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Patch size effects on richness, abundance, and diversity of leaf-litter lizards from Atlantic rainforest fragments

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Abstract. In order to analyse the implications of forest fragmentation for the conservation of leaf-litter lizards, the importance of fragment size was examined at 21 forest sites within a continuous forest on the Atlantic Plateau of São Paulo state, southeastern Brazil. The fragments were 7–43 ha in size and had different percentages of habitat loss (37–95%). The species recorded, with the exception of *Enyalius iheringii*, presented low abundance, which may indicate their unsuitability for occupation or lizard inability to recolonize isolated remnants. Our results suggest that the conservation of these leaf-litter lizards depends on the maintenance of large portions of continuous forests and not on the size of remnant patches.

Key words. Atlantic Rainforest, conservation, fragmentation, Squamata, South America, southeastern Brazil.

Introduction

The fragmentation of natural ecosystems is one of the major consequences of high levels of anthropic disturbance (Viana & Pinheiro 1998, Zanella 2011). In the Atlantic Rainforest, most forest remnants, especially those located in intensively cultivated landscapes, are small, highly disturbed, isolated, little known, and unprotected patches (Fonseca 1985, Viana 1995, Morellato & Haddad 2000, Ribeiro et al. 2009). This biome has high levels of biological diversity and endemism and is among the most seriously threatened hotspots in the world (Myers et al. 2000). Currently, it is reduced to about 11% of its original cover (Ribeiro et al. 2009).

A total of 248 species of lizards are currently known from Brazil (Bérnils & Costa 2012), with 87% of these being found in the Atlantic Forest. In the state of São Paulo, which includes phytophysiognomies typical of Cerrado in addition to the Atlantic Rainforest biome, the group is represented by about 212 species (Zaher et al. 2011).

The effects of fragmentation sensu lato, reduction of patches, and degree of isolation are still little known to the herpetofauna, especially in Brazil (Dixo 2005), and they may contribute to the decline of reptile populations (Gibbons et al. 2000, Araújo et al. 2006, Dixo & Verdade 2006, Hawlena et al. 2010). In a study conducted by Dixo & Metzger (2009) in Caucaia do Alto (Estado São Paulo = SP), lizards responded negatively to fragmentation by presenting a lower richness in the patches compared to other forested areas of the Atlantic Plateau of São Paulo (Cotia/Ibiuna). Variations in the richness and abundance of lizards in fragmented landscapes depend on structure characteristics, in particular the size of patches, as well as intrinsic characteristics of the habitat (Dixo & Metzger 2009). Not only is the size of a protected area critical for maintaining species abundance and richness, but also the shape of the remnant patches and the microclimatic conditions that it provides (Vallan 2000, Michael et al. 2010).

The few existing studies on reptiles, especially lizards, provide only an idea of the uneven effects of fragmentation on this group. Smith et al. (1996) studied lizards in forest remnants of *Eucalyptus salubris* in Australia and found that the lizards in remnants were subsets of pre-fragmented assemblies, indicating an arrangement of nested subsets most likely due to differential vulnerability for each species and local extinctions (Lomolino 1996, Worthen 1996). Similar effects were also reported by Hager (1998) for North America and Cosson et al. (1999) for French Guyana. Species that occur in low densities were considered more susceptible to declines due to stochastic processes (Karr 1982, Shaffer & Samson 1985, Goodman 1987, Pimm et al. 1988, Wissel & Stocker 1991, Tracy & George 1992, Henle et al. 2004). In addition, specialist species were considered more susceptible to local extinction than generalists, since specialized habitats are less likely to occur or more likely to be degraded into smaller areas, and specialist species are less able to use surrounding forest or corridors for recolonization (Humphreys & Kitchener 1982, Bennett 1991, 1992, 1999, Sarre et al. 1996, Foufopoulos & Ives 1999, Henle et al. 2004).

Studies considering the synergistic effects between habitat loss and habitat configuration on the maintenance of species in tropical forest regions are still rare for the Neotropics (Dixo 2001, 2005, Freire 2001, Silvano et al. 2003, Bell & Donnelly 2006, Develey & Metzger 2006), and there is no consensus regarding the influence of these factors on lizard communities (Smith et al. 1996, Burbrink et al. 1998, Maisonneuve & Rioux 2001, Driscoll 2004, Bell & Donnelly 2006).

