Searching for bioindicators of forest fragmentation: passerine birds in the Atlantic forest of southeastern Brazil

Piratelli, A.[a]**, Sousa, SD.*[b]*, Corrêa, JS.*[b]*, Andrade, VA.*[b]*,*
Ribeiro, RY.[b]*, Avelar, LH.*[b] *and Oliveira, EF.*[b]

[a]Campus Sorocaba, Universidade Federal de São Carlos – UFSCar,
Rodovia João Leme dos Santos, Km 110, Itinga, CEP 18052-780, Sorocaba, SP, Brasil

[b]Programa de Pós-Graduação em Biologia Animal, Departamento de Biologia Animal, Instituto de Biologia,
Universidade Federal Rural do Rio de Janeiro, BR 465, Km 07, CEP 23890-000, Seropédica, RJ, Brazil

*e-mail: piratelli@ufscar.br

Received April 28, 2006 – Accepted October 25, 2006 – Distributed May 31, 2008

Abstract

Aiming to evaluate the potential of Passerine birds as bioindicators of forest fragmentation, we studied the avifauna in the mountain region of the state of Rio de Janeiro by mist-netting between 2001 and 2005. We sampled six sites, including four small fragments (from 4 to 64 ha) in an agricultural area (Teresópolis), one second-growth forest (440 ha - Miguel Pereira) and a continuous forest (10,600 ha, Serra dos Órgãos National Park - SONP). Indicator Species analysis and a Monte Carlo test were run to detect associations between species and sites, considering at least 30% of perfect indication and a significant value for the statistical test, only considering species with at least 10 captures. A total of 30 Passerine birds were sampled, and due to their association to the largest area (SONP), we considered *Sclerurus scansor, Mionectes rufiventris, Chiroxiphia caudata* and *Habia rubica* as the best indicators for this area. Five species were more captured not by chance in the 440 ha second-growth: *Conopophaga melanops*, *Myiobius barbatus, Myrmeciza loricata, Philydor atricapillus* and *Schiffornis virescens* and no species were related to any small fragment. This analysis has identified specialized Passerine species in many aspects (foraging substract, needs for nesting, rarity status), and it can be a valuable tool for detecting possible bioindicators.

Keywords: Atlantic forest, bioindicators, birds, Brazil, indicator species analysis.

Busca por bioindicadores de fragmentação florestal: aves Passeriformes na Floresta Atlântica do Sudeste do Brasil

Resumo

Para avaliar o potencial de Passeriformes como bioindicadores de fragmentação florestal na Mata Atlântica, estudamos a avifauna da região serrana do Rio de Janeiro, utilizando capturas com redes de neblina entre 2001 e 2005. Foram amostradas seis áreas, sendo quatro pequenos fragmentos (de 4 a 64 ha) em áreas agrícolas (Teresópolis), uma mata secundária com cerca de 40 anos (440 ha - Miguel Pereira) e uma área de mata contínua de 10600 hectares (Parque Nacional da Serra dos Órgãos - PARNASO). A análise de espécies indicadoras e o teste de Monte Carlo foram empregados para que se verificassem as espécies mais associadas a cada local amostrado, considerando-se um mínimo de 30% de indicação e valor significativo para o teste mencionado, utilizando-se somente espécies com 10 ou mais capturas. Foi amostrado um total de 30 espécies e, pela sua associação com a maior área (PARNASO), consideramos *Sclerurus scansor*, *Mionectes rufiventris*, *Chiroxiphia caudata* e *Habia rubica* como as melhores indicadoras. Cinco espécies foram mais capturadas não ao acaso na área de 440 ha: *Conopophaga melanops*, *Myiobius barbatus*, *Myrmeciza loricata*, *Philydor atricapillus* e *Schiffornis virescens*. Nenhuma espécie foi associada aos pequenos fragmentos. Como esta análise identificou espécies de Passeriformes especialistas em diversos aspectos (substrato de forrageio, locais de nidificação, status de raridade), ela pode ser uma ferramenta útil na detecção de possíveis bioindicadores.

Palavras-chave: análise de espécies indicadoras, aves, bioindicadores, Brasil, Mata Atlântica.

1. Introduction

Ecological indicators have been used to detect changes in nature for the last 40 years, and currently, they are mainly used to assess the condition of the environment (Niemi and McDonald, 2004), and one of the aspects that have been evaluated by ecological indicators is the landscape fragmentation (O'Neill et al., 1988).

Fragmentation is a serious threat for the Brazilian Atlantic forest, and today it is estimated only 7% remains

(Mittermeier et al., 1999), mostly in small fragments. The Atlantic Forest harbors 688 breeding species of birds (Goerck, 1997), only one bird species is truly registered as extinct in this ecosystem, but many species are now endangered (Collar et al., 1992). In the state of Rio de Janeiro, the most important remnants of this ecosystem are in the mountains, and mainly restricted to fragments. This state hosts 653 taxa of birds, including 82 threatened, 38 probably threatened and 25 without enough data for evaluation of their status (Alves et al., 2000).

One of the primary goals of research on bioindicators is to identify species or other taxonomic units that would indicate disturbances in the environment, reflecting the responses of other species (Rainio and Niemelä, 2003). When searching for bioindicators, one has to find groups of species which respond quickly to environmental changes, being these answers clearly distinct from those generated by natural fluctuations (Furness and Greenwood, 1993). Birds have been used as bioindicators for having particular characteristics, as good taxonomic and systematic knowledge (Furness and Greenwood, 1993; Bierregaard and Stouffer, 1997), several species occupying higher levels on food chain (Bierregaard, 1990) and sensibility to habitat losses and fragmentation (Terborgh, 1977; Turner, 1996).

