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Influence of the size and degree of conservation of remnants of the Atlantic rain forest on chiropteran assemblages

Influência do tamanho e da conservação de remanescentes de mata atlântica sobre assembleias de quirópteros

Daniel Paulo de Souza **PIRES**[1, 3] & Cristina Vargas **CADEMARTORI**[2,3]

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ABSTRACT
Reduction in the size and loss of the quality of habitats are considered the greatest threats to bat species. Aiming to complement information, the objective of this study was to evaluate, from compiled data, the influence of the size of forest fragments and their degree of conservation on the richness and composition of chiropteran fauna in the Atlantic rain forest. A total of 33 publications on Chiroptera in the Atlantic rain forest was reviewed and a list of 86 species was extracted from them. The size of forest fragments exhibited positive and significant relationship with the total number of Relatively Common Species, Rare Species, Not Generalist species and with richness. Positive and significant relationship was observed between degree of conservation of the forest fragments and the total number of Rare Species, of Not Generalist species and with richness. The results here presented indicate that large and well-conserved fragments of Atlantic rain forest should be the priority when the intention is to maintain a high richness of Chiroptera and of Rare Species and Not Generalist Species.
Keywords: bats; forest fragmentation; habitat quality; species richness.

RESUMO
A redução e a perda da qualidade do hábitat são consideradas as maiores ameaças às espécies de morcegos. Visando complementar informações, o objetivo deste trabalho foi avaliar, mediante dados compilados, a influência do tamanho e do grau de conservação dos fragmentos florestais sobre a riqueza e a composição da fauna de quirópteros na mata atlântica. Foram revisadas 33 publicações sobre quirópteros na mata atlântica, com base nas quais se obteve a relação de 86 espécies. O tamanho dos fragmentos mostrou relação positiva e significativa com o total de espécies relativamente comuns, espécies raras, espécies não generalistas e com a riqueza em geral. Encontrou-se, também, relação positiva e significativa entre o estado de conservação dos fragmentos florestais e o total de espécies raras, assim como entre o total de espécies não generalistas e a riqueza. Os resultados aqui apresentados indicam que um fragmento florestal grande e conservado na mata atlântica deve ser prioridade quando se pretende manter uma alta riqueza de quirópteros, bem como de espécies raras e de espécies não generalistas.
Palavras-chave: fragmentação florestal; morcegos; qualidade do hábitat; riqueza de espécies.

[1] Conselho Regional de Biologia 3.ª Região, Setor de Fiscalização, Rua Coronel Corte Real, n. 662 – CEP 90630-080, Petrópolis, RS, Brasil.

[2] Universidade La Salle (Unilasalle), Canoas, RS, Brasil.

[3] Corresponding author: pires.daniel@yahoo.com.br.

INTRODUCTION

Currently, reductions of the size and loss of the quality of habitats are considered the greatest threats to bat species, this situation meaning that it is necessary to conduct supplementary studies of their interactions with the environment, in order to obtain fuller documentation (RACEY & ENTWISTLE, 2003). Although Neotropical bats have great mobility, great tolerance, easiness to adapt and to exploit environments that have been altered by humans, these animals appear to be sensitive to the loss and fragmentation of their natural habitats (ESTRADA & COATES-ESTRADA, 2002). Factors such as the size of forest fragments and their degree of conservation impact mammal species that inhabit the Atlantic rain forest, including chiropteran species (VIEIRA *et al*., 2003).

The process of fragmentation of forests in this biome has a direct effect on the diversity of bats, both in terms of the abundance of individuals and in terms of species composition and richness (GRUENER *et al*., 2012). However, while it is known that fragmentation has an impact, there is still uncertainty about how the degree of conservation and the size of forest fragments affect abundance, richness and other ecological features of chiropteran fauna in forest environments (NOVAES *et al*., 2014). From the perspective of conservation biology, there is no definitive consensus about the characteristics that a given landscape should offer to conserve the greatest number of chiropteran species as information on ecological conservation is still incomplete for many bat species (RACEY & ENTWISTLE, 2003).