The main goal of our research was to investigate the influence of the size of forest fragments on the abundance, richness and diversity of leaf-litter lizards in a fragmented landscape on the São Paulo Atlantic Plateau, where only 11% of the original forest cover is left. We expected that decreased fragment/area size would show in a lower abundance, richness and diversity of lizards. If this theory proved true, we expected that patch size would have an effect on the conservation of leaf-litter lizards. The present study also aims at contributing to the knowledge of the distribution of the lizard species in the area.

Table 1. Characteristics of the sampled areas: fragment name, size category (SF – small fragment; MF – medium fragment; L – large fragment; CT – control area), area, and habitat loss.

Name	Category	Area (ha)	Habitat loss (%)
Alteres	MF	32.3	82.54
Boiadeiro	SF	7.02	94.90
Bojado	LF	43.57	79.10
Citadini	LF	43.66	58.97
Cromossomo	MF	19.73	80.67
Divisa	LF	92.34	64.38
Harpa	MF	16.01	84.40
Lira	SF	6.66	89.57
Machucado	MF	12.79	88.23
Meninas	SF	7.18	90.40
Padre Pedro	SF	6.39	93.39
Paulo Nunes	SF	7.58	86.21
Pedro Onório	MF	12.03	89.34
Radialista	SF	9.25	83.14
Yoko	MF	11.63	86.51
Cogumelo	CT	–	41.28
Moacir	CT	–	43.81
Mulheres	CT	–	39.07
Museros	CT	–	39.11
Paraguai	CT	–	37.95
Três Quedas	CT	–	46.02

Material and methods

Study area

Our study was carried out on the Atlantic Plateau of São Paulo state, southeastern Brazil, in the municipalities of Ribeirão Grande and Capão Bonito (24°05’14” S, 48°20’53” W). The entire study area was originally covered by Atlantic Forest, classified as Lower-Montane Atlantic Forest (Oliveira-Filho & Fontes 2000), but is reduced to fragments at medium to advanced stages of succession today (Teixeira et al. 2009). The area is characterized as a highland region (Ponçano et al. 1981), with slope inclines greater than 15% and altitudes varying between 800 and 1,000 m above sea level (Ross & Moroz 1997). The climate is 'Cwa' and 'Cfa' of Köppen (1948), subtropical and humid subtropical, with annual rainfall varying between 1,221 and 1,807 mm, and mean annual temperature varying between 18 and 22°C for both municipalities (Cepagri 2007).

The study area is notable for being located adjacent to wide expanses of forests present along the Serra do Mar, Serra de Paranapiacaba, and Parque Estadual Intervales. Ribeirão Grande and Capão Bonito have undergone major antropic change and fragmentation, currently featuring widely isolated remnant patches of forest. Of their combined 100 ha, only 11% are forested. The landscape matrix is composed of open areas, with approximately 45% used as pastures for livestock and 34% for crop farming. The urban and rural installations take up about 1% of the land, and water covers approximately 1%, too.

Sampling design

Sampling was undertaken at 21 sites in 15 forest patches and six sites in continuous forest (control areas = CT). The fragments were classified in three size classes: large (> 40 ha, N = 3; LF), medium (10–40 ha, N = 6; MF), and small (6–9 ha, N = 6; SF) (Table 1, Fig. 1).

Leaf-litter lizard sampling

Our survey of leaf-litter lizards was carried out as per a standardized sampling protocol with pitfall traps (Condez et al. 2009, Dixo & Metzger 2009) at all 21 sites. At each site, the traps were arranged in one line containing 11 buckets of 60 litres along 10 m of drift fence (50 cm high) each, producing a series of 100 m in length. During the sampling period, the traps remained open around the clock and were inspected daily between 7:00 and 12:00 h. For all 21 sites, lizard sampling was undertaken during the rainy season in two campaigns of 16 nights each, totalling 32 nights per site and 7,392 traps per night. The first campaign was carried out during eight nights in November of 2005 and January of 2006 each, and the second one during eight nights in November of 2006 and January of 2007 each. Lizards captured in the traps were photographed, identified to species level, and released near their collection sites. Animals found dead were fixed in 10% formaldehyde and deposited in the herpetological collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP) according to collection licence number 0177/05 (IBAMA – Instituto Brasileiro de Meio Ambiente e Recursos Naturais Renováveis).

Data analysis

Habitat loss (HL) was calculated based on a detailed mapping done from an aerial photograph (SPOT; scale 1:10,000) obtained in 2005. We plotted a circumference of radius 800 m (buffers) around the central point of each fragment. Buffers were constructed from the geographical coordinates of the first bucket of the pitfall line with the aid of the software ArcGIS 9.2 (ESRI 2006). HL metrics were calculated with the software Fragstats 3.3 (McGarigal & Marks 1995) from raster images (resolution 10 m).

