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Birds from open environments in the caatinga from state of Alagoas, northeastern Brazil

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ABSTRACT. Even though the caatinga has been identified as an important area of endemism for South American birds, few studies have been conducted on the distribution, evolution and ecology of birds in this biome. Understanding how habitats contribute to maintain the regional bird diversity is extremely important. In this study, carried out in the backwoods of the state of Alagoas, we present a rapid survey of a caatinga area and discuss the composition of the avifauna in different habitats. From the record of 105 species, we estimated a local richness of 120 (± 5) species. Among the areas surveyed, the dense caatinga shrub areas contributed with more than 42% of the species, holding most of the forest-dependent birds. The open field areas and the vegetation patches contributed 26 and 24% of the observed richness, respectively. The bird community at the vegetation patches is more similar to that registered in the open caatinga shrub areas, than to the fauna of the open fields where these patches are located. Our results support the need to conserve environments which harbor typical caatinga vegetation, and also vegetation patches with those characteristics in greatly altered environments.

KEY WORDS. Avifauna; conservation; habitat preference; species richness.

The caatinga, with an area of 735,000 km², covers most of the northeastern Brazilian territory. Located between latitudes 2°54'S and 17°21'S, it extends through the dry valley from the middle Jequitinhonha River, in the state of Minas Gerais. The typical caatinga vegetation is characterized by xerophytic, deciduous arboreal and shrub formations, with trees and shrubs bearing thorns (Prado 2003, Leal *et al.* 2005).

Prado & Gibbs (1993) characterized the caatingas from the Brazilian Northeast as one of the largest areas of Seasonal Neotropical Dry Forests (SNDF) in South America. Other large SNDFs can be found in Misiones and Piedmont nuclei, and on the Caribbean coasts of Colombia and Venezuela. Smaller and more isolated SNDFs occur in dry valleys in the Andes in northern Bolivia, Peru, southern Ecuador and the adjacent northern Peru, Mato Grosso de Goiás in central Brazil, and scattered throughout the Brazilian Cerrado in areas of fertile soils (Ratter *et al*. 1978). SNDFs in the Neotropical region also occur in Mesoamerica, and in Florida (Pennington *et al*. 2006).

The diversity, species richness and number of endemic species in the caatinga region have for a long time been considered low (e.g., Vanzolini *et al*. 1980, Andrade-Lima 1982, Prance 1987). However, some recent studies have revealed significantly higher species richness in the region. As a consequence, the need to preserve this important component of the Brazilian biodiversity has been widely acknowledged (Leal *et al*. 2003, Silva *et al*. 2004, Leal *et al*. 2005). The true number of species in the caatinga region, however, is potentially much greater than the present estimates, because 41% of the region has never been surveyed, and 80% of it has been only poorly investigated (Tabarelli & Vicente 2004).

Even though the caatinga has been identified as an important area of endemism for South American birds (Muller 1973, Cracraft 1985, Haffer 1985, Rizzini 1997), the distribution, evolution and ecology of its avifauna have been poorly investigated (Silva *et al*. 2003).

Recently, Santos (2004) discussed the ecological preferences of birds in two caatinga physiognomies in the state of Piauí. Olmos *et al*. (2005) also discussed and compared the avifauna in different physiognomies in the states of Pernambuco and Ceará. However, our knowledge of how bird diversity is maintained in different caatinga environments is still incipient. This biome has a variety of habitats and is subjected to extensive anthropic alterations.

In this study we present the results of a rapid survey in a caatinga area in the backwoods of the state of Alagoas, and discus the avifauna composition of the different environments we found.

MATERIAL AND METHODS

We carried out our sampling at the adjacencies of the BR-316 road between the cities of Canapi and Inajá (37°40'21"W and 9°5'55"S), at the borders between the states of Alagoas and Pernambuco, at an area of approximately 63 km (Fig. 1). This area is inserted among the caatinga eco-regions from Planalto da Borborema and Depressão Sertaneja Sentetrional. It is also adjacent to the Raso da Catarina region (Veloso *et al.* 2002).

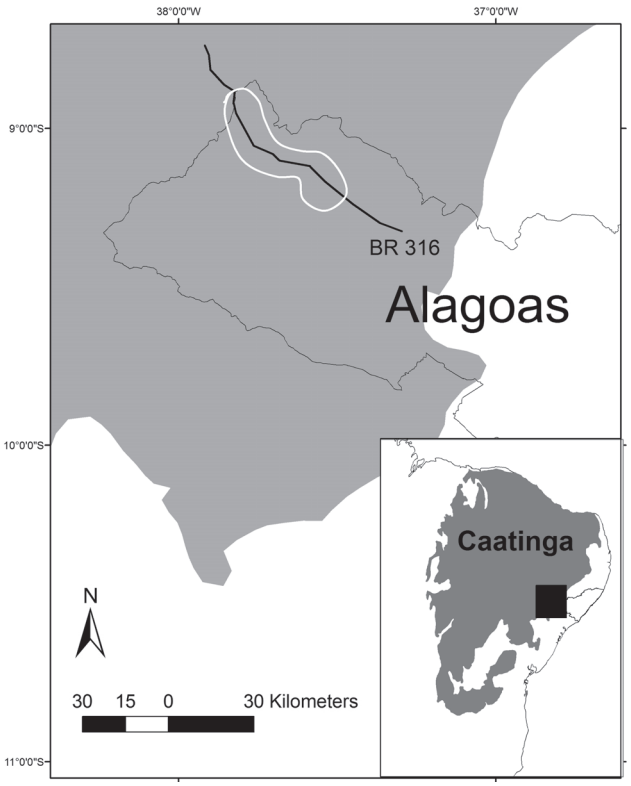


Figure 1. Location of the study area. BR 316 (black line) and sampled area (white line) are detached.