Even though forest fragmentation in the Atlantic rain forest has been increasing, and particularly so over recent years (MMA, 2016), there are few studies that have attempted to demonstrate how the size of a forest fragment and its degree of conservation influence the diversity of Chiroptera in this biome. The major part of studies that do exist consist of inventories comparing the communities in different fragments, some authors having investigated relationships between area, state of conservation of Atlantic rain forest fragments and species richness and abundance of Chiroptera (REIS *et al*., 2000; ESBÉRARD, 2003; REIS *et al*., 2003; MELLO & SCHITTINI, 2005; FARIA, 2006; REIS *et al*., 2006; GRUENER *et al*., 2012). However, these studies are localized, unconnected, many of them contradictory to each other and do not reveal any overall pattern or cause-effect relationship between the variables.

In this scenario, recognizing the patterns and characteristics that could offer a contribution to a better selection of conservation areas for chiropteran species, particularly in the Atlantic rain forest, should be a priority, since this biome, in addition to having been reduced to less than 8% of its original area, has become intensely fragmented (SILVA & CASTELETI, 2003; MMA, 2016).

In recognition of this, this study was undertaken aiming to assess, based on secondary data, the influence of size and degree of conservation of Atlantic rain forest fragments on the richness and abundance of chiropteran fauna.

MATERIAL AND METHODS

Data on bat species richness and abundance and on the state of conservation and size of forest fragments were obtained from published studies from 1995 to 2015. Articles and books, printed or available online and in university databases, were used as sources of the analyzed information.

Four criteria were applied to select these studies: 1) the Atlantic rain forest was the study area; 2) mist nets were the capture method; 3) sampling efforts encompassed at least 1 year; 4) the distinct sites were conducted with a minimum of 10 kilometers between them. For studies conducted in more than one fragment and with distances between them less than 10 km, each group of such fragments was considered as a single unit with a total size equivalent to the sum of the areas of all of the fragments composing the unit. The fragment area considered for the analysis was therefore the total area of the study sites described in the consulted source, even if sampling had only been conducted in part of the forest remnant.

The degree of conservation of the study areas was assessed using a descending scale, provided with descriptions of the areas, available in the consulted sources and scored as follows: (5) primarily conserved, (4) primarily and secondarily conserved (mixed area with both successional stages), (3) primarily disturbed, (2) secondarily conserved, (1) secondarily disturbed. Areas with primary forest are those that have suffered little human interference and maintain their original characteristics, whereas secondary areas are forest environments that are in regeneration after exploitation in the past. Both types of vegetation, primary and secondary, were classified according to the their disturbance degree (high or low) and by co-occurrence in the same study area. The classification of the disturbance degree was based on a set of factors related to the area described in each publication, such as edge effects, understorey conservation, vegetation extraction, invasive or exotic species presence, hunting intensity, fire occurrence and human presence, which is a method adapted from Magnus and Cáceres (2012).

Species were classified according to their degree of occurrence, by the calculation of the Constancy Index (adapted from DAJOZ, 1983) for each of the species recorded in the publications reviewed. Species with more than 50% occurrence in the entire set of publications, i.e., those recorded/ found with greater frequency in the studies, were classified as Common Species (CS), those with occurrence from 25% to 49% of the studies as Relatively Common Species (RCS) and those with less than 25% occurrence, i.e., those recorded/ found with low frequency in the studies, as Rare Species (RS).

Species were also classified in terms of how selective they were in terms of habitats requirements. Species with more than 50% of records were defined as Generalist Species (GS), i.e., species that are not highly selective in terms of habitat use, that occupy a variety of different habitats and are more tolerant of environmental impacts, and those with less than 50% were defined as Not Generalist Species (NGS), i.e., species that are more selective in terms of habitat use and are less tolerant of environmental impacts. The percentage of occurrence of each species was the ratio between the number of publications in which the species was recorded and the total number of publications reviewed.