In fragmented landscapes, a regular process is the substitution of rare-specialized species for abundant-generalist ones, more adapted to open and clear-cut areas (Willis, 1979; Restrepo and Gómez, 1998; Willis and Oniki, 2002a); thus we can associate the presence/absence of some species to environmental quality. In general, Suboscines Passerine birds are more closely-related to forested landscapes, and Oscines usually are more linked to open areas (Willis, 1979; Sick, 1997). If those assumptions are natural processes, some species usually would be more easily found in continuous forests; meanwhile other groups will appear mainly in open and fragmented areas. Therefore, this non-random distribution would be a clue for evaluating environmental quality.

Our goal in this study is to verify non-random distribution of some Passerine bird species in areas with different levels of disturbance at the Serra do Mar sub region of Atlantic Forest. Thus we intend to detect which species are more closed-related to each site (indicator species), investigating their potential as bioindicators of forest fragmentation.

2. Material and Methods

In order to estimate the potential of some Passerine birds as bioindicators of forest fragmentation in the Atlantic forest, we have conducted this research in the mountains of Rio de Janeiro state, southeastern Brazil, from October 2001 to July 2005. We used mist nets for sampling Passerine birds in six sites, including four small fragments (4, 9, 23 and 64 ha) in agricultural areas in Teresópolis municipality (22° 17' 22" S and 42° 52' 3 " W and 22° 16' 35" S and 42° 51' 49" W), a second-growth forest (Igapira Farm-440 ha) in the vicinity of Miguel Pereira (22° 30' S and 42° 23' W) and a continuous forest (10,600 ha) in Teresópolis municipality (Serra dos Órgãos National Park; 22° 24' 36" S and 42° 58' 48" W; from now SONP).

The vegetation in the four smaller fragments, from now named F1 to F4 (from smaller to larger), is second-growth forest. They are surrounded by pastureland for raising cattle (which usually is seen inside the fragments), and agricultural activities (in which pesticides are used). Excepted for F1 (where only one net line was operated), we performed a two-net lines protocol with from 6 to 10 mist nets in each fragment. In every fragment, one net line was close to the border and the other was located inside the forest. Every fragment and net line was sampled at least every two months, with the same sample effort in all studied sites.

Igapira Farm is a 910 hectares private farm in the municipality of Miguel Pereira. It is estimated that 440 hectares are covered by second-growth montane pluvial forest, and the remnant are buildings and large area of pasturelands for cattle and buffalo. The dominant native covering is montane semideciduous Atlantic Forest (Rizzini, 1997), with trees between 20 and 30 m, and emergent reaching up to 40 m. For sampling birds, eight to ten mist nets were operated every month in two sites (800 and 1,100 m high)

The vegetation in SONP is second-growth Atlantic pluvial forest, with palm trees, epiphytes and tall trees. It has 10 peaks higher than 2000 m and six other peaks over 1500 m high. The highest peak is Pedra do Sino at 2263 m, and the lowest is located in the relatively flat municipality of Magé, at 145 m. The average temperature at 1000 m is 17 °C (Wikipedia, 2006). We sampled two sites, located at 1000 m high and about 2 km far from each other. From 6 to 10 mist nets were used in each site, which was sampled every two months.

Due to different mist netting efforts (net-hours) in the six sampled areas (850 in each fragment, 2680 in Igapira Farm and 1800 in SONP), before using our data we divided captures by net-hours x 100; thereby we were able to compare our results of relative proportion of captures in these sites. Mist nets are probably free of biases associated with the observer (Bierregaard and Stouffer, 1997); however introduction biases themselves in that birds of different sizes and with differing behavior patterns, whose capture probabilities are distinct (Remsen and Good, 1996). Nevertheless, their use has provided satisfactory results in many studies (e.g., Bierregaard and Stouffer, 1997; Blake and Loiselle, 2001; Wang and Finch, 2002; Piratelli and Blake, 2006), and this methodology can be an useful tool for comparing bird communities of several sites when used in a similar sampling effort.

The Indicator Species analysis (Dufrene and Legendre, 1997) and a Monte Carlo test were run using the package PCOrd 4.01 (McCune and Mefford, 1997) to verify non-random species distribution in the sampled sites. We only considered species with 10 or more captures, a minimum of 30% of perfect indication and a significant value for the statistical test. We then assumed that those species more closely related to a given sampled site would be more specialized and probably more sensitive to the degradation of their habitats. Next, we searched in the literature for their biological characteristics, based on descriptions of their occurrence. Finally, we matched our results with previous descriptions in order to find the best bioindicators, and to test the use of Indicator Species analysis for detecting bioindicators.

3. Results

A total of 71 Passerine bird species from 11 families were sampled, and 30 had at least 10 captures, from which twenty (66.7%) were Suboscine, and 10 (33.4%) Oscine Passerines. The most well-represented families were Emberizidae (n = 15) and Tyrannidae and Furnariidae (n = 13), and the most common trophic guilds were understory insectivores (n = 27) and omnivores (n = 12) (Table 1).