Our sampling sites broadly correspond to two physiognomic landscapes. In the northern part of the road, on the mountains, the caatinga has open vegetation with shrubs and small trees, and some larger trees among them. In the surveyed central and southern parts of the road, we find open fields consisting of pastures and subsistence agricultural crops, with some shrub patches (Fig. 2). These open caatinga areas have been altered by wood removal, trails, and the presence of animals such as goats.

Sampling took place in January and May 2008, during the dry and rainy seasons, respectively. We applied 72 point counts, 200 m apart from one another, each lasting 10 minutes, totaling 36 point counts in each season. During the point counts, conducted during the first three hours in the morning, sounds and visual records and counts of birds were marked at a 50 m fixed radius and at an unlimited radius (Adapted from Hutto *et al.* 1986). We also conducted observations in random spots along the sampled road.

Figure 2. Typical landscape found in the study area, with open caatinga vegetation and open fields used for pasture and agriculture.

We grouped the recorded species into three categories according to habitat use, as follows: (IND) Independent: species associated only with open vegetation; (SMD) Semi-dependent: species occurring in mosaics formed in the contact areas between forests and open and semi-open vegetation; (DEP) Dependent: species found in forest habitats. Such classification was based on literature information (Silva 1995, Stotz *et al.* 1996, Silva *et al.* 2003). Nomenclature follows CBRO (2009).

We calculated the relative abundance (average number of individuals/point X 100) and frequency of occurrence of each species from records obtained within a 50 m radius, as well as the frequency of occurrence of data from unlimited radius, as recommended in an evaluation of the caatinga by the first author and collaborators (H.F.P. de Araujo unpubl. data).

The total number of species observed at the point counts (Sobs) was represented by a rarefaction curve. The performance of this curve can help estimate the number of species that have not yet been observed in the study area (Chazdon *et al.* 1998). To make this estimate, we used the Chao2 and Jack 1 richness estimators, which have performed better in the caatinga (H.F.P. de Araujo unpubl. data). The rarefaction curve and estimated richness were calculated using the software EstimateS 7.5 (Colwell 2005).

Diversity measures and descriptive statistics were used to compare the avifauna and the percentage distribution of the categories of habitat use in the registered environments. Such environments were classified as: open caatinga (21 point

counts sampled), open field (23 point counts), shrub patches in open fields (19 point counts) and aquatic environments (9 point counts).

In order to compare the proportion of each bird species in each of the different environment sampled, we used the Shannon's diversity index estimate and 95% confidence intervals in each habitat. This estimate technique is based on sampling coverage and also includes species which were expected but not sampled (Chao & Shen 2003). These calculations and the Shannon estimates were performed using the SPADE – Species Prediction and Diversity Estimation software program and 95% confidence intervals (Chao & Shen 2003, 2005).

We compared the avifauna composition among different environments using the Jaccard's similarity index based on estimates, with abundance data. This index was modified from the classical Jaccard index by Chao *et al.* (2005). The latter have adapted the Jaccard index to deal with abundance data, and have developed algorithms to calculate similarities between two assemblies that also take into account species which were not sampled. To this procedure uses "singletons" (species represented by only one individual) and "doubletons" (species represented by exactly two individuals). All similarity analysis was performed using the SPADE software. The similarity matrix obtained was subjected to ordination analysis using multidimensional scaling (MDS).

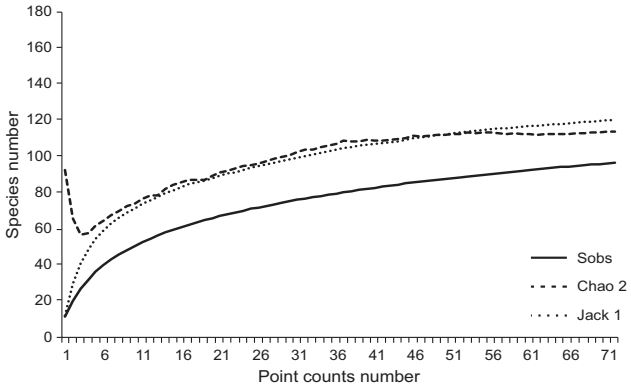


Figure 3. Rarefaction curve (Sobs) and species richness estimates (Chao2 and Jack1) of the birds recorded with point counts.

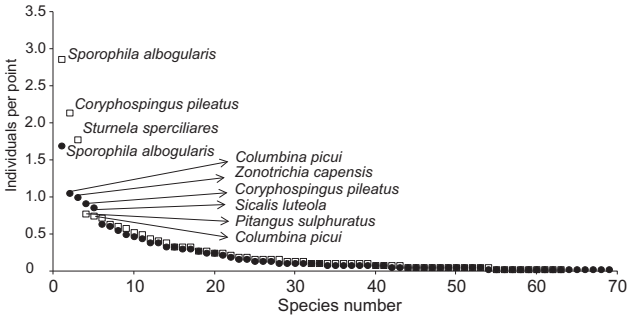


Figure 4. Abundance curve of bird species recorded with point counts (fixed radius of 50 m). Dry season (white squares) and rainy season (black circles).

RESULTS

Using point counts and unsystematic observations, we recorded 105 bird species distributed in 38 families. Tyrannidae, with 20 registered species, was the most ubiquitous family, followed closely by Emberizidae (nine species) and Columbidae (six species).

Using the systematic method of point counts, we counted 97 bird species, representing 93.2% of the total previously recorded for the area (Appendix 1). The rarefaction curve has shown that more, unrecorded species occur in the study area. However, a total species richness of about 120 (± 5) can be estimated with Chao2 and Jack 1 estimators (Fig. 3).

