



Structure of understory bird communities in Atlantic Forest Remnants in Northeastern Brazil

Daniela de Carvalho Melo^{1,2*}, Alvino Pedrosa Ferreira^{1,2} and Alan Loures-Ribeiro³

¹Programa de Pós-graduação em Ciências Biológicas, Universidade Federal da Paraíba, 58059-900, Cidade Universitária, Castelo Branco, João Pessoa, Paraíba, Brazil. ²Programa de Pós-Graduação em Ecologia e Recursos Naturais, Universidade Federal de São Carlos, Rod. Washington Luís, s/n, 13565-905, São Carlos, São Paulo, Brazil. ³Departamento de Sistemática e Ecologia, Universidade Federal da Paraíba, João Pessoa, Paraíba, Brazil. *Author for correspondence. E-mail: danycmpf@gmail.com

ABSTRACT. The Atlantic Forest in the State of Paraíba integrates the Pernambuco Center of Endemism. The present work investigated understory bird communities of three of its remnants using ten mist nets installed at eight different points of the forest understory of each area. We captured 333 birds of 44 species and 19 families. Bird richness and abundance did not differ between the three remnants (KW = 6.08; $p = 0.04$ and KW = 10.54; $p = 0.004$). The composition was little similar among them, and each area presented high species diversity and evenness. The most captured species were *Arremon taciturnus* ($n = 40$), *Chiroxiphia pareola* ($n = 32$) and *Conopophaga melanops* ($n = 28$). *C. melanops* has a local threat status of “vulnerable” and is considered endemic. Endangered and endemic species each represented 15.91% of the captures. Both Reserva Biológica Guaribas areas had the highest number of threatened species, while Reserva Particular do Patrimônio Natural Engenho Gargaú showed the highest number of endemic and understory insectivorous species, which indicates a better quality status in comparison to the other two. These results show the importance of the remnants to bird conservation in Northeastern Brazil.

Keywords: avifauna; endangered species; endemic species; mist nets; richness.

Estrutura das comunidades de aves de remanescentes de Mata Atlântica no nordeste do Brasil

RESUMO. A Mata Atlântica do Estado da Paraíba integra o Centro de Endemismo Pernambuco. O presente estudo investigou comunidades de aves de sub-bosque de três remanescentes da região, por meio da captura com redes de neblina. Dez redes foram posicionadas no sub-bosque florestal em oito pontos distintos ao longo de cada remanescente. Foram capturados 333 indivíduos de 44 espécies, divididas em 19 famílias. A riqueza e a abundância diferiram entre as comunidades amostradas (KW = 6,08; $p = 0,04$ e KW = 10,54; $p = 0,004$). A composição específica foi pouco similar entre elas e cada área apresentou elevada diversidade e equitabilidade na distribuição de espécies. As espécies mais representativas foram *Arremon taciturnus* ($n = 40$), *Chiroxiphia pareola* ($n = 32$) e *Conopophaga melanops* ($n = 28$), sendo este último táxon vulnerável e endêmico. As duas áreas da Reserva Biológica Guaribas tiveram o maior número de espécies ameaçadas, enquanto que a Reserva Particular do Patrimônio Natural Engenho Gargaú apresentou o maior número de espécies endêmicas, assim como de insetívoros de sub-bosque, sugerindo melhor qualidade em comparação aos outros dois. Esses resultados apontam a importância que os remanescentes estudados têm para a conservação da avifauna no nordeste brasileiro.

Palavras-chave: avifauna; espécies ameaçadas; espécies endêmicas; redes de neblina; riqueza.

Introduction

The tropical region presents high levels of biodiversity and endemism (Sodhi, Sekercioglu, Barlow, & Robinson, 2011). The Brazilian Atlantic Forest, for example, is considered one of five hotspots with the highest number of endemic species of plants and vertebrates (Myers, Mittermeier, Mittermeier, Fonseca, & Kent, 2000). Extending for roughly 150 million hectares (Ribeiro, Metzger, Martensen, & Hirota, 2009), the biome has been reduced to small forest remnants and holds a large proportion of threatened species (Goerck, 1997).

Different factors, such as size, form, isolation level, vegetation structure and forest matrix, influence the species richness and composition in a remnant (Holmes, 1990; Gimenes & Anjos, 2003; Barbosa, Knogge, Develey, Jenkins, & Uezu, 2017). Therefore, reductions in species richness and abundance may cause negative consequences and must be known in order to be restored (BirdLife International, 2008; Sodhi, Brook, & Bradshaw, 2011). Such changes can be observed in bird communities, as some species need particular resources to survive (Blake & Loiselle, 1991; Bierregaard Jr., Lovejoy, Kapos, dos Santos, & Hutchings, 1992).