In order to examine species richness at each sampled site, rarefaction curves (Gotelli & Colwell 2001) were calculated with the software EstimateS 7.5.0 (Colwell 2005) with 1,000 randomizations. Each day the traps remained open was considered a sample, producing 32 samples for each site. For each field trip and for each one of the 21 sampled sites, we considered the following dependent variables: richness (number of species), species abundance (total of captured individuals within the 16 days of each campaign), and total abundance (total of the abundance of all species trapped during the same period).

We used R (R Development Core Team 2015) for comparing species total abundance and richness between the four categories (small, medium, and large fragments, and control areas). Data were subjected to generalized linear modelling: Poisson and logistic regressions with a logit link and binomial error distribution (presence/absence data) (McCullagh & Nelder 1989).

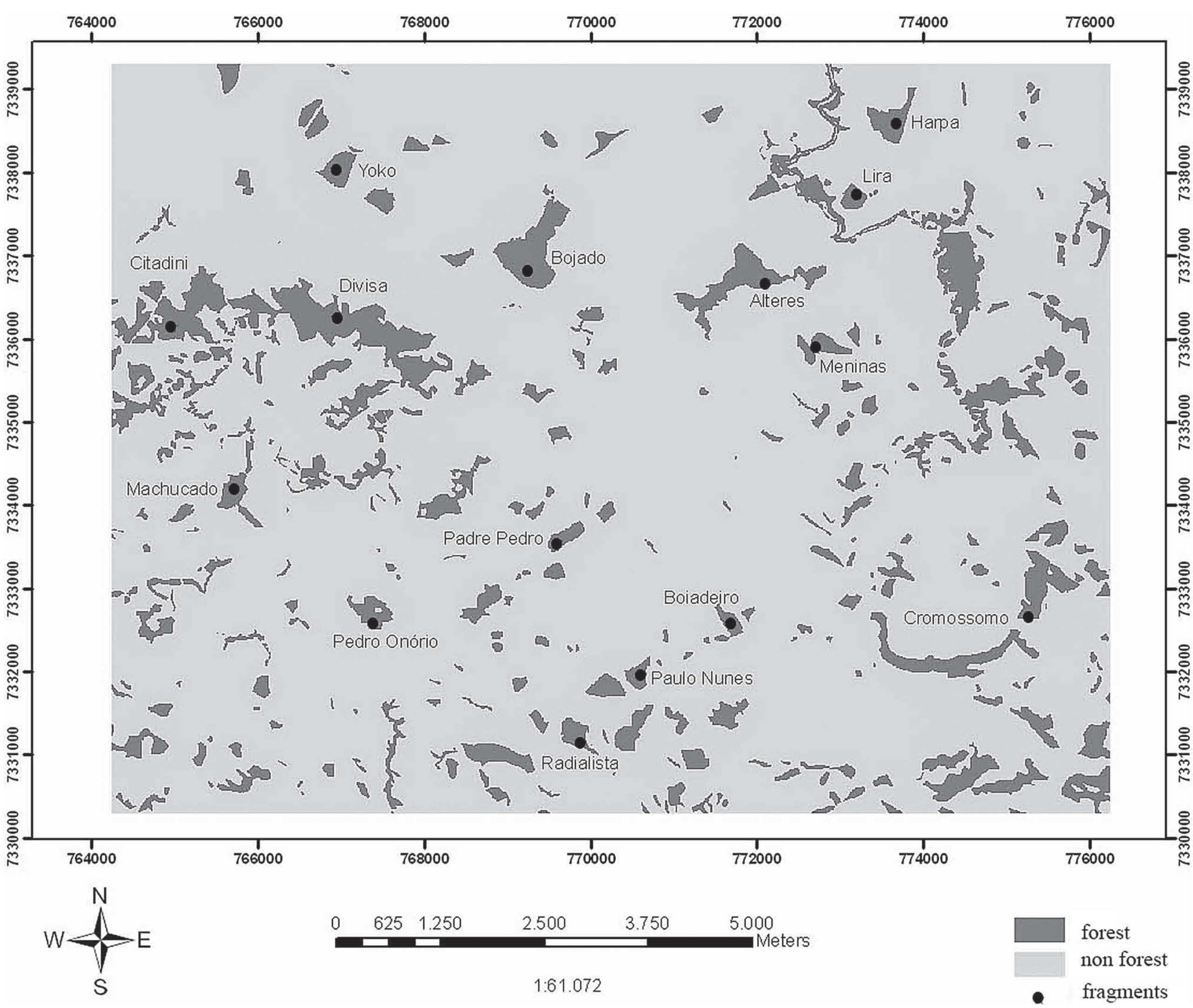

Figure 1. Location of the study site in the state of São Paulo, southeastern Brazil, and map of the forest remnants in the Ribeirão Grande and Capão Bonito region with the 15 sampled fragments.