The number of species observed in the rainy period represents 90.4% of the total number of species registered. In the dry season, by contrast, only 76.9% of the total number of species was found. The abundance curves of the species registered in the two seasons are shown in figure 4. Two species, *Sturnella superciliaris* (Bonaparte, 1850) and *Pitangus sulphuratus* (Linnaeus, 1766), were amongst the five most abundant species only in the dry season. *Zonotrichia capensis* (Statius Muller, 1776) and *Sicalis luteola* (Sparrman, 1789), by contrast, appeared among the five most abundant during the rainy season only.

We recorded 11 species with restricted distribution in Brazil, according to Ridgely & Tudor (1994), Sick (1997) and Ridgely *et al.* (2005). Seven are typical species from the Brazilian Northeast: *Caprimulgus hirundinaceus* Spix, 1825 – typical species from the caatinga region, registered in northern Espírito Santo (Ribon 1995); *Pseudoseisura cristata* (Spix, 1824) – endemic species which has been separated from the old combination *Pseudoseisura cristata unirufa*, and which occurs in the Pantanal and in Bolivia (Zimmer & Whittaker 2000); *Thamnophilus capistratus* Lesson, 1840 – recently validated within the *T. doliatus* (Linnaeus, 1764) complex (Assis *et al.* 2007); *Compsothraupis loricata* (Lichtenstein, 1819); *Sporophila albogularis* (Spix, 1825) – only two other records are from locations in northern Goiás and Mato Grosso (Silva 1995); *Paroaria dominicana* (Linnaeus, 1758) and *Agelaioides fringillarius* (Spix, 1824). Two species are restricted to eastern Brazil: *Heliomaster squamosus* (Temminck, 1823) and *Cantorchilus longirostris* (Vieillot, 1819). Two other species have a slightly wider distribution in the Brazilian central-eastern territory: *Nystalus maculatus* (Gmelin, 1788) and *Cyanocorax cyanopogon* (Wied, 1821).

The areas from open caatinga have contributed with more than 42% of the observed species richness. In these areas, most species that are at least partially dependent on forest environments were also observed (Fig. 5). The open fields, and shrub

patches found in the open fields contributed with about 26 and 24% of the observed richness, respectively. However, the percentages of species that are at least partially dependent on forests were greater in patches than in open fields (Fig. 5).

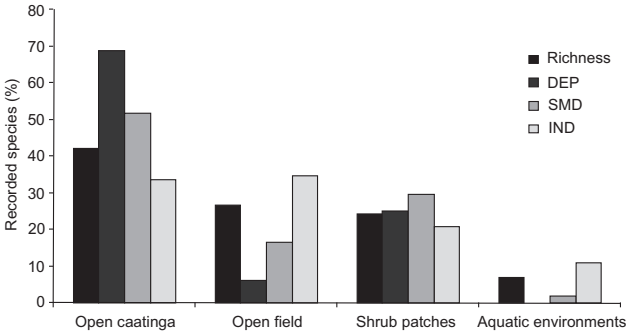


Figure 5. Percentage of species richness and their categories of habitat use in the recorded habitats. Categories of habitat use: IND. forest independent, SMD. forest semi-dependent, DEP. forest dependent.

The estimated diversity index was significantly higher in the open caatinga areas than in any of the other habitats. The values of this index were greater in the open field areas and shrub patches than in the aquatic environments, but did not differ significantly from one another (Fig. 6).

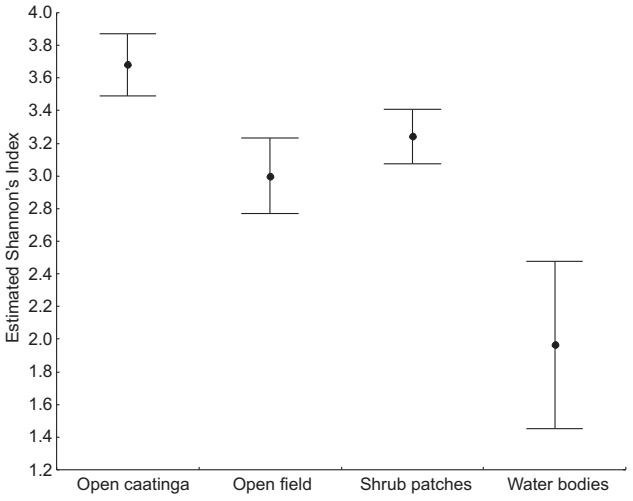


Figure 6. Estimate of Shannon's diversity index of bird species recorded in each environment. The bars indicate the confidence intervals of 95%.

The avifauna composition in the shrub patches was more similar to the avifauna registered in the open caatinga areas than to that found in the open fields where the shrub patches are inserted (Fig. 7). As expected, the avifauna composition of the aquatic environments differed from those of all other habitats the most.

