the PNSC divided into three treatments (Table 1):

A) Small forest patches: forest patches of small size (0.09 – 0.41 ha) isolated by grasslands (> 360 m to the nearest forest patch). Five forest patches were sampled, three in one location and two in another location;

B) Medium forest patches: Three small to medium forest patches (0.36 – 0.60 ha) isolated by grasslands (360 – 540 m to the nearest forest patch). One of these patches consisted of three small patches very close to each other (50 - 67 m), with intense movement of birds among them (Andrade & Marini 2001);

C) Large forest patches: Four medium to large forest patches (0.56 – 1.02 ha) connected by vegetation corridors (between 2 and 5 m wide with trees up to 5 m high), distant 180 – 660 m to the nearest forest patches. We also sampled a corridor area close to these large forest patches.

Experimental design was constrained because of the natural arrangement of forest patches and corridors. Large forest patches were associated with narrow corridors, whereas the smaller patches always lacked them.

Forest patch sizes and distances to the nearest forest patches were measured with a measuring tape except for one distance which was measured from aerial photographs because of the large distance (1.180 m) between patches. Patch isolation was the mean distance to the two nearest forest patches, taken as the minimum straight distance.

Data collection

Data collection took place between July 1997 and November 1998. Birds were captured with mist-nets (12-m long and 2.5 m high) between 6:00 and 17:00, totaling approximately 300 mist net/hours in each forest patch (Table 1). Individuals were metal and color banded with unique combinations of three color bands enabling later identification by binoculars. Birds were released at the same capture sites.

Birds were classified into three categories of levels of forest dependence following Silva (1995): a) Forest dependent species: which occur mostly inside forested habitats; b) Forest semi-dependent species: which occur both inside forests but also in open habitats; and c) forest independent species: which occur mostly in open habitats. Analyses considering forest dependent species were restricted to this group, not including forest semi-dependent species. Species sequence and taxonomy follow Sick (1997).

The relationships between the number of species and between number of individuals and forest patch area and isolation were tested with multiple regressions (Ott, 1988).

Results

We banded 554 individuals of 67 species of birds (Table 2, Appendix), of which 20 species were forest dependent (185 individuals), 18 were forest semi-dependent (140 individuals), and 29 were forest independent (186 individuals).

Due to the small size of the forest patches sampled, it was expected that the cumulative diversity curves had flattened, especially at the smallest patches. Stabilization of these curves was not homogeneous among the patches independently of patch size (Figure 2), and more species are expected to be recorded in some of these forest patches (Ex. patches number 2, 5, 11, 12 and 13, Figure 2B, E, I, J, L). However, when only forest dependent species are considered, stabilization was more evident, and usually occurred at a much lower level, between 2 and 13 species (Figure 2) than the overall number of species.

The cumulative diversity curve for all sites together shows a stabilization indicating that, at the regional (whole park) level, few species captured in mist nets are to be added (Figure 3). This stabilization occurred for all species and also for forest dependent species alone.