The relationships (influence) between fragment size, state of conservation, richness and composition of chiropteran species were analyzed using multivariate regression, in which the predictive (independent) variables were the degree of conservation of the fragment (DC) and its size (FS) in hectares. The outcome (dependent) variables observed were species richness (R) and Constancy (Common Species – CS, Relatively Common Species – RCS, or Rare Species – RS) and how selective of habitats they were (generalist – GS or not generalist – NGS). When parameters of p regressions are estimated as a whole by multivariate regression, a gain in the efficiency of estimators is obtained. However, this analysis also verifies p of each regression separately. In order to smooth out variations and achieve a linear curve, variables were log-transformed so that they met the prerequisites for the test. Analyses were conducted using PAST 3.12 (HAMMER *et al*., 2001).

RESULTS

A total of 33 publications on Chiroptera in the Atlantic rain forest was reviewed (table 1) and, from these publications, a list of 86 species was compiled (table 2). Eight (9%) of these species were considered Common Species (CS), 13 (15%) Relatively Common Species (RCS) and 65 (76%) Rare Species (RS). Nine (10%) species were classified as Generalists (GS) and 77 (90%) as Not Generalists (NGS).

Table 1 – List of publications on Chiroptera in the Atlantic rain forest, in chronological order of publication. DC (Degree of Conservation of the fragment, on a scale of 1 to 5 from lesser to greater degree of conservation); FS (Fragment Size in hectares); R (species Richness); CS (Common Species); RCS (Relatively Common Species); RS (Rare Species); GS (Generalist Species); NGS (Not Generalist Species).

Source	DC	FS	R	CS	RCS	RS	GS	NGS
Sipinski & Reis (1995)	5	1186	14	5	4	6	6	9
Reis *et al*. (1999)	4	11116	14	4	5	5	5	9
Pedro *et al*. (2001)	4	2178	20	7	6	6	10	10
Esbérard (2003)	2	3300	40	7	10	22	9	31
Passos *et al*. (2003)	4	41700	21	7	7	8	8	13
Bianconi *et al*. (2004)	1	863	14	5	5	4	6	8
Esbérard *et al*. (2006)	4	17400	36	7	11	17	9	27
Barros et al. (2006)	1	89	7	7	3	0	5	2
Faria (2006)	4	15000	38	7	6	25	7	31
Arnone & Passos (2007)	2	337	15	7	6	4	6	9
Moratelli & Peracchi (2007)	2	10653	16	7	6	3	8	8
Fogaça & Reis (2008)	1	118,5	12	4	7	1	5	7
Zanon & Reis (2007)	2	3,6	12	7	3	2	8	4
Dias & Peracchi (2008)	4	26000	28	8	8	12	9	19
Carvalho *et al*. (2009)	1	30	9	4	3	2	5	4
Ortêncio-Filho & Reis (2009)	1	25	17	7	5	5	8	9
Mello (2009)	2	6100	14	6	4	4	6	8
Oprea *et al*. (2009)	3	1500	14	6	4	4	7	7
Nobre *et al*. (2009)	4	10000	15	7	4	4	10	5
Brito *et al*. (2010)	2	40	10	6	3	1	7	3
Lourenço *et al*. (2010)	4	42000	34	7	12	15	8	26
Rocha *et al*. (2010)	1	72	18	6	4	8	7	11
Weber *et al*. (2011)	2	400	9	5	1	3	6	3
Peracchi *et al*. (2011)	3	22000	12	0	2	10	0	12
Silveira *et al*. (2011)	2	987	8	6	1	1	6	2
Brito & Bocchiglieri (2012)	4	1520	14	6	2	6	7	7
Bernardi & Passos (2012)	1	80	15	5	5	5	5	10
Pires & Fabián (2013)	2	1259	9	5	2	2	6	3
Esbérard *et al*. (2013)	2	350	28	7	10	11	8	20
Pires *et al*. (2014)	2	140	9	5	3	1	6	3
Gomes *et al*. (2014)	2	914	18	7	6	5	7	11
Novaes *et al*. (2014)	2	350	16	7	7	2	8	8
Miranda & Zago (2015)	4	41	10	3	2	5	3	7

Table 2 – List of chiropteran species recorded in the 33 publications resulting from studies undertaken in the Atlantic rain forest from 1995 to 2015. AO (absolute occurrence); % (percentage occurrence); C (Constancy: CS = Common Species; RCS = Relatively Common Species, RS = Rare Species); Type (GS = Generalist Species; NGS = Not Generalist Species).