Table 2. Leaf-litter lizard species, their abundance, and richness, recorded from 21 sampled sites. N – number of patches per size class.

Species	Fragments Small (N=6)	Medium (N=6)	Large (N=3)	Control areas (N=6)	Total
Gymnophthalmidae					
Colobodactylus taunayi	0	1	0	1	2
Ecpleopus gaudichaudii	0	0	0	3	3
Heterodactylus imbricatus	0	0	0	1	1
Placosoma glabellum	4	5	1	2	12
Leiosauridae					
Enyalius iheringii	23	26	19	35	103
Urostrophus vautieri	0	1	0	0	1
Total Abundance	27	33	20	42	122
Total Richness	2	4	2	5	6

Prior to analysis, data were checked for normality (Kolmogorov-Smirnov test) and homogeneity of variance of the dependent variables between the analyzed categories was tested with the Bartlett and Levene test. When necessary (only for simple regressions), data were converted (logarithm or scoring). Simple regressions were performed to examine the relationships between lizard richness and abundance and fragment area.

Results

We captured 122 individuals belonging to two families and six species (Table 2). The most abundant species was *Enyalius iheringii* representing 84.42% of the total of recorded individuals, followed by *Placosoma glabellum* (10%). Another two species together accounted for 16% of all lizards trapped in the region. A greater richness was found in control areas, where representatives of five out of the six species occurring here were recorded (Table 2). Richness in the large and small fragments (2 spp.) was lower compared to medium-sized fragments (4 spp.). The number of species observed per sampled site varied from zero ("Meninas", "Radialista", "Machucado", and "Padre Pedro" patches) to three ("Três-Quedas", control-area). The total observed richness equals six species, just a little bit below the range of the number of species estimated by Jackknife 1 estimator (8 spp.) (Table 3). The Shannon diversity index (H') varied between 0.30 and 0.83 (Table 3).

Rarefaction curves based on the number of samples (Fig. 2) do not tend to stabilize when control areas and fragments were considered together. They indicate that probably not all leaf-litter lizard species present were collected in our pitfall traps (Fig. 2). When we considered each size class, we could verify that the small (SF) and large fragments (LF) curves were closer to the asymptote. The medium fragments curve (MF) presented a high degree of slope, and finally the control areas (CT), as we expected, held a higher number of

Table 3. Diversity of lizards in the sampled fragments. Size classes of fragments (Size), Abundance (Ab), observed richness (R_obs), estimated richness by Jackknife (R_Jack1), and Shannon diversity index (H').

Fragment	Size	Ab	R_obs	R_Jack_1	H'
Boiadeiro	SF	10	1	1.00	0.00
Lira	SF	19	2	2.00	0.44
Meninas	SF	0	0	0.00	0.00
Paulo Nunes	SF	1	1	1.97	0.00
Padre Pedro	SF	0	0	0.00	0.00
Radialista	SF	0	0	0.00	0.00
Alteres	MF	8	1	1.00	0.00
Cromossomo	MF	6	1	1.00	0.00
Harpa	MF	14	2	2.00	0.60
Machucado	MF	0	0	0.00	0.00
Pedro Onório	MF	2	2	3.94	0.69
Yoko	MF	3	2	2.97	0.64
Bojado	LF	4	1	1.00	0.00
Citadini	LF	12	1	1.00	0.00
Divisa	LF	1	1	1.97	0.00
Cogumelo	CT	7	1	1.00	0.00
Moacir	CT	3	2	2.97	0.64
Mulheres	CT	11	2	2.97	0.30
Museros	CT	7	2	2.97	0.41
Paraguai	CT	1	2	1.97	0.00
Três Quedas	CT	13	3	3.00	0.83
Total		122	6	7.94	0.61