Due to their association to the largest area (SONP), we have linked *Sclerurus scansor* (Ménétriès, 1835), *Mionectes rufiventris* (Cabanis, 1846), *Chiroxiphia caudata* (Shaw & Nodder, 1793) and *Habia rubica* (Vieillot, 1817) to that site. Five species were further captured not by chance in the 440 ha second-growth (Igapira farm), suggesting some preference to that forest: *Conopophaga melanops* (Vieillot, 1818), *Myiobius barbatus* (Gmelin, 1789), *Myrmeciza loricata* (Lichtenstein, 1823), *Philydor atricapillus* (Wied, 1821) and *Schiffornis virescens* (Lafresnaye, 1838). No species were related to any small fragment (Table 2). All of these species excepted *H. rubica* and *M. barbatus* are endemic of Atlantic Forest (Brooks et al., 1999) and only *Habia rubica* is Oscine (Emberizidae, Thraupinae). Most (seven) of these nine species were understory insectivores; two (*Myiobius barbatus* and *Schiffornis virescens*) were classified as understory omnivores (see Table 1).

In this analysis some species, even with an expressive higher relative abundance in a given sampled site were not considered as indicator, due to their low frequencies of captures. This is the case of *Euphonia pectoralis* (Latham, 1801) and *Saltator similis* d'Orbigny & Lafresnaye, 1837 for SONP (Table 3).

4. Discussion

According to Indicator Species analysis, *Sclerurus scansor, Mionectes rufiventris, Chiroxiphia caudata* and *Habia rubica* were indicators for the largest area (SONP); and *Conopophaga melanops*, *Myiobius barbatus, Myrmeciza loricata, Philydor atricapillus,* and *Schiffornis virescens* for the medium-size site (410 ha, Igapira).

Sclerurus scansor usually is found on or near ground in humid lowland and montane forests (Brooks et al., 1999), nesting in holes in banks inside the forest (Develey and Endrigo, 2004). It has been considered a rare, specialized (Goerck, 1997) and highly sensitive species (Ribon et al., 2003), commonly as a member of fixed flocks (Develey and Peres, 2000). There are records of *S. scansor* in a 230 ha patch of semideciduous forest in cane fields of central São Paulo (Willis and Oniki, 2002b). These last authors did not find this species in further samplings, suggesting its disappearance due to loss of the few individuals present earlier. Even though it has already been observed in very small fragments by D'Ângelo-Neto et al. (1998) in Minas Gerais (5 to 8 ha) and in Rio Grande do Sul, foraging on the ground (*I. Accordi, p. comm.*), its abundance estimate was affected by logging in São Paulo, occurring mainly in a primary forest (Aleixo, 1999).

Mionectes rufiventris is a common species in lower growth of humid forest, secondary woodland and borders of southeastern Brazil (Ridgely and Tudor, 1994a) occurring in mixed flocks (Develey and Peres, 2000) both in lowland (Machado and Fonseca, 2000) and montane evergreen forests (Brooks et al., 1999). Aguilar et al. (2000) found 19 nests of this species in two of the three fragments (50, 200 and 300 ha) that they studied in Minas Gerais; however, they did not specify in which fragment the nests were found. All nests were constructed over water, fixed to tree roots under stream beds; the authors considered this species as nest-site specialist. Pizo and Aleixo (1998) has described its leck behavior in a 2000 ha protected area in São Paulo. There are records for this species in antropized areas in Minas Gerais (Manhães and Ribeiro, 2005) as well as in larger patches in Rio Grande do Sul (*I. Accordi, p. comm.*).

Chiroxiphia caudata is a common species in lower and middle growth of humid forest, secondary woodland, and borders (Brooks et al., 1999; Ridgely and Tudor, 1994a). It has been reported in a large fragment (21,840 ha) (Donatelli et al., 2004), and in smaller ones in São Paulo (Willis and Oniki, 2002b; Poza and Pires, 2003) and Minas Gerais (D'Ângelo-Neto et al., 1998; Ribon et al., 2004). In this last state, there are reports up to 500 m high in the Rio Doce Valley (Machado and Fonseca, 2000), and from 800 to 1,000 m high in Serra do Cipó (Mello-Júnior et al., 2001). It was not affected by logging in São Paulo, occurring both in a primary forest and in a logged area (Aleixo, 1999).

Habia rubica lives in lower growth of humid forest and forest borders, usually in mixed flocks (Ridgely and Tudor, 1994b). It is a low specialized species (Develey and Peres, 2000) having medium sensitivity (Ribon et al., 2003). There are records of this species in a 21,840 ha forest (Donatelli et al., 2004), and in smaller fragments (Willis and Oniki, 2002b) in São Paulo. It is currently seen as a nuclear species of mixed flocks in Rio Grande do Sul (*I. Accordi, p. com.*).

Those four species, regardless of their records in small fragments, have some ecological characteristics (e.g. rarity status, needs for nesting, foraging in mixed

Table 1. All Passerine birds (by Families) sampled in six sites at Atlantic Forest in the state of Rio de Janeiro, Brazil, their capture rates - (captures/net-hour) x 100 and trophic guilds (according to Willis, 1979 and Sick, 1997).