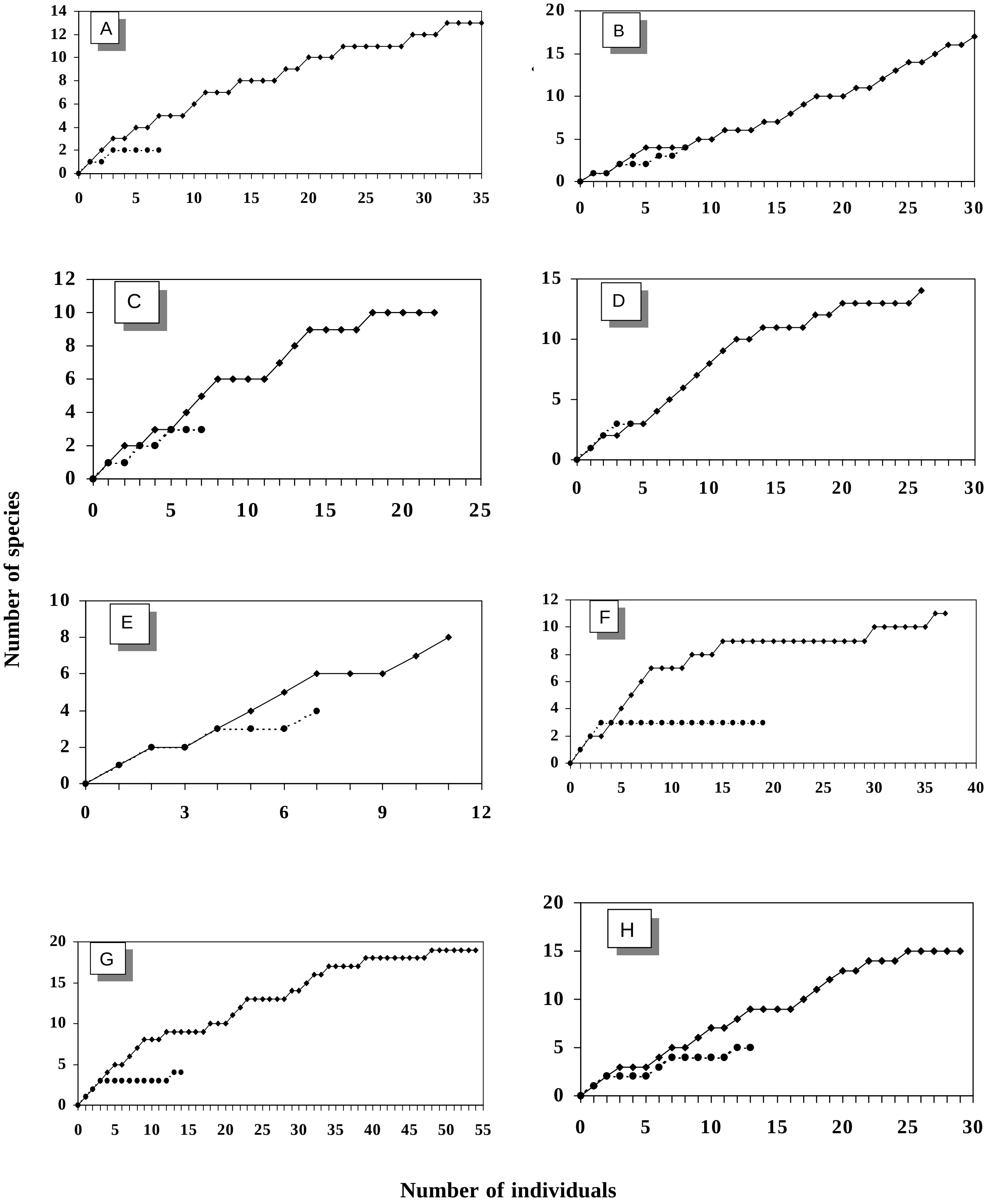
The relationship between the total number of species (r = 0.658; n = 12; p = 0.078) and the total number of individuals (r = 0.408; n = 12; p = 0.441) are not significantly related with area and isolation. However, when we consider only forest

Table 1 - Characteristics [area, straight distance to the nearest forest patch (m), distance to nearest forest patch through a corridor or a stream (m) and sampling effort] of the forest patches sampled in the Serra da Canastra National Park, MG, Brazil.

Patch group	Forest patch	Area (ha)	Straight distance (m)	Distance through corridor or stream (m)	Sampling effort (mist net/hour)
	1	0,09	400	600	302
	2	0,17	360	580	319
A	3	0,27	360	580	327
	4	0,16	400	720	318
	5	0,41	420	1180	300
	6	0,11	50	–	–
	7	0,05	50	–	–
B	8	0,39	67	–	–
	(6+7+8)	0,55	360	400	332
	9	0,60	360	400	322
	10	0,36	540	640	366
	11	1,02	660	700	319
C	12	1,01	280	320	306
	13	0,76	180	280	357
	14	0,53	180	280	378

Table 2 - Number of birds captured em each forest patch (and group) and at the corridor at the Parque Nacional da Serra da Canastra, MG, ordered by type or forest dependence.