Family / Species	**AO**	**%**	**C**	**Type**
Emballonuridae				
Peropteryx macrotis (Wagner, 1843)	3	9%	RS	NGS
Rhynchonycteris naso (Wied-Neuwied, 1820)	1	3%	RS	NGS
Saccopteryx bilineata (Temminck, 1838)	1	3%	RS	NGS
Saccopteryx leptura (Schreber, 1774)	3	9%	RS	NGS
Phyllostomidae				
Anoura caudifer (E. Geoffroy, 1818)	15	45%	RCS	NGS
Anoura geoffroyi Gray, 1838	14	42%	RCS	NGS
Artibeus fimbriatus Gray, 1838	25	76%	CS	GS
Artibeus jamaicensis Leach, 1821	7	23%	RS	NGS
Artibeus lituratus (Olfers, 1818)	29	94%	CS	GS
Artibeus obscurus (Schinz, 1821)	15	45%	RCS	NGS
Artibeus planirostris (Spix, 1823)	6	18%	RS	NGS
Carollia brevicauda (Schinz, 1821)	1	3%	RS	NGS
Carollia perspicillata (Linnaeus ,1758)	25	76%	CS	GS
Chiroderma doriae Thomas, 1891	9	27%	RCS	NGS
Chiroderma villosum Peters, 1860	7	21%	RS	NGS
Choeroniscus minor (Peters, 1868)	1	3%	RS	NGS
Chrotopterus auritus (Peters, 1856)	14	42%	RCS	NGS
Desmodus rotundus (É. Geoffroy, 1810)	23	70%	CS	GS
Diaemus youngi (Jentink, 1893)	3	9%	RS	NGS
Diphylla ecaudata Spix, 1823	5	15%	RS	NGS
Dermanura cinerea (Gervais, 1856)	8	24%	RS	NGS
Dermanura gnoma Handley, 1987	1	3%	RS	NGS
Glossophaga soricina (Pallas, 1766)	19	58%	CS	GS
Glyphonycteris sylvestris Thomas, 1896	1	3%	RS	NGS
Lampronycteris brachyotis (Dobson, 1879)	1	3%	RS	NGS
Lichonycteris obscura Thomas, 1895	1	3%	RS	NGS
Lonchophylla bokermanni Sazima, Vizotto & Taddei, 1978	5	15%	RS	NGS
Lonchophylla mordax Thomas, 1903	3	9%	RS	NGS
Lonchorhina aurita Tomes, 1863	1	3%	RS	NGS
Lophostoma brasiliense Peters, 1866	1	3%	RS	NGS
Lophostoma silvicola d'Orbigny, 1836	1	3%	RS	NGS
Macrophyllum macrophyllum (Schinz, 1821)	1	3%	RS	NGS
Micronycteris hirsuta (Peters, 1869)	1	3%	RS	NGS
Micronycteris megalotis (Gray, 1842)	8	24%	RCS	NGS
Micronycteris microtis Miller, 1898	6	18%	RS	NGS
Micronycteris minuta (Gervais, 1856)	4	12%	RS	NGS
Micronycteris schmidtorum Sanborn, 1935	1	3%	RS	NGS
Mimon bennetti (Gray, 1838)	5	15%	RS	NGS
Mimon crenulatum (É. Geoffroy, 1803)	2	6%	RS	NGS
Phylloderma stenops (Peters, 1865)	2	6%	RS	NGS
Phyllostomus discolor (Wagner, 1843)	7	21%	RS	NGS