Families	Species	F1	F2	F3	F4	Igapira	SONP	Trophic guilds
THAMNOPHILIDAE	*Mackenziana severa*	-	-	0.12	0.12	-	-	Bamboo or forest tangles insectivores
	Thamnophilus caerulescens	0.24	0.35	0.24	0.24	-	-	Understory insectivores
	Thamnophilus punctatus	-	-	-	-	0.04	-	Understory insectivores
	Dysithamnus mentalis	-	-	-	0.12	0.26	0.17	Understory insectivores
	Dysithamnus stictothorax	-	-	-	-	0.15	-	Understory insectivores
	Dysithamnus xanthopterus	-	-	-	-	0.07	-	Understory insectivores
	Myrmotherula gularis	-	-	-	-	0.30	0.11	Understory insectivores
	Drymophila ochropyga	-	-	-	-	0.04	-	Bamboo or forest tangles insectivores
	Pyriglena leucoptera	0.47	0.71	1.65	1.29	1.01	0.11	understory insectivores
	Myrmeciza loricata	-	-	-	-	0.45	-	Understory insectivores
FORMICARIIDAE	*Chamaeza campanisona*	-	-	-	-	0.11	-	Understory insectivores
	Grallaria varia	-	-	-	-	-	0.06	Ground insectivore
CONOPOPHAGIDAE	*Conopophaga lineata*	0.24	0.59	0.82	0.71	0.56	0.11	Understory insectivores
	Conopophaga melanops	-	-	-	-	0.26	-	Understory insectivores
FURNARIIDAE/ SYNALLAXINAE	*Synallaxis ruficapilla*	0.35	-	0.35	0.24	0.11	-	Understory insectivores
FURNARIIDAE/ PHILYDORINAE	*Anabazenops fuscus*	0.12	-	0.24	0.12	0.22	-	Understory insectivores
	Philydor atricapillus	-	-	-	-	0.34	-	Understory insectivores
	Syndactyla rufosuperciliata	-	0.35	-	0.12	0.41	0.06	Understory insectivores
	Anabacerthia amaurotis	-	-	-	0.24	-	0.33	Understory insectivores
	Automolus leucophthalmus	-	-	-	-	0.22	-	Understory insectivores
	Philydor lichtensteini	-	-	-	-	0.04	-	Understory insectivores
	Philydor rufus	-	0.12	-	-	0.04	0.11	Understory insectivores
	Heliobletus contaminatus	-	-	-	-	-	0.17	Understory insectivores
	Xenops minutus	-	-	-	-	0.15	-	trunk and twig insectivores
	Xenops rutilans	-	-	-	0.12	-	-	Trunk and twig insectivores
	Sclerurus scansor	-	-	-	-	0.56	0.33	Understory insectivores
	Lochmias nematura	-	0.12	-	-	-	0.17	Understory insectivores

Table 1. Continued...

Families	Species	F1	F2	F3	F4	Igapira	SONP	Trophic guilds
DENDROCOLAPTIDAE	*Dendrocincla fuliginosa*	-	-	-	-	0.04	-	Trunk and twig insectivores
	Sittasomus griseicapillus	-	0.24	0.12	-	0.37	0.11	Trunk and twig insectivores
	Xiphocolaptes albicollis	-	-	-	-	0.15	-	Understory insectivores
	Lepidocolaptes fuscus	0.24	0.47	0.24	0.94	0.52	0.39	Trunk and twig insectivores
	Campylorhamphus falcularius	-	0.12	0.12	-	0.07	-	Trunk and twig insectivores
TYRANNIDAE/ ELAENIINAE	*Mionectes rufiventris*	-	-	0.12	0.12	0.56	0.61	Understory insectivores
	Leptopogon amaurocephalus	-	-	0.12	0.12	0.26	-	Understory insectivores
	Phylloscartes difficilis	-	-	-	-	0.37	-	Canopy insectovores
	Phylloscartes ventralis	-	-	-	-	0.04	-	Canopy insectovores
	Hemitriccus diops	-	-	0.47	-	-	-	Bamboo or forest tangles insectivores
	Todirostrum plumbeiceps	-	0.12	-	-	-	-	Bamboo or forest tangles insectivores
	Rhynchocyclus olivaceus	-	-	-	-	0.04	-	Understory insectivores
	Tolmomyias sulphurescens	-	0.24	0.12	-	-	-	Understory omnivores
	Platyrinchus mystaceus	-	0.12	0.12	0.47	0.52	0.06	Understory omnivores
TYRANNIDAE/ FLUVICOLINAE	*Myiobius barbatus*	-	-	-	-	0.30	-	Understory omnivores
	Lathrotriccus euleri	0.24	0.35	-	0.35	0.04	-	Understory omnivores
TYRANNIDAE/ TYRANNINAE	*Attila rufus*	-	-	-	-	0.11	0.11	Understory omnivores
	Myiarchus swainsoni	0.12	-	-	-	-	-	Treetop insectivores
PIPRIDAE	*Chiroxiphia caudata*	-	0.59	0.59	0.71	1.27	0.89	Understory omnivores
	Ilicura militaris	-	-	-	-	0.07	-	Understory omnivores
	Schiffornis virescens	-	-	-	-	0.22	-	Understory omnivores
COTINGIDAE	*Carpornis cucullatus*	-	-	-	-	-	0.06	Canopy frugivores
MUSCICAPIDAE/ TURDINAE	*Platycichla flavipes*	-	-	-	-	-	0.28	Edge omnivores
	Turdus leucomelas	0.12	0.71	0.12	0.35	-	-	Edge omnivores
	Turdus rufiventris	0.94	1.53	1.76	0.59	-	0.28	Edge omnivores
	Turdus amaurochalinus	-	0.35	0.35	-	0.04	0.06	Edge omnivores
	Turdus albicollis	-	-	0.47	0.35	0.49	0.56	Understory omnivores
VIREONIDAE	*Cyclarhis gujanensis*	-	-	0.24	0.12	-	-	Treetop insectivores
	Hylophilus poicilotis	-	-	0.12	-	0.07	-	Edge insectivores
EMBERIZIDAE/ PARULINAE	*Basileuterus culicivorus*	0.24	0.12	0.24	0.35	0.26	-	Understory insectivores
	Basileuterus leucoblepharus	-	-	-	-	-	0.11	Understory insectivores

Table 1. Continued...