Species	Group A					Group B			Group C				Corridor	Total
	1	2	3	4	5	6-8	9	10	11	12	13	14		
Leptotila rufaxilla						2		2				1		5
Scytalopus novacapitalis												1		1
Thamnophilus caerulescens					2		3		3	2	4	2	1	17
Dysithamnus mentalis									1	1				2
Conopophaga lineata										1	3	4		8
Lochmias nematura	2	1	1	1			1	1	1	1				9
Philydor dimidiatus											1			1
Elaenia obscura	5	3	4			13	9	7	5	2	1	4	3	56
Lathrotriccus euleri										2	1	2		5
Platyrinchus mystaceus										3	2	1		6
Leptopogon amaurocephalus										1	1		1	3
Phylloscartes ventralis										1	1	1		3
Antilophia galeata									1	1	5	8	1	16
Turdus subalaris								1						1
Basileuterus culicivorus		1		2	1				2	5	3	5	2	21
Basileuterus leucophrys		3	2		2	4	1	2	1		2			17
Basileuterus leucoblepharus				1	2					3	1	2		9
Tachyphonus coronatus										1	2			3
Pipraeidea melanonota									1					1
Tersina viridis													1	1
Total	7	8	7	4	7	19	14	13	15	24	27	31	9	185


A
B
C
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H
Number of species
Number of individuals

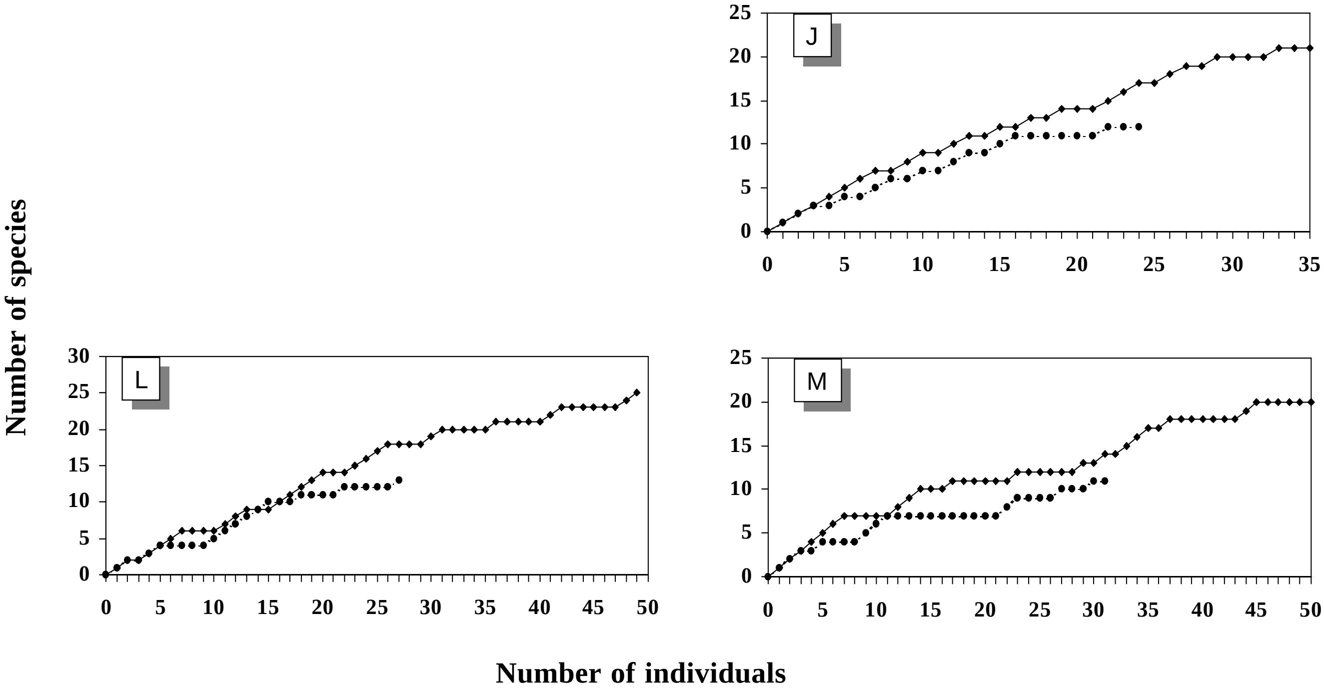
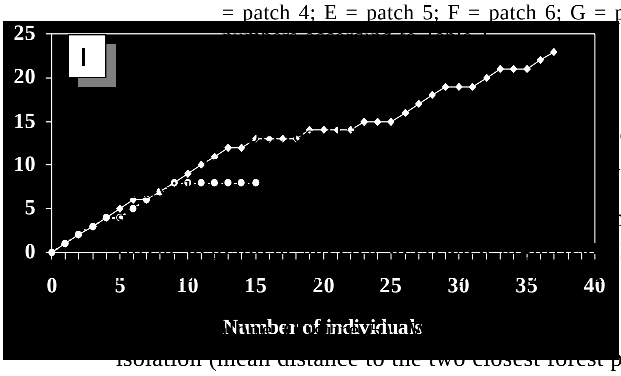