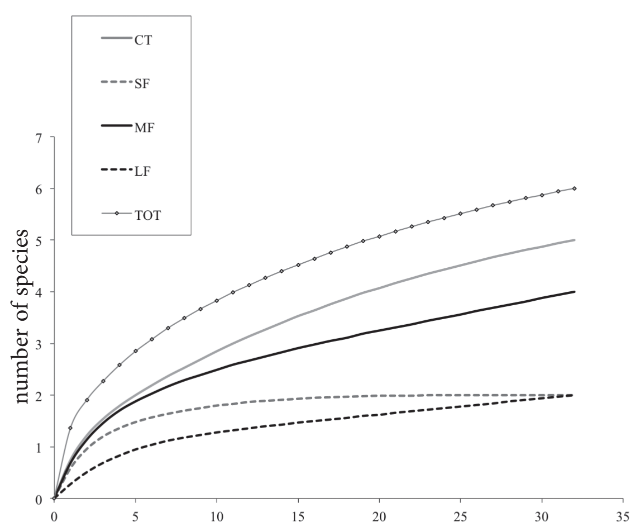

Figure 2. Rarefaction curves of species in the four size classes from sampled fragments, made from 1,000 randomizations in the order of the samples (CT – control área; SF – small fragments; MF – medium fragments; LF – large fragments; TOT – fragments + control áreas).

species. Poisson regression revealed no significant correlation comparing the response of the lizard community, richness ($p = 0.2128$) and total abundance ($p = 0.2607$) to patch size (control areas, small, medium, and large fragments). No relation was found when species detections were subjected to logistic regression ($p = 0.95$). Even from the two species for which the number of captured individuals allowed statistical analysis, *E. iheringii* and *P. glabellum*, neither exhibited significant relations to the four fragment size classes, with $p = 0.148$ and 0.333, respectively.

The simple regressions showed no relations between the logarithms of the patch size classes and richness ($N = 15$, $R^2 = 0.00$, $p = 0.792$), total abundance ($N = 15$, $R^2 = 0.00$, $p = 0.440$), and abundance of *E. iheringii* ($N = 20$, $R^2 = 0.00$, $p = 0.418$), respectively.

Discussion

Despite the low richness of leaf-litter lizards in the area, the number of species was expected for the region as a whole, and it is similar to other localities in the Atlantic Rainforest. Dixo & Verdade (2006) reported the presence of five lizard species in the Reserva Florestal do Morro Grande. In Tapiraí, also in the domain of the Atlantic Rainforest, eight species were recorded (Condez et al. 2009).

Different from what we expected, lizards had not responded to the decrease in area and fragmentation with regard to both the richness and abundance of species in remnant patches. The lizard assemblage of the Ibiúna Plateau was sensitive to fragmentation per se, but not to patch size or connectivity (Dixo & Metzger 2009). Other studies have also found positive responses to fragmentation (Sarre et al. 1995, Smith et al. 1996, Driscoll 2004, Bell & Donnelly 2006). Other surveys carried out in northeastern parts of the Atlantic Forest, where the landscape still has large patches of remnant vegetation (49%) and a permeable matrix that reduces the degree of isolation between patches, the responses were negative (Dixo 2001, Silvano et al. 2003).

The species recorded, with the exception of *E. iheringii*, occurred at low abundances at the sampled sites, which may indicate their unsuitability for occupation or lizard inability to recolonize isolated remnants. This suggests a rather irregular distribution that can be related to specific local factors, such as the structure of the habitat, but our data did not allow analyses in this respect. As found by Nally & Brown (2001) in Australia, even large 'blocks' of forest (> 10,000 ha) may not offer the refuge required by reptiles, and as we know relatively little or nothing about the ecological requirements of most species, more detailed work is needed to develop better conservation planning.

Enyalius iheringii, the most abundant species at the sites, was not found to be influenced by the fragment size, with the same result having been concluded for *E. perditus* in Ibiúna and Tapiraí (Dixo & Metzger 2009, Condez et al. 2009). The genus *Enyalius* Boulenger, 1885 is widely distributed throughout the Atlantic Forest, and the two species (*E. iheringii, E. perditus*) may occur sympatrically or allopatrically. Environmental disturbances seem to affect these two species differently, with the abundance of *E. iheringii* in sympatry being lower compared to the abundance of *E. perditus*, whereas *E. iheringii*, in allopatry, is extremely abundant. The abundance of species may indicate greater reproductive success in certain locales, and to the contrary, if the abundance of individuals is not as expected, it suggests that one species is favoured (Liou 2008). Furthermore, tracking lizards using thread-bobbins, Liou (2008) found that *E. iheringii* has a relatively small home range, even over large time frames, suggesting territoriality and high fidelity to the living area, i.e., it remains in the fragments after disturbances and this might explain why we did not find meaningful responses.