Birds participate in a large range of ecological functions, such as predation, pollination, seed dispersion, nutrient deposition through feces, and even decomposition, according to the species present in the ecosystem (Lundberg & Moberg, 2003). However, ecological information on the avifauna and the relationships between habitat and species is still limited (Sodhi, Brook, & Bradshaw, 2007), even though this knowledge can help understand the consequences of habitat change (MacNally & Bennett, 1997).

One of the areas where birds need studies is the northern portion of the Brazilian Atlantic Forest, which is considered the most vulnerable region of the biome (Silva & Tabarelli, 2000). The Pernambuco Center of Endemism, situated in this area, holds two thirds of the Brazilian Atlantic Forest birds (Roda, Pereira, & Albano, 2011) and, together with the Central Atlantic Forest Ecological Corridor, form the areas with the highest number of endemic species in the country (Olmos, 2005). The Center has 40 taxa threatened to some extent and one extinction, the species *Pauxi mitu* (Linnaeus, 1766) (Roda et al., 2011). Nonetheless, some states in the Center, such as Paraíba and Rio Grande do Norte, have been little studied.

Knowledge of the avifauna in the state of Paraíba is still incipient. There are 337 bird species registered in the state (Schulz-Neto, 1995), with few of the studies developed exclusively in the Atlantic Forest (Pinto & Camargo, 1961; Almeida & Teixeira, 2010; Pereira et al., 2014). Therefore, this research aimed to measure species richness, composition, diversity and similarity of three Atlantic Forest remnants in Northeastern Brazil.

Material and methods

Study area

This research was carried out in three Atlantic Forest remnants of the coastal portion of the State of Paraíba, Northeastern Brazil. The weather is predominantly hot and humid with the mean annual temperature ranging from 24 to 26°C, with maximum annual values of 36°C; the mean pluviosity is from 1,750 to 2,000 mm year⁻¹ and the mean relative humidity reaches a maximum of 90% (Ministério do Meio Ambiente / Instituto Brasileiro do Meio Ambiente [MMA/IBAMA], 2003).

Two of the remnants integrate the Reserva Biológica Guaribas (Sema 2 and Sema 3) and the third is the Reserva Particular do Patrimônio Natural Engenho Gargaú, which belongs to the Japungu Agroindustrial S/A company. The remnants were nominated in this work as follows: “RBG1” (6°

44' 7.56" S, 35° 8' 36.90" W, central coordinates), situated in the municipality of Mamanguape, Paraíba, with 3,016.09 ha; “RBG2” (6° 48' 17.82" S, 35° 4' 59.94" W, central coordinates) situated in the municipality of Rio Tinto, Paraíba, with 338.02 ha; and “RPEG” (6° 59' 28.86" S, 34° 57' 22.44" W, central coordinates), situated in the municipality of Santa Rita, Paraíba, with 1,058 ha (Figure 1).

The areas present vegetation dominated by secondary semideciduous forest and alluvial ombrophilous dense forest, in the highest portions and along watercourses, with canopies 30 m in height; and savannic formations and transition regions between both, in Tabuleiro areas (MMA/IBAMA, 2003). The remnants are undergoing a natural restoration process after wood extraction 31 to 74 years ago, with better quality portions in RBG2 (MMA/IBAMA, 2003) and RPEG, as can be observed by the tree heights and the presence of more lianas and epiphytes. The forest of RBG1 presents more signs of degradation (MMA/IBAMA, 2003). The areas are inserted in an anthropic matrix with fruit and sugarcane farming, as well as pastures and small farms. The remnant RBG1 is surrounded mainly by fruit plantations, while RBG2 has a small city and mostly sugarcane around its borders (MMA/IBAMA, 2003) and RPEG has its edge facing mainly sugarcane and pasture.

Methods

Eight expeditions were carried out on each remnant from October 2011 to September 2012, always covering different portions. We installed ten mist nets (12 × 3 m, five shelves, 19 mm mesh) to capture birds in the forest understory from 05:00 to 11:00 for two consecutive days on each visit (Keyes & Grue, 1982). The mist nets were installed as line clusters of five in the first 60 m from the forest edge and after 180 m, in the forest interior. The total mist-net effort was 2,880h.

After capture, birds were identified using field guides (Erize, Mata, & Rumboll, 2006; Sigris, 2007) and marked with CEMAVE/IBAMA metal rings on permit number 32568-1 and SISBIO authentication code 81552292. Systematics and taxonomy followed the list of the Brazilian Ornithological Records Committee of 2015 (Piacentini et al., 2015) and trophic information followed Sick (1997). The threat level of the species followed *Instituto Chico Mendes de Conservação da Biodiversidade* (ICMBio, 2016) and the endemism status for Atlantic Forest and Pernambuco Center of Endemism followed Parker III, Stotz, and Fitzpatrick (1996) and Roda et al. (2011) respectively.