Figure 2 - Cumulative diversity curves of forest dependent (circles – interrupted line) and of all species (diamonds - continuous line) captured in each forest patch sampled at the Serra da Canastra National Park, Minas Gerais state, Brazil. A = patch 1; B = patch 2; C = patch 3; D = patch 4; E = patch 5; F = patch 6; G = patch 7; H = patch 8; I = patch 9; J = patch 10; L = patch 11; and M = patch 12). Patch



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isolation (mean distance to the two closest forest patches) is not correlated with forest patch area (r = -0.369; n = 12; p = 0.238).

Of the 20 forest dependent species captured only eight (40%) (*Leptotila rufaxilla*, *Thamnophilus caerulescens*, *Lochmias nematura*, *Elaenia obscura*, *Turdus subalaris*, *Basileuterus leucophrys*, *B. leucoblepharus*, and *B. culicivorus*) were recorded in forest patches smaller than 0.49 ha (mean area of the 12 forest patches). Also, only the same eight species mentioned above were recorded in forest patches not linked to other forest patches by corridors and isolated by at least 420 m (mean isolation distance for the 12 forest patches). However, three species (*Leptopogon amaurocephalus*, *Antilophia galeata*, and *Tersina viridis*) were captured in the corridor sampled but not is forest patches smaller than 0.49 ha. The other nine (45 %) forest dependent species (*Scytalopus novacapitalis*, *Dysithamnus mentalis*, *Conopophaga lineata*, *Philydor dimidiatus*, *Lathrotriccus euleri*, *Platyrinchus mystaceus*, *Phylloscartes ventralis*, *Tachyphonus coronatus*, and *Pipraeidea melanonota*) occurred only in patches that were larger or linked by corridors.

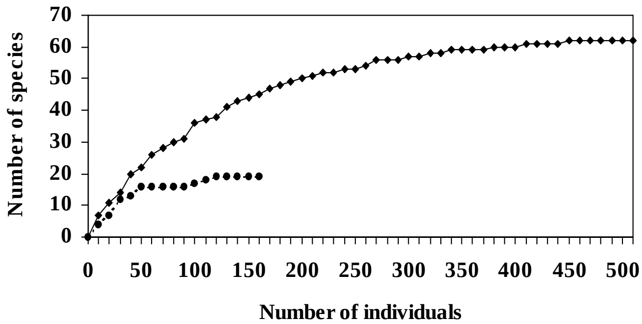

Figure 3 - Cumulative diversity curves of forest dependent (circles – interrupted line) and of all species (diamonds - continuous line) captured in all forest patches sampled at the Serra da Canastra National Park, Minas Gerais state, Brazil.

Discussion

The analysis with 12 forest patches revealed that for the overall bird community sampled with mist nets, the number of species and of individuals were not related with forest patch area and isolation. This is probably related to the presence of several forest independent species. However, contrary to the

Figure 4 - (a) Relationship between the number of forest dependent species (S) and forest patch area (ha); (b) Relationship between the residuals (species x area) and the mean distance to the two nearest forest patches (m). Letters represent forest patch groups (A, B, or C).