Most reptile species are confined to remnant vegetation because they do not use the local matrix (M. Dixo unpubl. data) and there is convincing evidence of the impacts of grazing, roads, and the shape of the remnants on them (Forman & Alexander 1998, Treweek 1998, Driscoll 2004). In another study carried out in Australia, Driscoll (2004) found combined effects of the 'landscape elements' (shape, management, and vegetation) that affected the distribution of reptiles depending on the species and that, despite the apparent connectivity in an agricultural landscape, the management of remnant vegetation had fragmented populations of reptiles, reducing the amount of available habitat and contributing to its decline.

Information about home range and use of vertical strata of the forest generates important data sets on the spatial requirements of species that live in priority areas for conservation. In that sense, researches that address these issues may help to understand the vulnerability of the leaf-litter lizard community to processes of fragmentation and habitat loss in areas in the domain of the Atlantic Forest.

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References

Araújo, M. B., W. Thuiller & R. G. Pearson (2006): Climate warming and the decline of amphibians and reptiles in Europe. – Journal of Biogeography, **33**: 1712–1728.

Bell, K. E. & M. A. Donnelly (2006): Influence of forest fragmentation on community structure of frogs and lizards in northeastern Costa Rica. – Conservation Biology, **20**: 1750–1760.

Bennett, A. F. (1991): Roads, roadsides, and wildlife conservation: a review. – pp. 99–118 in: Saunders, D. A. & R. J. Hobbs (eds): Nature conservation 2. The role of corridors. – Surrey Beatty: Sydney.

Bennett, A. F. (1992): Restoring connectivity to fragmented landscapes: does roadside vegetation have a role? – Victorian Naturalist, **109**: 105–110.

Bennett, A. F. (1999): Linkages in the landscape. The roles of corridors and connectivity in wildlife conservation. – IUCN: Gland.

Bérnils, R. S. & H. C. Costa (2012): Répteis brasileiros: Lista de espécies. Versão 2012.1. – Sociedade Brasileira de Herpetologia. Available at http://www.sbherpetologia.org.br/.

Burbrink, F. T., C. A. Phillips & E. J. Heske (1998): A riparian zone in southern Illinois as a potential dispersal corridor for reptiles and amphibians. – Biological Conservation, **86**: 107–115.

Colwell, R. K. (2005): EstimateS: Statistical estimation of species richness and shared species from samples. Version 5. – User's guide and application. Available at http://viceroy.eeb. uconn. edu/estimates

CEPAGRI (2007): Centro de Pesquisas Meteorológicas e Climáticas Aplicadas à Agricultura. – Campinas. Available at http//www.cpa.unicamp.br.

Condez, T. H., R. J. Sawaya & M. Dixo (2009): Herpetofauna dos remanescentes de Mata Atlântica da região de Tapiraí e Piedade, SP, sudeste do Brasil. – Biota Neotropica, **9**: 157–185.

Cosson, J. F., S. Ringuet, O. Claessens, J. C. de Massary, A. Dalecky, J. F. Villiers, L. Granjon & J. M. Pons (1999): Ecological changes in recent land-bridge islands in French Guiana, with emphasis on vertebrate communities. – Biological Conservation, **91**: 213–222.

Develey, P. F. & J. P. Metzger (2006): Emerging threats to birds in Brazilian Atlantic forests: the roles of forest loss and configuration in a severely fragmented ecosystem. – pp. 269–290 in: Laurance, W. & C. Peres (eds): Emerging Threats to Tropical Forests. – University of Chicago Press, Chicago.

Driscoll, D. A. (2004): Extinction and outbreaks accompany fragmentation of a reptile community. – Ecological Applications, **14**: 220–240.

Dixo, M. (2001): Efeito da fragmentação da floresta sobre a comunidade de sapos e lagartos de serapilheira no sul da Bahia. – Unpublished MSc thesis, Universidade de São Paulo, São Paulo.

Dixo, M. (2005): Diversidade de sapos e lagartos de serapilheira numa paisagem fragmentada do Planalto Atlântico de São Paulo. – Unpublished PhD thesis, Universidade de São Paulo, São Paulo.

Dixo, M. & V. K. Verdade (2006): Herpetofauna de serapilheira da Reserva Biológica de Morro Grande, Cotia (SP). – Biota Neotropica, **6**: 1–20.