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Continuação da tabela 2

Family / Species	**AO**	**%**	**C**	**Type**
Phyllostomus elongatus (É. Geoffroy, 1810)	1	3%	RS	NGS
Phyllostomus hastatus (Pallas, 1767)	11	33%	RCS	NGS
Platyrrhinus lineatus (É. Geoffroy, 1810)	18	55%	CS	GS
Platyrrhinus recifinus (Thomas, 1901)	9	27%	RCS	NGS
Pygoderma bilabiatum (Wagner, 1843)	20	61%	CS	GS
Rhinophylla pumilio Peters, 1865	1	3%	RS	NGS
Sturnira lilium (É. Geoffroy, 1810)	31	94%	CS	GS
Sturnira tildae de la Torre, 1959	3	9%	RS	NGS
Tonatia bidens (Spix, 1823)	6	18%	RS	NGS
Tonatia saurophila Koopman & Williams, 1951	3	9%	RS	NGS
Trachops cirrhosus (Spix, 1823)	6	18%	RS	NGS
Trinycteris nicefori Sanborn, 1949	2	6%	RS	NGS
Uroderma magnirostrum Davis, 1968	3	9%	RS	NGS
Uroderma bilobatum Peters, 1866	2	6%	RS	NGS
Vampyressa pusilla (Wagner, 1843)	11	33%	RCS	NGS
Vampyrodes caraccioli (Thomas, 1889)	2	6%	RS	NGS
Noctilionidae				
Noctilio albiventris Desmarest, 1818	3	9%	RS	NGS
Noctilio leporinus (Linnaeus, 1758)	7	21%	RS	NGS
Furipteridae				
Furipterus horrens (Cuvier, 1828)	2	6%	RS	NGS
Molossidae				
Cynomops abrasus (Temminck, 1827)	3	9%	RS	NGS
Cynomops planirostris (Peters, 1866)	3	9%	RS	NGS
Eumops auripendulus (Schaw, 1800)	1	3%	RS	NGS
Molossops neglectus Williams & Genoways, 1980	2	6%	RS	NGS
Molossus molossus (Pallas, 1766)	16	48%	RCS	NGS
Molossus rufus É. Geoffroy, 1805	9	27%	RCS	NGS
Nyctinomops aurispinosus (Peale, 1848)	1	3%	RS	NGS
Nyctinomops laticaudatus (É. Geoffroy 1805)	2	6%	RS	NGS
Nyctinomops macrotis (Gray, 1840)	3	9%	RS	NGS
Tadarida brasiliensis (I. Geoffroy, 1824)	1	3%	RS	NGS
Vespertilionidae				
Eptesicus brasiliensis (Desmarest, 1819)	5	15%	RS	NGS
Eptesicus diminutus Osgood, 1915	5	15%	RS	NGS
Eptesicus furinalis (d'Orbigny, 1847)	5	15%	RS	NGS
Eptesicus taddeii Miranda, Bernardi & Passos, *2006*	2	6%	RS	NGS
Histiotus montanus (Philippi & Landbeck, 1861)	2	6%	RS	NGS
Histiotus velatus (I. Geoffroy, 1824)	6	18%	RS	NGS
Lasiurus blossevillii (Lesson & Garnot, 1826)	10	30%	RCS	NGS
Lasiurus cinereus (Palisot de Beauvois, 1796)	1	3%	RS	NGS
Lasiurus ega (Gervais, 1856)	7	21%	RS	NGS
Myotis albescens (É. Geoffroy, 1806)	3	9%	RS	NGS
Myotis levis (I. Geoffroy, 1824)	7	21%	RS	NGS
Myotis nigricans (Schinz, 1821)	27	82%	RCS	GS
Myotis riparius (Handley, 1960)	8	24%	RS	NGS
Myotis ruber (É. Geoffroy, 1806)	9	27%	RS	NGS