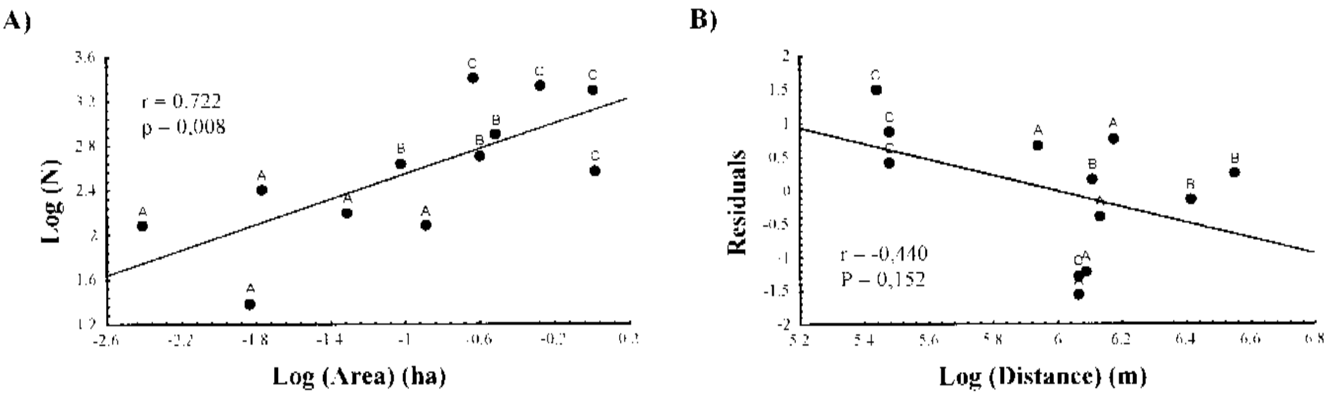

Figure 5 - (a) Relationship between the number of forest dependent individuals (I) and forest patch area (ha); (b) Relationship between the residuals (individuals x area) and the mean distance to the two nearest forest patches (m). Letters represent forest patch groups (A, B, or C).

analysis with all species, when only forest dependent species were considered, they were significantly affected by both forest patch area and isolation, suggesting that the distribution of these birds is highly related to forest patch area and is limited by dispersal ability. This agrees with the prediction that forest dependent species require larger patches of forest to survive, and have lower dispersal ability than forest semi-dependent or independent species. Blake & Karr (1984) studying fragments from 1.8 to 600 ha also found that birds of different forest dependence classes were affected differently by forest fragment area. Opdam *et al.* (1985) studying birds in fragments from 1 to 20 ha with different levels of isolation found an effect of isolation only for a selected number of forest dependent species. In a study conducted in forest fragments of the Triângulo Mineiro region, 200 Km west of PNSC, Marini (2001) showed that the proportion of forest-dependent species increased with fragment area, while that of semi-dependent species decreased, and the proportion of forest independent species did not change.

The positive relationship between of number of individuals of forest dependent species and area (Figure 5) suggests either that they are more abundant or that they have higher densities in the larger than in the smaller patches. Since the slope of the line in figure 3 is smaller than 45°, this represents that the density of birds in the larger forest patches is smaller than in the smaller patches (around 60 ind./ha in a 0,1 ha patch; 30 ind./ha in a 0,5 ha patch; and 23 ind./ha in a 1,0 ha patch). This very high density of birds in the very small patches may indicate that these patches have a high density of resources or that birds can explore the open areas around the forest patches while residing in it.

According to Offerman *et al.* (1995), Machtans *et al.* (1996) and Gascon *et al.* (1999), the use of the matrix that surrounds fragments may help explain the variety of responses by different species to fragmentation, with species that tolerate the matrix also being tolerant to the fragmentation of their habitat. This occurs because the forest independent species may use habitats around the fragments, making easier to move between them. As forest dependent species may not use or use less the matrix, and become more restricted to a single or a few forest patches, they require larger forest patches to survive. During this study, several bird movements were recorded between forest patches (Andrade & Marini, 2001), both of forest dependent and other species.

As expected, most forest dependent species were recorded only in the larger and less isolated forest patches. However, some individuals of some species (*Thamnophilus caerulescens*, and *Basileuterus leucophrys*) were also found in the very small (0.05 ha) or most isolated (430 to 660 m) patches. This fact may be related to an adaptation of these species to the naturally fragmented landscape, since this is a landscape which have not been altered considerably at least since the early 1800's.