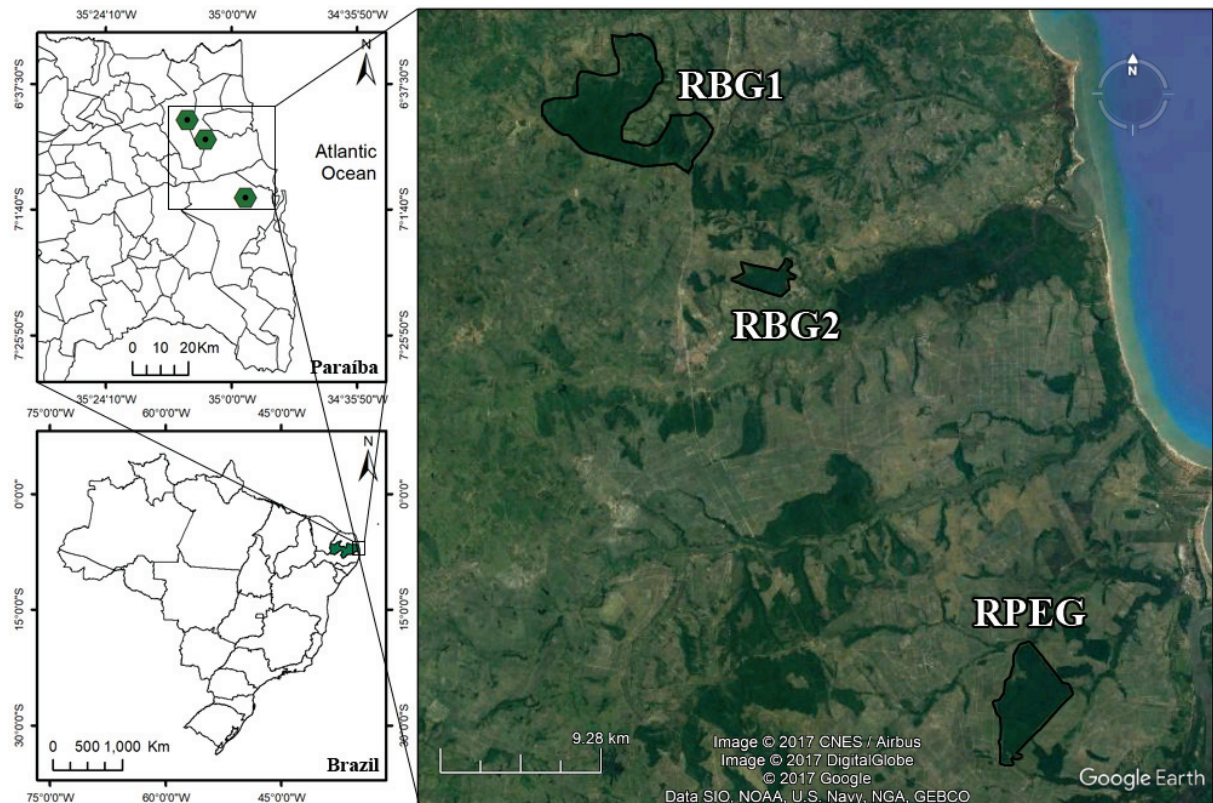


Figure 1. Map of the Atlantic Forest remnants studied in this research. RBG1 (Reserva Biológica Guaribas Sema 2), RBG2: Reserva Biológica Guaribas Sema 3, RPEG: Reserva Particular do Patrimônio Natural Engenho Gargaú.

Data analysis

We compared remnant richness and abundance from the capture data using a Kruskal-Wallis test followed by Dunn's post-hoc test ($p < 0.05$). The Shannon-Wiener diversity index was used to access bird diversity of the areas, while the Pielou index was used to verify their evenness. The similarity between remnants was measured through the Jaccard similarity index. Specimen recaptures were removed from all data analysis to avoid overestimation.

Results

We captured 333 individuals from 44 species and 23 families (Table 1). Thamnophilidae (insectivorous species), Trochilidae (nectarivorous), Rhinocyclidae (insectivorous) and Thraupidae (mostly frugivorous) were the families with the highest number of captured species ($n = 6, 5, 4$ and 4 , summed up to 43.18% of the data), while Thamnophilidae, Pipridae (insectivorous) and Passerellidae (insectivorous) comprised most of the individuals ($n = 60, 52$ and $40, 45, 65\%$). *Arremon taciturnus* (Hermann, 1783) ($n = 40$), *Chiroxiphia pareola* (Linnaeus, 1766) ($n = 32$) and *Conopophaga melanops* (Vieillot, 1818) ($n = 28$) were the most captured species.