Multivariate regression analysis revealed a significant relationship between the dependent variables bat species richness and composition and the size and state of conservation of the forest fragment (F: 3,01; p = 0,003). A positive and significant relationship (figure 1) was detected between the degree of conservation of the area and total Rare Species, with total Not Generalist Species and with Richness (RS: r^2 = 0.170; p = 0.010; NGS: r^2 = 0.129; p = 0.039; R: r^2 = 0.130; p = 0.038). Non-significant relationships were detected with total Common Species, Relatively Common Species, and Generalist Species (CS: r^2 = 0.002; p = 0.770; RCS: r^2 = 0.035; p = 0.292; GS: r^2 = 0.19; p = 0.270).

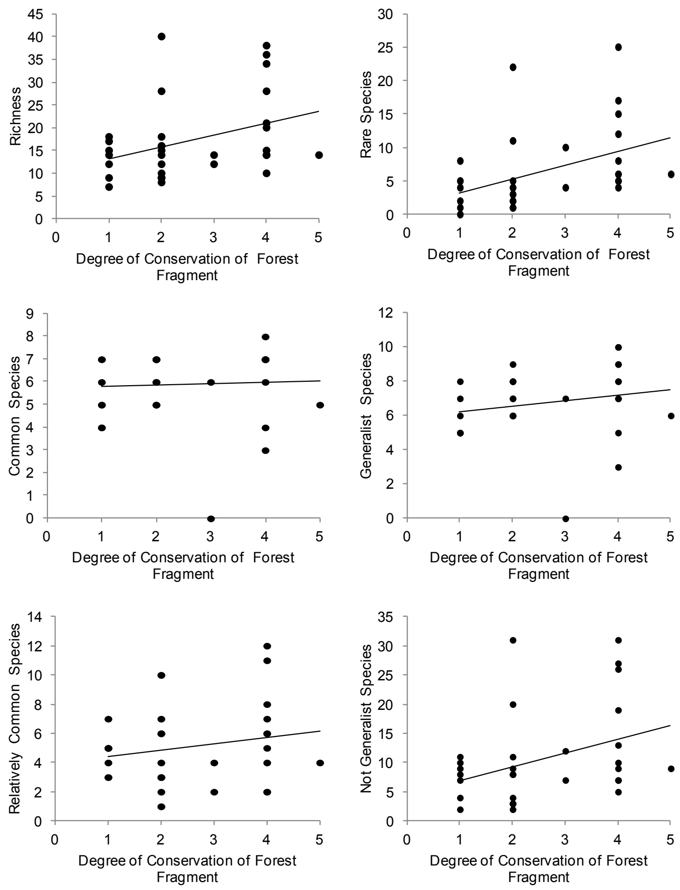

Figure 1 – Relationships between the conservation degree of the forest fragment (on a scale of 1 to 5 from lesser to greater degree of conservation) and Richness (R), Common Species (CS), Relatively Common Species (RCS), Rare Species (RS), Generalist Species (GS), and Not Generalist Species (NGS) of Chiroptera in the results of 33 studies undertaken in fragments of Atlantic rain forest from 1995 to 2015.

The results for fragment size (figure 2) revealed positive and significant relationships with total Relatively Common Species, Rare Species, Not Generalist Species, and Richness (RCS: r^2 = 0.232; p = 0.004; RS: r^2 = 0.239; p = 0.003; NGS: r^2 = 0.232; p = 0.004; R: r^2 = 0.271; p = 0.002).