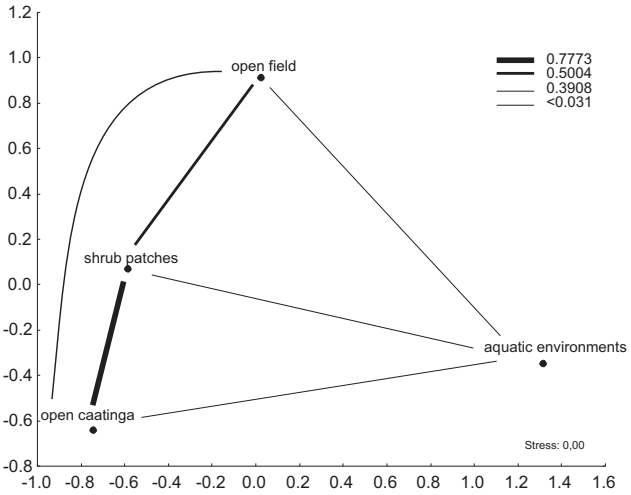
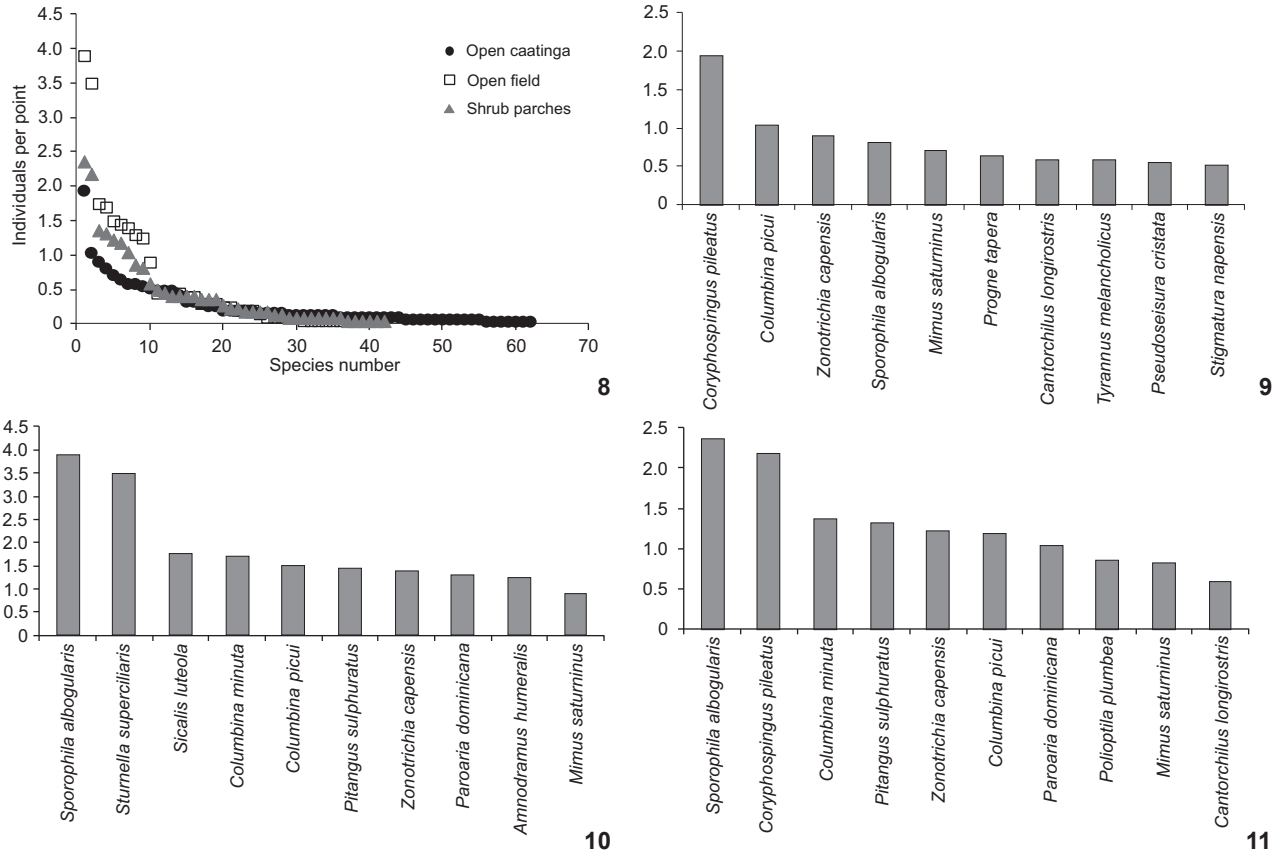


Figure 7. Multidimensional scaling (MDS) with similarity matrix using Jaccard's index estimates with abundance data, of the bird species composition in the each habitat. The thickness of the lines indicates the similarity values that are demonstrated in the legend.

The differences and similarities among open caatinga, shrub patches and open fields can be demonstrated using their most abundant species. Approximately after the 10th most abundant species, there is a sharp fall in the species abundance curves for open field and shrub patches. For this reason, we used the 10 most abundant species to compare among the habitats (Figs 8-11). Four species were among the 10 mostabundant in the three habitats: *Columbina picui* (Temminck, 1813), *Mimus saturninus* (Lichtenstein, 1823), *Zonotrichia capensis* (Statius Muller, 1776) and *Sporophila albogularis* (Spix, 1825). The abundance curve of the open caatinga area shows a more equitable distribution when compared with the other two habitats. This area has four exclusive species among the 10 most abundant: *Pseudoseisura cristata* (Spix, 1824), *Stigmatura napensis* Chapman, 1926, *Tyrannus melancholicus* Vieillot, 1819 and *Progne tapera* (Vieillot, 1817). The record of *Progne tapera* among the most abundant may be the result of the presence of a single flock in the area. The open field area also presents four exclusive species among the 10 most abundant: *Pitangus sulphuratus* (Linnaeus, 1766), *Ammodramus humeralis* (Bosc, 1792), *Sicalis luteola* (Sparrman, 1789) and *Sturnella superciliaris* (Bonaparte, 1850). Even in the shrub patches, only *Polioptila plumbea* (Gmelin, 1788) appears exclusively among the 10 most abundant, the others are among the most abundant in both open caatinga and open field areas (Figs 8-11).



Figures 8-11. (8) Abundance curves of recorded species in each habitat and the ten species more abundant; (9) open caatinga; (10) open field; (11) shrub patches.