The remnant with the highest number of species was RBG1 ($n = 30$), followed by RBG2 ($n = 27$) and RPEG ($n = 24$), which is different to the number of individuals, where RBG2 ($n = 148$) was followed by RBG1 ($n = 103$) and RPEG ($n = 82$). The recapture rate was 2%. Bird richness varied significantly between remnants (KW = 6.08; $p < 0.05$), as well as the abundance (KW = 10.54; $p < 0.05$). *Neopelma pallescens* (Lafresnaye, 1853) ($n = 15$) was the most captured species in RBG1, while *A. taciturnus* ($n = 33$) was the most captured in RBG2 and *Pyriglena leuconota* (Spix, 1824) ($n = 19$) was the most captured in RPEG.

The bird communities of the remnants presented high diversity and evenness of species distribution. The remnant RBG1 had the highest values ($H' = 3.00$, $J' = 0.88$), followed by RBG2 ($H' = 2.72$; $J' = 0.82$) and RPEG ($H' = 2.65$; $J' = 0.83$). The similarity index indicated that the remnants were not similar on species composition, with RBG1 and RBG2 showing 43% of common species, while RBG2 and RPEG were the most different, with only 29% of similarity.

Table 1. Species (Piacentini et al., 2015), abundance (N), conservation status (VU – vulnerable, EN – endangered, CR – critically endangered; ICMBio, 2016) and endemism level (AF – Atlantic Forest, CP – Pernambuco Center of Endemism; Parker III et al., 1996; Roda et al., 2011) of understory bird species of three Atlantic Forest remnants in the state of Paraíba, Northeastern Brazil, from October 2011 to September 2012. Remnants: RBG1 (Reserva Biológica Guaribas Sema 2), RBG2 (Reserva Biológica Guaribas Sema 3) and REPG (Reserva Particular do Patrimônio Natural Engenho Gargaú).

Species	RBG1 N	RBG2 N	RPEG N	Conservation / Endemism
Cracidae				
<i>Ortalis guttata</i> (Spix, 1825)	1	-	-	CR / AF
Accipitridae				
<i>Rupornis magnirostris</i> (Gmelin, 1788)	-	2	-	-
Columbidae				
<i>Columbina talpacoti</i> (Temminck, 1811)	1	-	-	-
<i>Geotrygon montana</i> (Linnaeus, 1758)	-	1	-	-
<i>Leptotila rufaxilla</i> (Richard & Bernard, 1792)	2	-	2	-
Caprimulgidae				
<i>Nyctidromus albicollis</i> (Gmelin, 1789)	2	-	1	-
Trochilidae				
<i>Chlorestes notata</i> (Reich, 1793)	1	1	-	-
<i>Eupetomena macroura</i> (Gmelin, 1788)	1	-	-	-
<i>Glaucis hirsutus</i> (Gmelin, 1788)	3	2	3	-
<i>Phaethornis pretrei</i> (Lesson & Delattre, 1839)	2	-	1	-
<i>Phaethornis ruber</i> (Linnaeus, 1758)	-	-	1	-
Momotidae				
<i>Momotus momota</i> (Linnaeus, 1766)	2	6	-	EN / CP
Galbulidae				
<i>Galbula ruficauda</i> Cuvier, 1816	3	4	-	-
Thamnophilidae				
<i>Cercomacroides laeta</i> (Todd, 1920)	-	-	1	- / CP
<i>Dysithamnus mentalis</i> (Temminck, 1823)	8	14	1	-
<i>Formicivora grisea</i> (Boddaert, 1783)	2	2	1	-
<i>Myrmotherula axillaris</i> (Vieillot, 1817)	-	-	10	-
<i>Pyriglena leuconota</i> (Spix, 1824)	-	-	19	- / CP
<i>Thamnophilus pelzelni</i> Hellmayr, 1924	2	-	-	-
Conopophagidae				
<i>Conopophaga melanops</i> (Vieillot, 1818)	-	13	15	VU / AF-CP
Dendrocolaptidae				
<i>Sittasomus griseicapillus</i> (Vieillot, 1818)	3	7	-	-
<i>Xiphorhynchus atlanticus</i> (Cory, 1916)	1	2	1	VU / AF
Xenopidae				
<i>Xenops minutus</i> (Sparman, 1788)	4	4	4	VU / CP
Pipridae				
<i>Chiroxiphia pareola</i> (Linnaeus, 1766)	14	12	6	-
<i>Manacus manacus</i> (Linnaeus, 1766)	-	-	1	-
<i>Neopelma pallescens</i> (Lafresnaye, 1853)	15	2	2	-
Rhynchocyclidae				
<i>Hemitriccus griseipectus</i> (Sneath, 1907)	8	9	-	VU / -
<i>Hemitriccus striatocollis</i> (Lafresnaye, 1853)	-	1	-	-
<i>Leptopogon amaurocephalus</i> Tschudi, 1846	3	2	2	-
Continuation				
<i>Tolmomyias flaviventris</i> (Wied, 1831)	1	1	-	-
Onychorhynchidae				
<i>Myiobius barbatus</i> (Gmelin, 1789)	1	2	1	-
Tyrannidae				
<i>Rhytipterna simplex</i> (Lichtenstein, 1823)	-	-	1	-
Pipritidae				
<i>Platyrinchus mystaceus</i> Vieillot, 1818	3	7	2	VU / -
Vireonidae				
<i>Vireo olivaceus</i> (Linnaeus, 1766)	-	1	-	-
Troglodytidae				
<i>Pheugopedius genibarbis</i> (Swainson, 1838)	-	2	-	-
<i>Troglodytes musculus</i> Naumann, 1823	-	1	-	-
Turdidae				
<i>Turdus leucomelas</i> Vieillot, 1818	1	15	1	-
Thraupidae				
<i>Coereba flaveola</i> (Linnaeus, 1758)	1	-	1	-
<i>Cyanerpes cyaneus</i> (Linnaeus, 1766)	1	1	-	-
<i>Lanio cristatus</i> (Linnaeus, 1766)	4	-	1	-
<i>Tachyphonus rufus</i> (Boddaert, 1783)	2	-	-	-
Passerellidae				
<i>Arremon taciturnus</i> (Hermann, 1783)	3	33	4	-
Parulidae				
<i>Myiothlypis flaveola</i> (Baird, 1865)	8	-	-	-
Fringillidae				
<i>Euphonia violacea</i> (Linnaeus, 1758)	-	1	-	-
Total	103	148	82	
Diversity (H')	3.00	2.72	2.65	
Evenness (J')	0.88	0.82	0.83	