Families	Species	F1	F2	F3	F4	Igapira	SONP	Trophic guilds
EMBERIZIDAE/ COEREBINAE	*Coereba flaveola*	-	-	-	-	0.04	-	Nectar and insect eaters
EMBERIZIDAE/ THRAUPINAE	*Tachyphonus cristatus*	-	-	-	-	0.04	-	Edge omnivores
	Tachyphonus coronatus	0.59	0.94	0.35	0.47	0.19	0.06	Edge omnivores
	Tachyphonus rufus	-	-	-	-	0.04	-	Edge omnivores
	Trichothraupis melanops	0.59	0.47	0.82	0.59	0.60	0.39	Understory omnivores
	Habia rubica	-	-	-	-	0.11	0.28	Understory omnivores
	Thraupis sayaca	-	-	0.12	-	-	-	Understory omnivores
	Euphonia pectoralis	-	-	-	-	0.34	-	Edge omnivores
	Tangara desmaresti	-	-	0.12	-	-	-	Edge frugivores
EMBERIZIDAE/ EMBERIZINAE	*Haplospiza unicolor*	-	-	-	-	0.11	0.06	Edge seedaters
	Arremon taciturnus	0.35	0.47	0.12	-	0.04	-	Edge seedaters
EMBERIZIDAE/ CARDINALINAE	*Pitylus fuliginosus*	-	-	-	-	0.04	-	Edge seedaters
	Saltator similis	-	-	-	-	0.37	-	Edge omnivores

F1 = fragment 1 (4 ha); F2 = fragment 2 (9 ha); F3 = fragment 3 (23 ha); F4 = fragment 4 (64 ha); Igapira = Igapira Farm (440 ha); and SONP = Serra dos Órgãos National Park (10,600 ha).

Table 2. Indicator values (% of perfect indication, based on combining values for relative abundance and relative frequency) and Monte Carlo test of significance of observed maximum indicator value. Only bird species with ten or more captures were considered in this analysis.

Species	F1	F2	F3	F4	Igapira	SONP	F
Dysithamnus mentalis	-	-	-	3	9	11	0.346
Myrmotherula gularis	-	-	-	-	23	8	0.035
Pyriglena leucoptera	4	4	26	13	7	-	0.125
Myrmeciza loricata	-	-	-	-	42	-	0.002*
Conopophaga lineata	2	5	13	12	7	1	0.648
Conopophaga melanops	-	-	-	-	31	-	0.008*
Synallaxis ruficapilla	15	-	8	4	1	-	0.226
Anabazenops fuscus	3	-	5	2	2	-	0.894
Philydor atricapillus	-	-	-	-	35	-	0.004*
Syndactyla rufosuperciliata	-	8	-	1	26	1	0.026
Sclerurus scansor	-	-	-	-	18	46	0.001*
Sittasomus griseicapillus	-	2	2	3	11	-	0.501
Lepidocolaptes fuscus	2	4	2	13	7	12	0.760
Mionectes rufiventris	-	-	1	1	11	33	0.014*
Phylloscartes difficilis	-	-	-	-	27	-	0.011
Platyrinchus mystaceus	-	1	1	7	28	1	0.002
Myiobius barbatus	-	-	-	-	38	-	0.002*
Lathrotriccus euleri	7	7	1	10	-	-	0.402
Chiroxiphia caudata	-	3	6	7	10	39	0.004*
Schiffornis virescens	-	-	-	-	38	-	0.003*
Turdus leucomelas	2	16	4	5	-	-	0.132
Turdus rufiventris	10	12	16	2	-	3	0.300
Turdus albicollis	-	-	7	4	7	26	0.056
Basileuterus culicivorus	6	3	2	9	2	-	0.692
Tachyphonus coronatus	14	12	7	4	1	-	0.441
Trichothraupis melanops	8	3	13	7	2	9	0.548
Habia rubica	-	-	-	-	1	34	0.002*
Euphonia pectoralis	-	-	-	-	15	-	0.149
Arremon taciturnus	17	13	1	-	-	-	0.107
Saltator similis	-	-	-	-	15	-	0.149

F1 = fragment 1 (4 ha); F2 = fragment 2 (9 ha); F3 = fragment 3 (23 ha); F4 = fragment 4 (64 ha); Igapira = Igapira Farm (440 ha); and SONP = Serra dos Órgãos National Park (10,600 ha).

flocks, sometimes as nuclear species) which would limit their occurrence and/or their nesting activities, leading them to prefer less altered areas. Thus, their indication for the largest area (SONP) in our analysis has matched their ecological specialization.

Conopophaga melanops is a usual member of mixed flocks (Develey and Peres, 2000) in lowland forests (Brooks et al., 1999). Machado and Fonseca (2000) captured this species up to 500 m high in the Rio Doce Valley, Minas Gerais. It also was not affected by logging in São Paulo, occurring in the same areas described before for *C. caudata* (Aleixo, 1999).

Myiobius barbatus is an uncommon to fairly common species in lower growth of humid forest and mature secondary woodlands (Ridgely and Tudor, 1994a). Machado and Fonseca (2002) sampled this species in the highest area of Rio Doce Valle. Its estimate of abundance was affected by logging in São Paulo, occurring mainly in a primary forest (Aleixo, 1999).