DISCUSSION

The great number of species in Tyrannidae, Emberizidae and Columbidae had been previously observed in other communities in the caatinga by Telino-Júnior *et al.* (2005) and Roos *et al.* (2006). Nascimento *et al.* (2000) and Santos (2004) also recorded the Tyrannidae and the Emberizidae among the three largest families in their surveys. However, the Thamnophilidae, Furnariidae, Trochilidae and Accipitridae in the first, and Thamnophilidae, Furnariidae in the second, were better represented than the Columbidae; in Olmos *et al.* (2005) the Trochilidae was better represented than Emberizidae and Columbidae. In those examples, only in the Chapada do Araripe – Ceará (Nascimento *et al.* 2000) and areas in Piauí (Santos 2004) a pattern for the best represented families that resembles the pattern found for the entire caatinga (Silva *et al.* 2003) has been found. Thus, even though some species seem to occur only in certain areas and have restricted distribution, they are important representatives of the regional richness.

The estimated richness of 120 (+5) species is comparable to that found in previous surveys conducted in areas of the caatinga. Bird counts in protected areas, however, have revealed a higher richness of species, as follows: Olmos (1993) registered 208 species in Serra da Capivara, Piauí; Nascimento *et al.* (2000) registered 193 species in Chapada do Araripe; Nascimento (2000) registered 154 in the Estação Ecológica de Aiuaba, Ceará; Lima *et al.* (2003) registered 191 in the Raso da Catarina, Bahia; Telino-Junior *et al.* (2005) have registered 145 species in a private reserve in the state of Paraíba; and Farias *et al.* (2006) registered 193 species in Serra das Almas, Ceará. Also, higher species richness (155 species) have been reported by Santos (2004) for unprotected caatinga areas in Piauí; by Roos *et al.* (2006) (145 species) in the Sobradinho region, Bahia, and by Farias *et al.* (2006) (65species) in Betânia, Pernambuco. In the Ecological Station from Seridó, Rio Grande do Norte, Nascimento (2000) registered 116 bird species, a number similar to ours. However, when our results are compared with the species richness estimated for other locations under human impact, they are equivalent or lower. For instance, Olmos *et al.* (2005) after surveying eight areas in the states of Ceará and Pernambuco, found 96, 109, 102, 101, 72, 93, 94 and 125 species; Farias *et al.* (2006) found 94 species in the Curimataú, Paraíba; and Farias (2007)

listed 106 in Caraíbas, 92 in Brígida, 58 in Icó Mandante and 56 species in Apolônio Sales, Pernambuco. Even though these comparisons may not be appropriate because curves based on effort and/or estimates is lacking for several contributions, they offer an overview of the distribution of species richness in a geographical scale, which is consistent with the conservation status of different areas.

Species that varied considerably in abundance between the dry and rainy season, for instance *S. superciliaris*, *P. sulphuratus*, *Z. capensis* and *S. luteola*, are not known to be migratory. Their variation in abundance can be explained by changes in their spatial distribution between seasons. Some species may be found grouped in habitats where resources are concentrated during the dry period and spaced across the landscape in the rainy season, when resources and humidity are more widely available (Silva *et al.* 2003, Olmos *et al.* 2005). However, our results have revealed the importance of conducting systematic studies over a longer period of time in the caatinga in order to understand more fully the dynamics of frequency and abundance of bird species.

Our lack of knowledge about inter-tropical migrations and other smaller scale displacements makes it difficult for us to classify the species we found as migratory with broad displacements, or small seasonal migrants in the caatinga region (Olmos *et al.* 2005). However, 18 species recorded by us either performed displacements related to water availability, or are known to be migratory:

– *Tachybaptus dominicus* (Linnaeus, 1766), *Porphyrio martinica* (Linnaeus, 1766), *Megaceryle torquta* (Linnaeus, 1766), *Chloroceryle americana* (Gmelin, 1788) and *Fluvicola albiventer* (Spix, 1825) are species associated with aquatic environments and only occurred in the study area during the rainy season.
– *Zenaida auriculata* (Des Murs, 1847), in spite the few individuals spotted in the two sampling periods, is a typical migratory species in the caatinga, performing displacements according to the rain (Azevedo Júnior & Antas 1990). Personal observations in the state of Paraíba have registered large flocks of *Z. auriculata* in the second half and in the end of the rainy season, when seeds, an important dietary item for the species, are more widely available. The fact that sampling in Alagoas occurred in the first half of the rainy season may explain the observation of only a few individuals of this species.
– *Coccyzus melacoryphus* Vieillot, 1817, *Myiopagis viridicata* (Vieillot, 1817), *Euscarthmus meloryphus* Wied, 1831, *Cnemotriccus fuscatus* (Wied, 1831) and *Pachyramphus polychopterus* (Vieillot, 1818) are species that migrate among different areas in the Neotropical region, they occurred mainly in the caatinga during the rainy season.
– Five Tyrannidae species registered, *Elaenia spectabilis* Pelzeln, 1868, *Camptostoma obsoletum* (Temminck, 1824), *Phaeomyias murina* (Spix, 1825), *Empidonomus varius* (Vieillot, 1818) and *Tyrannus melancholicus* Vieillot, 1819 are mentioned in the literature as migratory. However, their higher frequencies in the dry season may have resulted from the fact that they passed through the study area just before the beginning of the rainy season, because sampling in the dry season was performed near the beginning of the rainy season in the region.
– The hummingbird *Chrysolampis mosquitus* (Linnaeus, 1758) and the bay-winged *Agelaioides fringillarius* (Spix, 1824) were seen during the rainy season. Due to variations in their abundance and frequency in the area and in other caatinga areas (personal observations), we suggest that displacements in these two species are seasonal.
– *Volatinia jacarina* (Linnaeus, 1766) varied in abundance and frequency, and were observed more often during the rainy season; therefore, we suggest that displacements of this species are seasonal, as mentioned by Olmos *et al.* (2005).