Among the captured species, 15.91% (24.64% of the individuals) are considered threatened to some extent: *Ortalis guttata* (Spix, 1825) (n = 1); *Momotus momota* (Linnaeus, 1766) (n = 8); *C. melanops* (n = 28); *Xiphorhynchus atlanticus* (Cory, 1916) (n = 4); *Xenops minutus* (Sparrman, 1788) (n = 12); *Hemitriccus griseipectus* (Snethlage, 1907) (n = 17); *Platyrinchus mystaceus* Vieillot, 1818 (n = 12) (Table 1). With the exception of *H. griseipectus* and *P. mystaceus*, these same species, as well as *Cercomacroides laeta* (Todd, 1920) (n = 1) and *Pyrgilena leuconota* (Spix, 1824) (n = 19), are endemic, with a similar sum of 15.91% (21.92% of the individuals). The remnants RBG1 and RBG2 had six of the threatened and four of the endemic species, while RPEG presented four and five, respectively (Table 1).

Discussion

The passeriforms are the most representative birds in Atlantic Forest remnants of tropical regions (Donatelli, Costa, & Ferreira, 2004; Donatelli, Ferreira, Dalbeto, & Posso, 2007), mainly the insectivorous and nectarivorous species accessed by mist-net techniques (Dunn & Ralph, 2004). The families Thamnophilidae and Trochilidae, for example, had some of the most captured species in the understory studied in both other research (Ribeiro et al., 2009; Gouvêa-Maia, Gouvêa, & Piratelli, 2005) and this study.

The remnants investigated here presented bird communities with species commonly found in the Atlantic Forest of Northeastern Brazil (Telino-Júnior, Dias, Azevedo-Júnior, Neves, & Larrazabal, 2005; Farias, Alves, & Silva, 2007; Farias, 2009; Roda et al., 2011). *A. taciturnus*, *N. pallescens* and *C. pareola*, for example, abundant in this study, are commonly registered in the Pernambuco Center of Endemism, using the edges and interiors of the areas (Ridgely & Tudor, 1997; Lyra-Neves, Dias, Azevedo-Junior, Telino-Junior, & Larrazabal 2004; Roda et al., 2011). Species with low representativity in this study, such as *X. atlanticus*, *X. minutus* and *Myiobius barbatus* (Gmelin, 1789), were also marginally observed in the studies above (Lyra-Neves et al., 2004; Farias, Alves, & Silva, 2007). Low capture rates of three or four individuals are considered a common event in bird communities of tropical forests (Karr, Robinson, Blake, & Bierregaard, 1990).

On the other hand, some threatened species and those of higher sensitivity levels, such as *P. mystaceus*, *P. leuconota* and *C. melanops* (Parker III et al., 1996; ICMBio, 2016), registered at a high frequency here, were represented by low numbers in other alluvial ombrophilous dense forest remnants studies in Pernambuco (Lyra-Neves et al., 2004; Farias, 2009).