Some of our cumulative diversity curves did not stabilize completely with our sample efforts, what may be common in areas with a high influence of species from other habitats. In a point-count study conducted in Atlantic forest fragments near Viçosa, Minas Gerais state, Ribon (1998) also detected non-stabilization of cumulative diversity curves of small fragments (< 20 ha). He suggested that this pattern is related to the occurrence of forest semi-dependent species with a high ability to move between fragments. This influence of the semi-dependent species does not exist when only forest dependent species are analyzed. In this case, the curves stabilized sooner and at a lower species level, indicating that most sampling efforts were enough to detect most forest dependent species. The cumulative diversity curves for all patches (Figure 3) showed that the sampling effort was appropriate to estimate the richness of birds at the regional level. However, one forest dependent species was recorded only once in the corridor (*Tersina viridis*) (Table 2), and another (*Schiffornis virescens*) was recorded in a larger fragment away from the fragments of this study (pers. obs.). Our data suggests that the community of understory forest dependent birds inhabiting forest patches of the Park is close to 20 species.

A problem which is a concern for studies of species-area relationship (Beier & Noss 1998) is that the smaller fragments are also more isolated from larger fragments and sometimes closer to farms and cities than the larger fragments connected by corridors. This association also occurred at our study sites, since the larger forest patches where usually connected to other patches by natural vegetation corridors (ex. group C). These corridors probably did not increase much the area of the fragments since they were usually narrow and with small trees, but they may facilitate the movement of individuals between forest patches (Andrade & Marini, 2001).

We showed that forest dependent species of birds benefited from the presence of larger and less isolated forest patches in the region. The presence of these species in these relatively small-sized forest patches (< 1 ha) is probably the result of behavioral adaptations to move between forest patches in this landscape. Our results showed that this natural landscape of small and isolated forest patches imbedded in a grassland matrix may support populations of several forest-dependent species of birds, increasing the regional biodiversity. The conservation of these small forest patches is also important for non-forest birds which used the patches probably for foraging and for protection against predators. Several arguments have already been raised stressing the importance of small forest fragments (Turner & Corlett, 1996) and management and conservation policies in the region should give special attention to these small (< 1 ha) forest patches.

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Appendix - Number of forest semi-dependent and independent birds captured at the Parque Nacional da Serra da Canastra, MG.

Species	Number of individuals
Forest semi-dependent	
Coccyzus melacoryphus	1
Thalurania furcata	6
Colibri serrirostris	6
Phaethornis pretrei	5
Chlorostilbon aureoventris	1
Chloroceryle americana	2
Picumnus cirratus	9
Veniliornis passerinus	2
Synallaxis spixi	24
Phacellodomus rufifrons	4
Myiarchus ferox	25
Todirostrum cinereum	16
Serpophaga subcristata	2
Elaenia flavogaster	3
Turdus leucomelas	22
Thraupis sayaca	1
Dacnis cayana	1
Saltator similis	10
Subtotal	**140**

Species	Number of individuals
Forest independent	
Eupetomena macroura	1
Lepidocolaptes angustirostris	2
Myiophobus fasciatus	29
Serpophaga nigricans	8
Knipolegus lophotes	5
Culicivora caudacuta	2
Elaenia chiriquensis	2
Alectrurus tricolor	1
Tyrannus melancholicus	1
Elaenia sp.	5
Myiarchus sp.	1
Stelgidopteryx ruficollis	7
Troglodytes aedon	3
Schistochlamys ruficapillus	28
Tangara cayana	15
Geothlypis aequinoctialis	10
Emberizoides herbicola	9
Embernagra platensis	4
Sicalis citrina	3
Volatinia jacarina	3
Zonotrichia capensis	3
Amnodramus humeralis	21
Sporophila nigricollis	4
Sporophila caerulescens	1
Sporophila plumbea	1
Porphyrospiza caerulescens	1
Sporophila sp.	5
Gnorimopsar chopi	6
Carduelis magellanicus	5
Subtotal	**186**