Dixo, M. & J. P. Metzger (2009): Are corridors, fragment size and forest structure important for the conservation of leaf-litter lizards in a fragmented landscape? – Oryx, **43**: 435–442.

ESRI (2006): ArcGIS Desktop version 9.2. – ArcInfoTM. ESRI Inc., USA (CD-ROM).

Fonseca, G. A. B. (1985): The vanishing Brazilian Atlantic Forest. – Biological Conservation, **34**: 17–34.

Foufopoulos, J. & A. R. Ives (1999): Reptile extinctions on land-bridge islands: life-history attributes and vulnerability to extinction. – American Naturalist, **153**: 1–25.

Forman, R. T. T. & L. E. Alexander (1998): Roads and their major ecological effects. – Annual Review of Ecology and Systematics, **29**: 207–231.

Freire, M. E. X. (2001): Composição, taxonomia, diversidade e considerações zoogeográficas sobre a fauna de lagartos e serpentes de remanescentes da Mata Atlântica do estado de Alagoas, Brasil. – Unpublished PhD thesis, Museu Nacional, Rio de Janeiro.

Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville & B. S. Metts (2000). The global decline of reptiles, déjà vu amphibians. – BioScience, **50**: 653–666.

Goodman, D. (1987): The demography of chance extinction. – pp. 11–34 in: Soulé, M. E. (ed.): Viable populations for conservation. – Cambridge University Press: Cambridge.

Gotelli, N. J. & R. K. Colwell (2001): Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. – Ecological Letters, **4**: 379–391.

Hager, H. A. (1998): Area-sensitivity of reptiles and amphibians: are there indicator species for habitat fragmentation? – Ecoscience, **5**: 139–147.

Hawlena, D., D. Saltz, Z. Abramsky & A. Bouskila (2010): Ecological trap for desert lizards caused by anthropogenic changes in habitat structure that favor predator activity. – Conservation Biology, **24**: 803–809.

Henle, K., K. F. Davies, M. Kleyer, C. Margules & J. Settele (2004): Predictors of species sensitivity to fragmentation. – Biodiversity and Conservation, **13**: 207–251.

Humphreys, W. F. & D. J. Kitchener, (1982): The effect of habitat utilization on species-area curves: implications for optimal reserve design. – Journal of Biogeography, **9**: 391–396.

Karr, J. R. (1982): Population variability and extinction in the avifauna of a tropical land bridge island. – Ecology, **63**: 1975–1978.

Köppen, W. (1948): Climatologia. Com un estudio de los climas de la tierra. – Fondo Cultura Economica, México City.

Liou, N. S. (2008): História natural de duas espécies simpátricas de *Enyalius* (Squamata, Leiosauridae) na Mata Atlântica do sudeste brasileiro. – Unpublished MsC thesis, Universidade de São Paulo, São Paulo.

Lomolino, M. V. (1996): Investigating causality of nestedness of insular communities: selective immigrations or extinctions. – Journal of Biogeography, **23**: 699–703.

Maisonneuve, C. & S. Rioux (2001): Importance of riparian habitats for small mammal and herpetofauna communities in agricultural landscapes of southern Québec. Agriculture. – Ecosystem and Environment, **83**: 165–175.

McCullagh, P. & J. A. Nelder (1989). Generalized Linear Models, 2nd edition. – Chapman and Hall, London.

McGarigal, K. & B. J. Marks (1995): FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. – Gen. Tech. Report PNW-GTR-351, USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Michael, D. R., R. B. Cunningham & D. B. Lindenmayer (2010): Microhabitat relationships among five lizard species associated with granite outcrops in fragmented agricultural landscapes of south-eastern Australia. – Austral Ecology, **35**: 214–225.

Morellato, L. P. C. & C. F. B. Haddad (2000): Introduction: the Brazilian Atlantic forest. – Biotropica, **32**: 786–792.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. Fonseca & J. Kent (2000): Biodiversity hotspots for conservation priorities. – Nature, **403**: 853–858.

Nally, R. M. & G. W. Brown. (2001): Reptiles and habitat fragmentation in the box-ironbark forests of central Victoria, Australia: predictions, compositional change and faunal nestedness. – Oecologia, **128**: 116–125.

Oliveira-Filho, A. T. & M. A. L. Fontes (2000): Patterns of floristic differentiation among Atlantic Forests in southeastern Brazil and influence of climate. – Biotropica, **32**: 793–810.