These species feed mainly on insects in the understory and sometimes follow army ants, aiming for exposed arthropods flushed by the swarms (Remsen et al., 1983), which was seen during this study (mainly in RPEG) and may have influenced their presence. This disparity between research and areas within this study may also occur because of differences in the vegetation, size and quality of the areas, as well as the different anthropic use and occupation history (Martin, Gaston, & Hitier, 1995; Farias et al., 2007).

The highest richness and diversity found in RBG1 may be mainly due to its larger size in comparison to the other remnants (Gimenes & Anjos, 2003; Telles & Dias, 2010), since several factors, such as size, shape, isolation degree and characteristics of remnants may influence species presence, richness and diversity (Farias et al., 2007; Martin et al., 1995). Also, the habitat chosen by some bird species may be highly specific and influenced by the vegetation of the forest remnant and surrounding matrix structures (Gimenes & Anjos, 2003). The dissimilarity found between the bird communities of each area may have been influenced by the different surrounding matrices and the fact that RBG1 and RBG2 are administrated by government and legal protection, while RPEG is a private area (MMA/IBAMA, 2003). The surrounding matrices of forest remnants directly influence habitat quality, species composition and their dispersion (Bierregaard & Stouffer, 1997; Sisk, Haddad, & Ehrlich, 1997), as the distance between remnants may make dispersion of individuals between areas difficult and select distinct species (Sisk et al., 1997; Telles & Dias, 2010; Ferraz et al., 2007).

The presence of some threatened and endemic species in this portion of the Atlantic Forest was one of the main aspects found in this study (Roda et al., 2011; Telino-Júnior et al., (2005), Farias et al., 2007; Farias, 2009). This may suggest that the investigated areas are still capable of presenting good habitat quality (Gouvêa-Maia et al., 2005). On the other hand, even though our samples were limited by the use of mist nets, the presence of species with special habitat requirements, such as understory insectivores (e.g. *P. leuconota* and *C. laeta* in RPEG), and their absence in both Reserva Biológica Guaribas areas may indicate that their local conditions may not be as good as those found in RPEG.

Conclusion

The data suggests the need to understand the factors capable of maintaining a group of species in fragmented areas; this particularly concerns species

that are highly sensitive to disturbance. More detailed studies may help define their actual conservation status.

Even though the remnants present a similar history of anthropic pressure and a great portion of the areas were intensely disturbed in recent decades (MMA/IBAMA, 2003), the high diversity found, as well as the presence of endangered and endemic species shows the importance for the bird conservation in Northeastern Brazil and the importance of studying forest remnants and their biodiversity.