Other species registered only in one sampling period, for instance *Patagioenas picazuro* (Temminck, 1813) and *Leptotila verreauxi* Bonaparte, 1855, are more prone to local displacements to habitats where water and resources concentrate than to wider migrations (pers. obs.). The low richness or abundance of aquatic species in caatinga areas is most likely due to the scarcity of aquatic environments (Olmos *et al.* 2005). The open caatinga from the backwoods of Alagoas maintains greater bird diversity, with almost twice as many species as registered in open fields, or in the small shrub patches found in these fields. A more equitable distribution of the abundance curve of birds that occur in areas of open caatinga shows a greater heterogeneity in the community and supports the idea that this environment is the most diverse among the three evaluated.

Olmos *et al.* (2005) commented that some species which are endemic or almost endemic to the caatinga seem to benefit from anthropogenic habitats, where their populations are denser. They mention *P. dominicana* and *A. fringillarius* as examples. In our study area, *P. dominicana* was among the ten most abundant in the open fields and shrub patches, but was the 25th in abundance in the open caatinga. *Sporophila albogularis*, which was more abundant in the open fields and shrub patches, had a similar abundance value as other most abundant species in the open caatinga.

Santos (2004) demonstrated a clear difference in the composition of bird species between arboreal and shrub physiognomies in a caatinga area in the state of Piauí; Olmos *et al.* (2005) registered species found only in arboreal formations or forests, and species which benefit from anthropogenic habitats in caatinga areas in the states of Pernambuco and Ceará; in this study, we observed a clear distinction among the studied habitats, even in the open fields which have been differently impacted by human occupation. These results do reinforce the need to conserve environments that include the typical caatinga vegetation, both for maintaining the ± diversity and the species which are endemic to these environments. The

maintenance of vegetation patches in altered habitats may also help some species which occur in forest areas and do not thrive in areas as open fields used for pasture and agriculture.

The results of this study also suggest that researchers trying to evaluate species richness or similarities in the composition of the avifauna at a regional scale within a historical framework should take into consideration the fact that some places in the caatinga have been altered to the point that they longer harbor their original fauna.

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Appendix 1. Bird species recorded along the BR 316 road in the west of state of Alagoas, northeast Brazil. Record: S. sound, V. visual. Environment: habitat where the species occurred: (1) open caatinga, (2) open fields, (3) shrub patches, (4) aquatic environments. Habitat use: (IND) forest independent, (SMD) forest semi-dependent, (DEP) forest dependent. Med/pont: individuals number per point in the 50 m radius (x100); freq.(50m): proportion of point counts in which the species was detected within the 50 m radius; freq.(ilim.): proportion of point counts in which the species was detected in the unlimited radius. The 'x' marked in some freq(ilim.) fields corresponds to the occurrence record in samplings of the respective periods but out of the point counts.

Taxon	Record	Environment	Habit. Use	Dry season		Rainy season			
				med/pont	freq.(50m)	freq.(ilim.)	med/pont	freq.(50m)	freq.(ilim.)
Tinamidae									
Crypturellus parvirostris (Wagler, 1827)	S	2	IND	0.03	2.78	8.33			16.67
Crypturellus tataupa (Temminck, 1815)	VS	1 3	DEP			8.33	0.06	5.56	19.44
Nothura boraquira (Spix, 1825)	S	3	SMD						5.56
Podicipedidae									
Tachybaptus dominicus (Linnaeus, 1766)	V	4	IND						x
Ardeidae									
Butorides striata (Linnaeus, 1758)	VS	4	IND			2.78			x
Bubulcus ibis (Linnaeus, 1758)	V	2	IND			2.78			x
Ardea alba Linnaeus, 1758	V	4	IND			8.33			x
Egretta thula (Molina, 1782)	V	4	IND			x			x
Cathartidae									
Cathartes aura (Linnaeus, 1758)	V	1 2	IND	0.11	8.33	8.33			2.78
Cathartes burrovianus Cassin, 1845	V	1 2	IND	0.03	2.78	2.78	0.03	2.78	2.78
Coragyps atratus (Bechstein, 1793)	V	1 2	IND	0.06	2.78	5.56	0.08	2.78	2.78
Accipitridae									
Elanus leucurus (Vieillot, 1818)	V	1 2	IND	0.03	2.78	2.78			
Rupornis magnirostris (Gmelin, 1788)	VS	1 2	IND	0.14	11.11	13.89	0.08	8.33	16.67
Falconidae									
Caracara plancus (Miller, 1777)	VS	1 2	IND	0.11	8.33	13.89			5.56
Herpetotheres cachinnans (Linnaeus, 1758)	S	1	SMD						5.56
Falco sparverius Linnaeus, 1758	VS	2	IND			x	0.06	5.56	5.56
Rallidae									
Porphyrio martinica (Linnaeus, 1766)	V	4	IND						x
Cariamidae									
Cariama cristata (Linnaeus, 1766)	S	1	IND				0.06	2.78	2.78
Charadriidae									
Vanellus chilensis (Molina, 1782)	VS	2 4	IND			13.89	0.11	5.56	30.56
Jacanidae									
Jacana jacana (Linnaeus, 1766)	V	4	IND			x			x
Columbidae									
Columbina minuta (Linnaeus, 1766)	VS	1 3	IND	0.72	27.78	27.78	0.50	27.78	30.56
Columbina squammata (Lesson, 1831)	S	1	IND						2.78
Columbina picui (Temminck, 1813)	VS	1 3	IND	0.75	30.56	44.44	1.06	47.22	58.33
Patagioenas picazuro (Temminck, 1813)	S	1	SMD				0.08	2.78	2.78
Zenaida auriculata (Des Murs, 1847)	V	2 3	IND			x			x
Leptotila verreauxi Bonaparte, 1855	S	1	SMD				0.08	8.33	8.33
Psittacidae									
Forpus xanthopterygius (Spix, 1824)	VS	1 2	IND	0.11	5.56	11.11	0.33	11.11	13.89

Continue

Appendix 1. Continued.