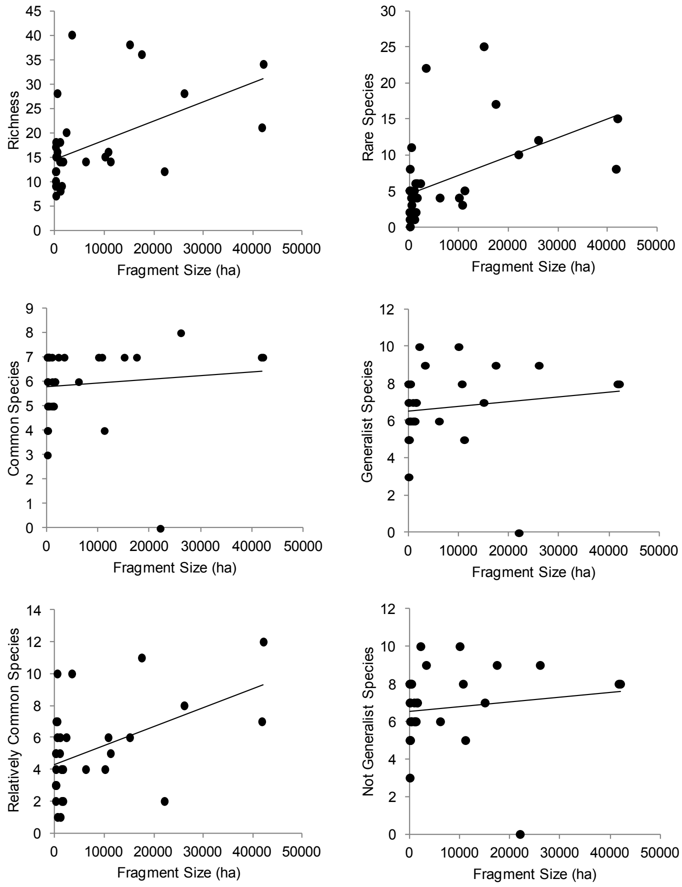

Figure 2 – Relationships between fragment size and Richness (R), Common Species (CS), Relatively Common Species (RCS), Rare Species (RS), Generalist Species (G), and Not Generalist Species (NGS) of Chiroptera in the results of 33 studies undertaken in Atlantic rain forest fragments from 1995 to 2014.

DISCUSSION

The results of this study show that the size of a fragment and its degree of conservation influence the richness and composition of species of Chiroptera in Atlantic rain forest. The total species richness recorded in different fragments of the Atlantic rain forest had a positive relationship with both the size of the forest fragments and their state of conservation.

However, some inventories that were conducted in very close fragments of varying sizes showed little association between richness and the size of the fragment, illustrating similar richness levels for small and large fragments (BIANCONI *et al*., 2004; BARROS *et al*., 2006; FARIA, 2006; NOVAES *et al*., 2014). This depicts that bats can use small fragments with low levels of conservation as "stepping stones" when moving about, giving a false impression that they are able to live in these habitats (ESTRADA & COATES-ESTRADA, 2002).

Although many species of bats are tolerant to forest fragmentation and impoverishment of habitat quality, large and well-conserved fragments exhibit a considerably richer chiropteran fauna because of the greater complexity of vegetation and the consequently greater variety of food resources (fruit, pollen, nectar, insects, other animals) and availability of refuges. These characteristics make it easier for bats to establish themselves and remain in these environments than in degraded and isolated areas (ESTRADA *et al*., 1993).

Vieira *et al*. (2003) claim that the positive relationship between richness and fragment size is primarily seen when large areas are taken into account (> 1,000 ha) and that this correlation disappears when only small fragments (< 100 ha) are taken into account. The pattern observed in this study, of increasing species richness as fragment size increases, may have been influenced by this fact, since areas of different sizes (both large and small) were included in the analysis. The previous authors also point out that, taken together, small fragments may even contain higher numbers of species than larger areas of forest that are continuous and in better states of conservation, because of occurrence of species from open or disturbed areas at the edges of fragments. Notwithstanding, edge effects may have greater impact on smaller fragments, contributing to lower total species richness (FARIA, 2006).