References

- Almeida, A. C. C., & Teixeira, D. M. (2010). Aves da Reserva Biológica Guaribas, Mamanguape, Paraíba, Brasil. *Revista Nordestina de Biologia*, 19(2), 3-14.
- Barbosa, K. V. C., Knogge, C., Develey, P. F., Jenkins, C. N., & Uezu, A. (2017). Use of small Atlantic Forest fragments by birds in Southeast Brazil. *Perspectives in Ecology and Conservation*, 15(1), 42-46. doi: 10.1016/j.pecon.2016.11.001
- Bierregaard Jr., R. O., Lovejoy, T. E., Kapos, V., dos Santos, A. A., & Hutchings, R. W. (1992). The biological dynamics of tropical rainforest fragments. *Bioscience*, 42(11), 859-866. doi: 10.2307/1312085
- Bierregaard Jr., R. O., & Stouffer, P. C. (1997). Understory birds and dynamic habitat mosaics in Amazonian Rainforest. In W. F. Laurance, R. O. Bierregaard (Eds.), *Tropical forest remnants: ecology, management, and conservation of fragmented communities* (p. 138-155). Chicago, IL: The University of Chicago Press. doi: 10.1017/s0376892900038315
- BirdLife International. (2008). *State of the World's Birds: indicators for our changing world*. Cambridge, UK: BirdLife International. doi: 10.1017/s003060530523 0181
- Blake, J. G., & Loiselle, B. A. (1991). Variation in Resource Abundance Affects Capture Rates of Birds in Three Lowland Habitats in Costa Rica. *The Auk*, 108(1), 114-130.
- Donatelli, R. J., Costa, T. V. V., & Ferreira, C. V. (2004). Dinâmica da avifauna em um fragmento florestal na Fazenda Rio Claro, Lençóis Paulista, São Paulo, Brasil. *Revista Brasileira de Zoologia*, 21(1), 97-114. doi: 10.1590/s0101-81752004000100017
- Donatelli, R. J., Ferreira, C. D., Dalbeto, A. C., & Posso, S. R. (2007). Análises comparativas de assembléias de aves de dois remanescentes florestais no interior de São Paulo, Brasil. *Revista Brasileira de Zoologia*, 24(2), 362-375. doi: 10.1590/s0101-81752007000200015
- Dunn, E. H., & Ralph, J. C. (2004). Use of mist nets as a tool for bird population monitoring. *Studies in Avian Biology*, 29, 1-6.
- Erize, F., Mata, J. R. R., & Rumboll, M. (2006). *Birds of South America: Non-Passerines (Rheas to Woodpeckers)*. Princeton, NJ: Princeton University Press.
- Farias, G. B., Alves, A. G. C., & Silva, A. C. B. L. (2007). Riqueza de aves de cinco fragmentos de Mata Atlântica na Zona da Mata Norte de Pernambuco, Brasil. *Biotemas*, 20(4), 111-122. doi: 10.5007/%25x
- Farias, G. B. (2009). Variação temporal em comunidades de aves de uma área de Mata Atlântica da Estação Ecológica de Caetés, Pernambuco, Brasil. *Atualidades Ornitológicas On-line*, 147, 40-45.
- Ferraz, G., Nichols, J. D., Hines, J. E., Stouffer, P. C., Bierregaard Jr., R. O., & Lovejoy T. E. (2007). A Large-Scale Deforestation Experiment: Effects of patch area and isolation on Amazon birds. *Science*, 315(5809), 238-241. doi: 10.1126/science.1133097
- Gimenes, M. R., & Anjos, L. (2003). Efeitos da fragmentação florestal sobre as comunidades de aves. *Acta Scientiarum Biological Sciences*, 25(2), 391-402. doi: 10.4025/actascibiolsci.v25i2.2030
- Goerck, J. M. (1997). Patterns of Rarity in the Birds of the Atlantic Forest of Brazil. *Conservation Biology*, 11(1), 112-118. doi: 10.1046/j.1523-1739.1997.95314.x
- Gouvêa-Maia, E. R., Gouvêa, E., & Piratelli, A. (2005). Comunidades de aves de sub-bosque em uma área do Parque Nacional do Itatiaia, Rio de Janeiro, Brasil. *Revista Brasileira de Zoologia*, 22(4), 859-866. doi: 10.1590/s0101-81752005000400009
- Holmes, R. T. (1990). Food resource availability and use in forest bird communities: a comparative view and critique. In A. Keast (Ed.), *Biogeography and ecology of forest bird communities* (p. 387-393). Hague, SH: SPB Academic Publishing.
- Instituto Chico Mendes de Conservação da Biodiversidade. [ICMBio]. (2016). *Sumário executivo do Livro Vermelho da fauna brasileira ameaçada de extinção*. Retrieved on September, 18, 2016 from www.icmbio.gov.br/portal/images/stories/comunicacao/publicacoes/publicacoes-diversas/dcom_sumario_executivo_livro_vermelho_da_fauna_brasileira_ameacada_de_extincao_2016.pdf
- Keyes, B. E., & Grue, C. E. (1982). Capturing birds with mist nets: a review. *North American Bird Bander*, 7(1), 2-14.
- Karr, J. R., Robinson, S. K., Blake, J. G., & Bierregaard, R. O. (1990). Birds of four Neotropical forests. In A. H. Gentry (Ed.), *Four Neotropical forests* (p. 237-269). Yale, CT: Yale University Press.
- Lundberg, J., & Moberg, F. (2003). Mobile link organisms and ecosystem functioning: implications for ecosystem resilience and management. *Ecosystems*, 6(1), 87-98. doi: 10.1007/s10021-002-0150-4
- Lyra-Neves, R. M., Dias, M. M., Azevedo-Júnior, S. M., Telino-Júnior, W. R., & Larrazábal, M. E. L. (2004). Comunidades de aves da Reserva Estadual de Gurjaú, Pernambuco, Brasil. *Revista Brasileira de Zoologia*, 21(3), 581-592. doi: 10.1590/s0101-81752004000300021
- Martin, J. L., Gaston, A. J., & Hitier, S. (1995). The effect of island size and isolation and old growth forest habitat and bird diversity in Gwaii Haanas (Queen Charlotte Islands, Canada). *Oikos*, 72(1), 115-131. doi: 10.2307/3546045