Myrmeciza loricata is a lowland and montane forest species (Brooks et al., 1999), living, for example, in the lower area of the Rio Doce Valle. (Machado and Fonseca, 2000) and having medium sensitivity (Ribon et al., 2003).

Philydor atricapillus is an inconspicuous bird in lower growth of humid forest and mature secondary woodland (Ridgely and Tudor, 1994a). It is a medium-sensibility species (Ribon et al., 2003) typical of mixed-flocks (Develey and Peres, 2000). These last authors

Table 3. Relative abundance, frequency of captures (in parenthesis) and percentile of perfect indication (when statistically significant) of birds with ten or more captures in six sites at Atlantic Forest in the state of Rio de Janeiro, Brazil.

Species	F1		F2		F3		F4		Igapira		SONP		(%) of perfect indication	F
Dysithamnus mentalis	0	(0)	0	(0)	0	(0)	12	(10)	42	(31)	46	(25)	-	0.346
Myrmotherula gularis	0	(0)	0	(0)	0	(0)	0	(0)	75	(35)	25	(25)	-	0.035
Pyriglena leucoptera	9	(38)	9	(33)	31	(67)	21	(50)	25	(77)	5	(13)	-	0.125
Myrmeciza loricata	0	(0)	0	(0)	0	(0)	0	(0)	100	(42)	0	(0)	42 (Igapira)	0.002*
Conopophaga lineata	7	(25)	14	(25)	22	(44)	17	(50)	32	(50)	7	(13)	-	0.648
Conopophaga melanops	0	(0)	0	(0)	0	(0)	0	(0)	100	(31)	0	(0)	31 (Igapira)	0.008*
Synallaxis ruficapilla	34	(38)	0	(0)	30	(22)	18	(20)	17	(19)	0	(0)	-	0.226
Anabazenops fuscus	17	(13)	0	(0)	31	(11)	14	(10)	38	(15)	0	(0)	-	0.894
Philydor atricapillus	0	(0)	0	(0)	0	(0)	0	(0)	100	(35)	0	(0)	35 (Igapira)	0.004*
Syndactyla rufosuperciliata	0	(0)	16	(25)	0	(0)	6	(10)	69	(58)	8	(13)	-	0.026
Sclerurus scansor	0	(0)	0	(0)	0	(0)	0	(0)	48	(46)	52	(75)	46 (SONP)	0.001*
Sittasomus griseicapillus	16	(0)	53	(8)	11	(11)	20	(10)	5	(42)	0	(0)	-	0.501
Lepidocolaptes fuscus	6	(25)	9	(33)	6	(22)	21	(40)	27	(50)	32	(50)	-	0.760
Mionectes rufiventris	0	(0)	0	(0)	4	(11)	3	(10)	28	(58)	65	(50)	33 (SONP)	0.014*
Phylloscartes difficilis	0	(0)	0	(0)	0	(0)	0	(0)	100	(27)	0	(0)	-	0.011
Platyrinchus mystaceus	0	(0)	4	(8)	5	(11)	20	(20)	65	(73)	6	(13)	-	0.002
Myiobius barbatus	0	(0)	0	(0)	0	(0)	0	(0)	100	(38)	0	(0)	38 (Igapira)	0.002*
Lathrotriccus euleri	26	(25)	26	(25)	12	(11)	32	(30)	4	(4)	0	(0)	-	0.402
Chiroxiphia caudata	0	(0)	6	(25)	10	(33)	9	(40)	27	(65)	46	(100)	39 (SONP)	0.004*
Schiffornis virescens	0	(0)	0	(0)	0	(0)	0	(0)	100	(38)	0	(0)	38 (Igapira)	0.003*
Turdus leucomelas	20	(13)	39	(42)	17	(22)	24	(20)	0	(0)	0	(0)	-	0.132
Turdus rufiventris	19	(50)	22	(50)	33	(44)	9	(20)	0	(0)	16	(38)	-	0.300
Turdus albicollis	0	(0)	0	(0)	12	(33)	8	(30)	21	(54)	59	(50)	-	0.056
Basileuterus culicivorus	20	(25)	13	(17)	18	(11)	24	(30)	25	(19)	0	(0)	-	0.692
Tachyphonus coronatus	25	(50)	27	(42)	18	(33)	16	(20)	9	(19)	5	(13)	-	0.441
Trichothraupis melanops	16	(38)	8	(25)	22	(44)	13	(40)	18	(27)	22	(63)	-	0.548
Habia rubica	0	(0)	0	(0)	0	(0)	0	(0)	0	(12)	87	(38)	34 (SONP)	0.002*
Euphonia pectoralis	0	(0)	0	(0)	0	(0)	0	(0)	100	(15)	0	(0)	-	0.149
Arremon taciturnus	42	(38)	37	(33)	12	(11)	9	(0)	9	(4)	0	(0)	-	0.107
Saltator similis	0	(0)	0	(0)	0	(0)	0	(0)	100	(15)	0	(0)	-	0.149

F1 = fragment 1 (4 ha); F2 = fragment 2 (9 ha); F3 = fragment 3 (23 ha); F4 = fragment 4 (64 ha); Igapira = Igapira Farm (440 ha); and SONP = Serra dos Órgãos National Park (10,600 ha).

have reported young individuals in an 80,000 ha protected area in São Paulo; in this state it also was not affected by logging (Aleixo, 1999). It is critically endangered in Rio Grande do Sul, occurring only in a few fragments of lowland forests in Northeastern, following *Habia rubica* (*I. Accordy, p. com.*).