Considering the results of this study about the rarity of species, it can be stated that certain bat species are recorded less than others in inventories conducted in the Atlantic rain forest and that few individuals from these species are captured. In general, it can be stated that Rare and Not Generalist Species occur in better conserved and larger fragments, which is a pattern that has been observed in several different studies (PASSOS *et al*., 2003; ESBÉRARD *et al*., 2006; FARIA, 2006; DIAS & PERACCHI, 2008; LOURENÇO *et al*., 2010; BRITO & BOCCHIGLIERI, 2012). Complementing this, Racey & Entwistle (2003) state that Rare Species tend to be less recorded in impacted areas, showing that such species are positively correlated with better quality environments. Along these lines, it is worth noting that Mello & Schittini (2005) sampled three conservation units of different sizes and found that even when they are much larger than more conserved areas, disturbed habitats can still exhibit lower richness and diversity and harbor assemblages comprising Generalist Species.

Species considered common and generalists in this study are those that are known for their tolerance and ability to adapt to impacts caused by human activity (REIS *et al*., 2007). This pattern can be easily discerned in all of the publications reviewed in this study, in which these species exhibited greater numbers of captures and were part of the majority of assemblages inventoried in disturbed and fragmented environments with considerable human presence throughout the area of distribution of the Atlantic rain forest biome. In turn, species considered relatively common comprise a category that is slightly more demanding in terms of habitat, containing species that are less tolerant to environmental changes and are not easy to capture using mist nets at ground level, such as the high-flying insectivorous species (KALKO *et al*., 2008).

The majority of the recorded species were considered rare and not generalist, suggesting that they are members of a category of more selective species, whose occurrence is dependent on certain specific characteristics of habitat or which are naturally rare. However, some of these species, such as *Eptesicus brasiliensis* and *Tadarida brasiliensis* for instance, are known for their great capacity to adapt to the presence of humans, for the formation of large colonies in cities and are not associated with forest environments (GARDNER, 2007). The inventories conducted in different sites in the Atlantic rain forest that were reviewed for this study and which recorded *Eptesicus brasiliensis* and *Tadarida brasiliensis* confirm their low levels of occurrence in forests, when compared with urban centers.

Although larger and more conserved fragments are closer to the ideal for the settlement of greater numbers of chiropteran species, small portions may also be essential in scenarios in which the surrounding matrix is important for bats moving, which may utilize all parts of a divided landscape for foraging, turning both small and large remnants necessary (ESTRADA & COATES-ESTRADA, 2002). Gorrensen & Willig (2004) demonstrated that variations in richness in relation to patch size can be significant and positive for some species and significant and negative for others and that small and isolated patches may have higher species richness than large and well-conserved landscapes. Nevertheless, they point out that for rarer and more selective species, less disturbed environments are more important and appropriate.

According to Faria (2006), the positive relationship between richness and habitat conservation state may be linked to a greater stratification of the habitat. The same author also points out that richness may be reduced in habitats in which there are fewer trees with thick trunks, a less dense upper strata and reduced density foliage in the understorey. In modified environments such as stretches at the edges of fragments and in secondary forests or scrub that have a reduced number of trees with thick trunks, less dense upper strata and reduced density foliage in the understorey, the abundance, diversity and richness of bat species also tend to be reduced (VIEIRA *et al*., 2003). So, the degree of conservation and size of remnants are not the only factors that can affect the richness and composition of bat species. Ecological agents are also important, such as those associated with the structure of the vegetation, vertical stratification, vegetation density and availability of food.

Predators and competitors should also be considered as possible determinant factors of variations in richness and composition of species (VIEIRA *et al.*, 2003).

The results presented in this study show that common and generalist bat species are well-established and capable of occupying small and disturbed fragments of Atlantic rain forest, although they are also frequently found in larger and more conserved remnants. In contrast, the rarer species and those that are more selective in terms of habitat quality are found in large and well-conserved forest fragments and disturbed and smaller patches are less favorable to colonization by these species. The results of this study confirm the hypothesis that richness and composition of chiropteran species are directly affected by forest fragmentation. Large and conserved forest fragments in the Atlantic rain forest should be the priority in attempts to maintain a high richness of Chiroptera and Rare and Not Generalist Species.

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