Taxon	Record	Environment	Habit. Use	Dry season		Rainy season			
				med/pont	freq.(50m)	freq.(ilim.)	med/pont	freq.(50m)	freq.(ilim.)
Cuculidae									
Coccyzus melacoryphus Vieillot, 1817	S	1 3	SMD			2.78	0.06	2.78	5.56
Crotophaga ani Linnaeus, 1758	VS	2	IND			2.78	0.06	2.78	16.67
Guira guira (Gmelin, 1788)	VS	2	IND	0.06	2.78	11.11	0.14	5.56	11.11
Tapera naevia (Linnaeus, 1766)	S	1 2	IND			2.78	0.03	2.78	11.11
Strigidae									
Athene cunicularia (Molina, 1782)	VS	1 2	IND			2.78	0.03	2.78	2.78
Caprimulgidae									
Caprimulgus hirundinaceus Spix, 1825	V	1	IND						x
Trochilidae									
Eupetomena macroura (Gmelin, 1788)	V	1 2	IND	0.08	8.33	8.33	0.03	2.78	2.78
Chrysolampis mosquitus (Linnaeus, 1758)	V	1	IND				0.06	5.56	5.56
Chlorostilbon lucidus (Shaw, 1812)	VS	1 2	SMD	0.25	25.00	25.00	0.28	25.00	27.78
Amazilia sp.	V	3	?	0.03	2.78	2.78			
Heliomaster squamosus (Temminck, 1823)	VS	1	DEP				0.03	2.78	2.78
Alcedinidae									
Megaceryle torquata (Linnaeus, 1766)	VS	4	IND						2.78
Chloroceryle americana (Gmelin, 1788)	VS	4	SMD				0.03	2.78	2.78
Bucconidae									
Nystalus maculatus (Gmelin, 1788)	VS	1 2 3	SMD	0.11	8.33	30.56	0.19	16.67	33.33
Picidae									
Veniliornis passerinus (Linnaeus, 1766)	VS	1	SMD	0.06	5.56	13.89	0.08	8.33	8.33
Colaptes melanochloros (Gmelin, 1788)	V	1	SMD			x			
Thamnophilidae Swainson, 1824									
Thamnophilus capistratus (Lesson, 1840)	VS	1 3	SMD	0.19	16.67	25.00	0.11	8.33	25.00
Myrmorchilus strigilatus (Wied, 1831)	S	1 3	SMD	0.17	13.89	30.56	0.06	5.56	13.89
Formicivora melanogaster Pelzeln, 1868	VS	1 3	SMD	0.33	33.33	36.11	0.25	16.67	19.44
Dendrocolaptidae									
Lepidocolaptes angustirostris (Vieillot, 1818)	VS	1 3	IND	0.06	5.56	8.33	0.06	5.56	5.56
Furnariidae									
Furnarius leucopus Swainson, 1838	S	1	SMD			2.78			x
Synallaxis frontalis Pelzeln, 1859	S	1	DEP				0.03	2.78	2.78
Synallaxis albescens Temminck, 1823	VS	1 3	IND				0.14	8.33	8.33
Phacellodomus rufifrons (Wied, 1821)	S	1 3	SMD	0.06	2.78	5.56			2.78
Pseudoseisura cristata (Spix, 1824)	VS	1 2 3	IND	0.39	19.44	58.33	0.33	13.89	38.89
Tyrannidae									
Hemitriccus margaritaceiventer (d'Orbigny e Lafresnaye, 1837)	VS	1 3	SMD	0.14	13.89	13.89	0.11	11.11	11.11
Todirostrum cinereum (Linnaeus, 1766)	VS	1 2	SMD	0.28	25.00	25.00	0.17	16.67	16.67
Phyllomyias fasciatus (Thunberg, 1822)	VS	1	SMD						2.78
Myiopagis viridicata (Vieillot, 1817)	VS	1	DEP				0.08	5.56	5.56
Elaenia flavogaster (Thunberg, 1822)	S	1 3	SMD	0.06	2.78	2.78			x
Elaenia spectabilis Pelzeln, 1868	S	1 3	DEP	0.08	8.33	8.33	0.06	5.56	5.56

Continue

Appendix 1. Continued.