Pimm, S. L., H. L Jones & J. Diamond (1988): On the risk of extinction. – American Naturalist, **132**: 757–785.

Ponçano, W. L., C. D. R. Carneiro, C. A. Bistrichi, F. F. M. Almeida & F. L. Prandini (1981): Mapa Geomorfológico do Estado de São Paulo. – Instituto de Pesquisas Tecnológicas, São Paulo.

R Development Core Team (2015): R: A language and environment for statistical computing. – R Foundation for Statistical Computing, Vienna, Austria. Available at https://333.R-project.org/.

Ribeiro, M. C., J. P. Metzger, A. C. Martensen, F. J. Ponzoni & M. M. Hirota (2009): The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for conservation. – Biological Conservation, **142**: 1141–1153.

Ross, J. L. S. & I. C. Moroz (1997): Mapa geomorfológico do Estado de São Paulo, escala 1:500.000. – FFLCH-USP/IPT/FAPESP, São Paulo.

Sarre, S, K. Wiegand & K. Henle (1996): Survival of a specialist and generalist gecko in the fragmented landscape of the Western Australian wheatbelt. – pp. 39–51 in: Settele J., C. R. Margules, P. Poschlod & K. Henle. (eds): Survival of Species in Fragmented Landscapes. – Kluwer, Dordrecht.

Shaffer, M. L. & F. B. Samson (1985): Population size and extinction: a note on determining critical population sizes. – American Naturalist, **125**: 144–152.

Silvano, D., G. Colli, M. Dixo, B. Pimenta & H. C. Wiederhecker (2003): Anfíbios e répteis. – pp. 183–200 in: D. Rambaldi & D. A. S. Oliveira (eds): Fragmentação de ecossistemas: causas, efeitos sobre a biodiversidade e recomendações de políticas públicas. – MMA/SBF, Brasília.

Smith, G. T., G. W. Arnold, S. Sarre, M. Abensperg-Traun & D. E. Steven (1996): The effect of habitat fragmentation and livestock grazing on animal communities in remnants of gimlet *Eucalyptus salubris* woodland in the Western Australian wheatbelt. II. Lizards. – Journal of Applied Ecology, **33**: 1302–1310.

Teixeira, A. M. G., B. S. Soares-Filho, S. R. Freitas & J. P. Metzger (2009): Modeling landscape dynamics in an Atlantic Rainforest region: implications for conservation. – Forest Ecology and Management, **257**: 1219–1230.

Tracy, C. R. & T. L. George (1992): On the determinants of extinction. – American Naturalist, **139**: 102–122.

Treweek, J. R., P. Hankard, D. B. Roy, H. Arnold & S. Thompson (1998): Scope for strategic ecological assessment of trunkroad development in England with respect to potential impacts on lowland heathland, the Dartford warbler (*Sylvia undata*) and the sand lizard (*Lacerta agilis*). – Journal of Environmental Management, **53**: 147–163.

Vallan, D. (2000): Influence of forest fragmentation on amphibian diversity in the nature reserve of Ambohitantely, highland Madagascar. – Biological Conservation, **96**: 31–43.

Viana, V. M. (1995): Conservação da biodiversidade de fragmentos de florestas tropicais em paisagens intensivamente cultivadas. – pp. 135–154 in: Abordagens interdisciplinares para a conservação da biodiverdade e dinâmica do uso da terra no novo mundo. Belo Horizonte/Gainesville. – Conservation International do Brasil/Universidade Federal de Minas Gerais/University of Florida.

Viana, V. M. & L. A. F. V. Pinheiro (1998): Conservação da biodiversidade em fragmentos florestais. – Série Técnica IPEF, **12**: 25–42.

Wissel, C. & S. Stöcker (1991): Extinction of populations by random influences. – Theoretical Population Biology, **39**: 315–328.

Worthen, W. B. (1996): Community composition and nested-subset analyses: basic descriptors for community ecology. – Oikos, **76**: 417–426.

Zaher, H., F. E. Barbo, P. S. Martínez, C. Nogueira, M. T. Rodrigues & R. J. Sawaya (2011): Répteis do Estado de São Paulo: Conhecimento Atual e Perspectivas. – Biota Neotropica, **11**: 1–15.

Zanella, L. (2011): Análise da interferência antrópica na fragmentação da Mata Atlântica e modelos de simulação da paisagem na microrregião da Serra da Mantiqueira do Estado de Minas Gerais. – Unpublished MSc thesis, Universidade Federal de Lavras, Lavras.