- MacNally, R., & Bennett, A. F. (1997). Species-specific predictions of the impact of habitat fragmentation: local extinction of birds in the box-ironbox forests of central Victoria, Australia. *Biological Conservation*, 82, 147-155. doi: 10.1016/s0006-3207(97)00028-1
- Ministério do Meio Ambiente / Instituto Brasileiro do Meio Ambiente [MMA/IBAMA]. (2003). *Plano de Manejo da Reserva Biológica Guaribas*. Brasília, DF: Ibama.
- Myers, N., Mittermeier, R. A., Mittermeier, C. G., Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403(6772), 853-855. doi: 10.1038/35002501
- Olmos, F. (2005). Aves ameaçadas, prioridades e políticas de conservação no Brasil. *Natureza & Conservação*, 3(1), 21-42.
- Parker, T. A. III, Stotz, D. F., & Fitzpatrick, J. W. (1996). Ecological and Distributional Databases. In D. F. Stotz, J. W. Fitzpatrick, T. A. Parker III, & D. K. Moskovits, (Ed.), *Neotropical Birds: Ecology and Conservation* (p. 115-291). Chicago, IL: The University of Chicago Press.
- Pereira, G. A., Lobo-Araújo, L. W., Leal, S., Medcraft, J., Marantz, C. A., Toledo, M. T. F., ... Pioli, D. (2014). Important bird records from Alagoas, Pernambuco and Paraíba, north-east Brazil. *Cotinga*, 34(2014), 17-22.
- Piacentini, V. de, Q., Aleixo, A., Agne, C. E., Maurício, G. N., Pacheco, J. F., Bravo, G. A., ... Cesari, E. (2015). Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee/Lista comentada das aves do Brasil pelo Comitê Brasileiro de Registros. *Revista Brasileira de Ornitologia*, 23(2), 90-298.
- Pinto, O. M. O., & Camargo, E. A. (1961). Resultados ornitológicos de quatro recentes expedições do Departamento de Zoologia ao nordeste do Brasil, com descrição de seis novas sub-espécies. *Arquivos de Zoologia*, 11(9), 193-284.
- Remsen Jr, J. V., Cadena, C. D., Jaramillo, A., Nores, M., Pacheco, J. F., Pérez-Emán, J., Rettenmeyer, C. W. (1983). *Ecton burchelli* and other army ants (*Hormiga arriera*), Army Ants. In D. H. Janzen (Ed.), *Costa Rican Natural History* (p.716-718). Chicago, IL: University of Chicago Press.
- Ribeiro, M. C., Metzger, J. P., Martensen, A. C., & Hirota, M. M. (2009). The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation*, 142(6), 1141-1153. doi: 10.1016/j.biocon.2009.02.021
- Ridgely, R. S., & Tudor, G. (1997). *The birds of South America: the Oscines Passerines* (v. 1). Austin, TX: University of Texas Press.
- Roda, S. A., Pereira, G. A., & Albano, C. (2011). *Conservação das aves endêmicas do Centro de Endemismo Pernambuco*. Recife, PE: Editora Universitária da UFPE.
- Silva, J. M. C. & Tabarelli, M. (2000). Tree species impoverishment and the future flora of the Atlantic forest of northeast Brazil. *Nature*, 404, 72-74. doi: 10.1038/35003563
- Schulz-Neto, A. (1995). *Lista de aves da Paraíba*. João Pessoa, PB: Superintendência do IBAMA no Estado da Paraíba.
- Sick, H. (1997) *Ornitologia Brasileira* (v. 1). Rio de Janeiro, RJ: Editora Nova Fronteira.
- Sigrist, T. (2007). *Aves do Brasil oriental*. São Paulo, SP: Avis Brasilis.
- Sisk, T. D., Haddad, N. M., & Ehrlich, O. R. (1997). Bird assemblages in patchy woodlands: modeling the effects of edge and matrix habitats. *Ecological Applications*, 7(4), 1170-1180. doi: 10.2307/2641205
- Sodhi, N. S., Brook, B. W., & Bradshaw, C. J. A. (2007). *Tropical Conservation Biology*. Oxford, OX: Blackwell Publishing.
- Sodhi, N. S., Şekercioğlu, C. H., Barlow, J., & Robinson, S. K. (2011). *Conservation of Tropical Birds*. Oxford, OX: Wiley-Blackwell. doi: 10.1002/9781444342611
- Telino-Júnior, W. R., Dias, M. M., Azevedo-Júnior, S. M., Neves, R. M. L., & Larrazabal, M. E. L. (2005). Estrutura trófica da avifauna na Reserva Estadual de Gurjá, Zona da Mata Sul, Pernambuco, Brasil. *Revista Brasileira de Zoologia*, 22(4), 962-973. doi: 10.1590/s0101-81752005000400024
- Telles, M., & Dias, M. M. (2010). Bird communities in two fragments of Cerrado in Itirapina, Brazil. *Brazilian Journal of Biology*, 70(3), 537-550. doi: 10.1590/s1519-69842010000300010

Received on May 9, 2017.

Accepted on May 17, 2018.

License information: This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.