Taxon	Record	Environment	Habit. Use	Dry season		Rainy season			
				med/pont	freq.(50m)	freq.(ilim.)	med/pont	freq.(50m)	freq.(ilim.)
Camptostoma obsoletum (Temminck, 1824)	S	1 3	IND	0.08	8.33	11.11	0.03	2.78	2.78
Phaeomyias murina (Spix, 1825)	S	1 3	IND	0.33	27.78	27.78	0.11	11.11	13.89
Euscarthmus meloryphus Wied, 1831	VS	1 3	SMD				0.47	25.00	25.00
Stigmatura napensis Chapman, 1926	VS	1 3	IND	0.53	36.11	44.44	0.61	38.89	44.44
Tolmomyias flaviventris (Wied, 1831)	S	1	DEP				0.03	2.78	2.78
Cnemotriccus fuscatus (Wied, 1831)	VS	1	DEP				0.11	8.33	8.33
Xolmis irupero (Vieillot, 1823)	VS	1 3	IND	0.03	2.78	2.78	0.03	2.78	2.78
Fluvicola albiventer (Spix, 1825)	VS	4	IND						x
Fluvicola nengeta (Linnaeus, 1766)	VS	2 4	IND	0.25	16.67	16.67	0.03	2.78	2.78
Myiozetetes similis (Spix, 1825)	V	2 3	SMD	0.03	2.78	2.78			
Pitangus sulphuratus (Linnaeus, 1766)	VS	1 2	IND	0.78	47.22	61.11	0.31	16.67	19.44
Empidonomus varius (Vieillot, 1818)	VS	1 2	SMD	0.03	2.78	2.78	0.03	2.78	2.78
Tyrannus melancholicus Vieillot, 1819	VS	1 2 3	IND	0.33	25.00	44.44	0.39	30.56	33.33
Myiarchus tyrannulus (Statius Muller, 1776)	VS	1 2	SMD	0.14	13.89	19.44	0.06	5.56	5.56
Tityridae									
Pachyramphus polychopterus (Vieillot, 1818)	VS	1 3	SMD				0.08	8.33	8.33
Vireonidae									
Cyclarhis gujanensis (Gmelin, 1789)	S	1 3	SMD	0.11	8.33	19.44	0.08	8.33	22.22
Hylophilus amaurocephalus (Nordmann, 1835)	VS	1 2	DEP	0.11	11.11	13.89	0.06	5.56	5.56
Corvidae									
Cyanocorax cyanopogon (Wied, 1821)	VS	1	SMD	0.11	2.78	2.78			2.78
Hirundinidae									
Progne tapera (Vieillot, 1817)	V	1 2	IND				0.56	2.78	2.78
Progne chalybea (Gmelin, 1789)	V	2	IND			x			
Tachycineta albiventer (Boddaert, 1783)	VS	4	IND	0.03	2.78	2.78			x
Troglodytidae									
Troglodytes musculus Naumann, 1823	VS	1 2 3	IND	0.28	22.22	22.22	0.11	8.33	16.67
Cantorchilus longirostris (Vieillot, 1819)	VS	1 3	DEP	0.42	38.89	38.89	0.44	36.11	44.44
Polioptilidae									
Polioptila plumbea (Gmelin, 1788)	VS	1 3	SMD	0.64	52.78	52.78	0.31	27.78	38.89
Turdidae									
Turdus rufiventris Vieillot, 1818	VS	1 3	IND	0.06	5.56	11.11	0.03	2.78	5.56
Mimidae									
Mimus saturninus (Lichtenstein, 1823)	VS	1 3	IND	0.50	27.78	41.67	0.64	38.89	38.89
Motacillidae									
Anthus lutescens Pucheran, 1855	VS	1 3	IND			2.78			
Coerebidae									
Coereba flaveola (Linnaeus, 1758)	VS	1 2	SMD	0.06	2.78	2.78	0.03	2.78	2.78
Thraupidae									
Compsothraupis loricata (Lichtenstein, 1819)	S	2	SMD	0.17	2.78	2.78			
Tachyphonus rufus (Boddaert, 1783)	VS	1	DEP	0.06	5.56	5.56			
Thraupis sayaca (Linnaeus, 1766)	VS	1 2	SMD	0.19	11.11	13.89	0.06	2.78	2.78

Continue

Appendix 1. Continued.

Taxon	Record	Environment	Habit. Use	Dry season			Rainy season		
				med/pont	freq.(50m)	freq.(ilim.)	med/pont	freq.(50m)	freq.(ilim.)
Emberizidae									
Zonotrichia capensis (Statius Muller, 1776)	VS	1 2 3	IND	0.58	38.89	41.67	1.00	61.11	75.00
Ammodramus humeralis (Bosc, 1792)	VS	2	IND	0.44	25.00	38.89	0.39	36.11	44.44
Sicalis flaveola (Linnaeus, 1766)	VS	2	IND						x
Sicalis luteola (Sparrman, 1789)	VS	2 3	IND	0.22	2.78	2.78	0.86	19.44	19.44
Volatinia jacarina (Linnaeus, 1766)	VS	2 3	IND	0.06	5.56	5.56	0.22	16.67	16.67
Sporophila albogularis (Spix, 1825)	VS	1 2 3	IND	2.86	38.89	41.67	1.69	50.00	50.00
Sporophila bouvreuil (Statius Muller, 1776)	VS	2	IND	0.03	2.78	2.78			
Coryphospingus pileatus (Wied, 1821)	VS	1 3	SMD	2.14	72.22	72.22	0.92	41.67	44.44
Paroaria dominicana (Linnaeus, 1758)	VS	1 2 3	IND	0.61	27.78	30.56	0.25	19.44	22.22
Cardinalidae									
Cyanoloxia brissonii (Lichtenstein, 1823)	VS	1 3	DEP	0.06	5.56	5.56	0.03	2.78	2.78
Icteridae									
Icterus cayanensis (Linnaeus, 1766)	VS	1 3	SMD	0.08	5.56	5.56			x
Agelaioides fringillarius (Spix 1824)	VS	2	IND				0.17	2.78	2.78
Molothrus bonariensis (Gmelin, 1789)	VS	1 2	IND	0.17	5.56	5.56			x
Sturnella superciliaris (Bonaparte, 1850)	VS	2	IND	1.78	16.67	16.67	0.14	5.56	8.33
Fringillidae									
Euphonia chlorotica (Linnaeus, 1766)	VS	1 3	IND	0.11	8.33	13.89	0.03	2.78	5.56
Passeridae									
Passer domesticus (Linnaeus, 1758)	V	2	IND	0.17	2.78	2.78			x