Schiffornis virescens is common in montane secondary forest (Brooks et al., 1999) and in mature secondary woodlands (Ridgely and Tudor, 1994a). It was recorded in São Paulo (Willis and Oniki, 2002b; Donatelli et al., 2004) in areas ranging in size from 230 to over 21,000 ha). Aleixo (1999) detected the influence of logging in this species in that state.

The last five species also have some characteristics (e.g. foraging in mixed flocks, medium sensibility, reports for very large areas, been affected by logging) that would restrict their occurrence to medium to large area and/or mature secondary woodlots. Again Indicator Species analysis has detected some sensitive species.

Because indicator species analysis combines both species relative abundance and frequency of occurrence (Dufrene and Legendre, 1997), it can indicate which species are more closely associated to specifics habitats not by chance. Ecological indicators should trade off two potential endpoints; they should be sensitive enough to react in a detectable way when a system is affected by anthropogenic stress and they should also remain reasonably predictable in unperturbed ecosystems (Niemy and McDonald, 2004).

In accordance with Stotz et al. (1996), who have suggested that for guiding principles for bird conservation in the Neotropics, one might focus on assemblages of endemics and habitat specialists rather than on sheer number of species, we do suggest using Indicator Species analysis as a clue for detecting groups of Passerine bird species that would be bioindicators. This could be a valuable tool for a quick and primarily evaluation of the environmental quality (mainly focusing on habitat fragmentation) and for bird conservation as well.

Acknowledgements — We thank Sandro Von Matter and Rafael Kiffer for help with data collecting; CNPq for scholarships, BMBF and Fazenda Igapira for field support, IBAMA, Cristina Santos, and farmers from Teresópolis for permission to conduct this research. For valuable comments, we thank Iury Accordi.

References

AGUILAR, TM., MALDONADO-COELHO, M. and MARINI, MÄ., 2000. Nesting biology of the Gray-hooded Flycatcher (*Mionectes rufiventris*). *Ornitol. Neotrop.*, vol. 11, no. 3, p. 223-230.

ALEIXO, A., 1999. Effects of selective logging on a bird community in the Brazilian Atlantic Forest. *Condor,* vol. 101, no. 3, p. 537-548.

ALVES, MAS., PACHECO, JF., GONZAGA, LAP., CAVALCANTI, RB., RAPOSO, MA., YAMASHITA, C., MACIEL, NC. and CASTANHEIRA, M., 2000. Aves. In BERGALLO, HG., DUARTE-DA-OCHA, CF., ALVES, MAS. and VAN-SLUYS, M. (orgs.), *A fauna ameaçada de extinção do estado do Rio de Janeiro.* Rio de Janeiro: Editora UERJ.

BIERREGAARD-JR., RO., 1990. Species composition and trophic organization of the understory bird community in a Central Amazonian terra firme forest. In GENTRY, A. (ed.), *Four Neotropical Rainforests.* New Haven: Yale University Press. p. 217-236.

BIERREGAARD-JR, RO. and STOUFFER, PC., 1997. Understory birds and dynamic habitat mosaics in Amazonian rainforests. In LAURANCE, WF. and BIERREGAARD, RO., Jr. (orgs), *Tropical forest remnants, ecology, management, and conservation of fragmented communities*. Chicago: The University of Chicago Press. p. 138-155.

BLAKE, JG., and LOISELLE, BA., 2001. Bird assemblages in second-growth and old-growth forests, Costa Rica: perspectives from mist nets and point counts. *Auk,* vol. 118, no. 2, 304-326.

BROOKS, T., TOBIAS, J. and BALMFORD, A., 1999. Deforestation and bird extinctions in the Atlantic forest. *Anim. Conserv.,* vol. 2, n. 3, 211-222.

COLLAR, NJ., GONZAGA, LP., KRABBE, N., MADROÑO-NIETO, A., NARANJO, LG., PARKER III, TA. and WEGE, DC., 1992. *Threatened birds of the Americas- The ICBP/IUCN Red Data Book.* Washington, DC: Smithsonian Institution Press. p. 1150.

D'ÄNGELO-NETO, S., VENTURIN, N., OLIVEIRA-FILHO, AT. and COSTA, FAF., 1998. Avifauna de quatro fisionomias florestais de pequeno tamanho (5-8 ha) no Campus da UFLA. *Rev. Bras. Biol. = Braz. J. Biol.,* vol. 58, no. 3, p. 463-472.

DEVELEY, PF. and PERES, CA., 2000. Resource seasonality and the structure of mixed-flocks species in a coastal Atlantic forest of southeastern Brazil. *J. Trop. Ecol*., vol. 16, no. 1, p. 33-53.

DEVELEY, PF. and ENDRIGO, E., 2004. *Aves da grande São Paulo: guia de campo*.São Paulo: Aves e Fotos Editora. p. 295.

DONATELLI, RJ., COSTA, TVV. and FERREIRA, CD., 2004. Dinâmica da avifauna em fragmento de mata na Fazenda Rio Claro, Lençóis Paulista, São Paulo, Brasil. *Rev. Bras. Zool.*, vol. 21, no. 1, p. 97-114.

DUFRENE, M. and LEGENDRE, P., 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. *Ecol. Monographs.,* vol. 67, no. 3, 345-366.

FURNESS, RJ. and GREENWOOD, J., 1993. *Birds as monitors of environmental change*. London: Chapman and Hall. p. 356.

GOERCK, JM., 1997. Patterns of rarity in the birds of the Atlantic forest of Brazil. *Conserv. Biol.,* vol. 11, no. 1, p. 112-118.

MACHADO, RB. and DA FONSECA, GAB., 2000. The Avifauna of Rio Doce Valley, Southeastern Brazil, a highly fragmented area. *Biotropica*, vol. 32, no. 4b, p. 914-924.

MANHÃES, MA. and RIBEIRO, AL, 2005.Spatial distribution and diversity of bird community in an urban area of southeast Brazil. *Braz. Arch. Biol. Technol*., vol. 48, no. 2, p. 285-294.

MC-CUNE, B. and MEFFORD, MJ., 1997. *PC-ORD. Multivariate analysis of ecological data.* Gleneden Beach, Oregon: MJM Software Design.

MELO-JÚNIOR, TA., VASCONCELOS, MF., FERNANDES, GW. and MARINI, MÄ., 2001. Bird species distribution and conservation in Serra do Cipó, Minas Gerais, Brazil. *Bird Conserv. Int.,* vol. 11, no. 1, 189-204.

MITTERMEIER, RA., DA FONSECA, GAB., RYLANDS, AB. and MITTERMEIER, CG., 1999. In MITTERMEIER, RA., MYETS, N., GILL, PR. and MITTERMEIER, CG. (eds.), *Hotspots: Earth's biologically richest and endangered terrestrial ecoregions*. Mexico City, Mexico: Cemex. 432 p.

NIEMI, GJ. and MCDONALD, ME., 2004. Application of ecological indicators. *Ann. Rev. Ecol. Evol. Syst.,* vol. 35, no. 1, p. 89-111.

O'NEILL, RV., KRUMMEL, JR., GARDNER, RH., SUGIHARA, G. and JACKSON, B., 1988. Indices of landscape pattern. *Landscape Ecol.*, vol. 1, no. 3, p. 153-62.

PIRATELLI, A. and BLAKE, JG., 2006. Bird communities of the southeastern Cerrado region, Brazil. *Ornitol. Neotrop.,* vol. 17, no. 3, p. 213-225

PIZO, MA. and ALEIXO, A., 1998. Lek behavior of the Gray-hooded Flycatcher. *Condor,* vol. 100, no. 4, p. 726-731.

POZA, DD. and PIRES, JSR., 2003. Bird communities in two fragments of semideciduous forest in rural the state of São Paulo, Brazil. *Braz. J. Biol. = Rev. Bras. Biol.,* vol. 63, no. 2, p. 307-319.

RAINIO, J. and NIEMELÄ, J., 2003. Ground beetles (Coleoptera: Carabidae) as bioindicators. *Biodivers. Conserv.,* vol. 12, no. 3, p. 487-506.

REMSEN, JV., and GOOD, DA., 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. *Auk,* vol. 113, no. 2, p. 381-398.

RESTREPO, C. and GÓMEZ, N., 1998. Responses of understory birds to anthropogenic edges in a neotropical montane forest. *Ecol. Appl.,* vol. 8, no. 1, p. 170-183.

RIBON, R., LAMAS, IR. and GOMES, HB., 2004. Avifauna da Zona da Mata de Minas Gerais: Municípios de Goiná e Rio Novo, com alguns registros para Coronel Pacheco e Juiz de Fora. *Rev. Árvore*, vol. 28, no. 2, p. 291-305.

RIBON, R., SIMON, JE. and MATTOS, GT., 2003. Bird extinctions in Atlantic Forest fragments of the Viçosa region, Southeastern Brazil. *Conserv. Biol.,* vol. 17, no. 6, p. 1827-1839.

RIDGELY, RS., and TUDOR, G., 1994a. *The birds of South America. Vol. I. The Oscine Passerines.* Austin: University of Texas Press. 516 p.

-, 1994b. *The birds of South America. Vol. II. The Suboscine Passerines.* Austin: University of Texas Press. 814 p.

RIZINNI, CT., 1997. *Tratado de fitogeografia do Brasil: aspectos ecológicos, sociológicos e florísticos*. Rio de Janeiro: Âmbito Cultural. 747 p.

STOTZ, D., FITZPATRICK, JW., PARKER III, TA. and. MOSKOVITS, K., 1996. *Neotropical Birds, Ecology and Conservation.* Chicago, Illinois: The University of Chicago Press.

TERBORGH, J., 1977. Bird species diversity on an Andean elevational gradient. *Ecolog*y, vol. 58, no. 5, p. 1007-1019.

TURNER, IM., 1996. Species loss in fragments of tropical rain forest: a review of the evidence. *J. Appl. Ecol.,* vol. 33, no. 2, p. 200-209.

WANG, Y., and FINCH, DM., 2002. Consistency of mist netting and point counts in assessing landbird species richness and relative abundance during migration. *Condor,* vol. 104, no. 1, p. 59-72.

WIKIPEDIA 2006. *Serra dos Órgãos*. Available from http://en.wikipedia.org/wiki/Serra_dos_%C3%93rg%C3%A3os_National_Park. [Accessed in 20/06/2006.]

WILLIS, EO., 1979. The composition of avian communities in remanescent woodlots in southern Brazil. *Pap. Avulsos Zool.,* vol. 33, no. 1, p. 1-25.

WILLIS, EO. and ONIKI, Y., 2002a. Birds of Santa Teresa, Espírito Santo, Brazil: do humans add or subtract species? *Pap. Avulsos Zool.,* vol. 42, no. 9, p. 193-264.

-, 2002b. Birds of a central São Paulo Woodlot: 1. Censuses 1982-2000. *Braz. J. Biol.= Rev. Bras. Biol,* vol. 62, no. 2, p. 197-210.