

A *Cerrado* bird community in the northernmost portion of northeastern Brazil - recommendations for conservation

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ABSTRACT: The *Cerrado* is the largest savanna in South America and it is rich in fauna and flora and considered a biodiversity hotspot. Its contact with the surrounding Amazon, Atlantic Forest and *Caatinga* is irregular, forming large diffuse ecotones in some regions and disjointed patches in others. The *Cerrado* patches located in the Amazon are relatively studied, but little is known about those in the Atlantic Forest and *Caatinga*. This article presents information on the composition of a bird community in a savanna formation on the coast of the northernmost portion of northeast Brazil (5°23'25"S / 35°30'25"W). This site was visited 17 times between October 2006 and August 2013. The total richness was 87 species distributed into 32 families. The following *Cerrado* endemics were recorded: *Charitospiza eucosma* and *Porphyrospiza caerulescens*. Other species recorded associated mainly with the *Cerrado* biome were *Heliactin bilophus*, *Cypsnagra hirundinacea* and *Coryphaspsiza melanotis*. Some vulnerable and near threatened species were also recorded for the first time in the northernmost portion of northeastern Brazil, with some of these more than 1,000 km from their previously known localities. The results broaden the knowledge on the distribution of various species, in addition to providing information on seasonality and reproduction of others and revealing an overall lack of information on the composition of avian communities in little studied areas of Brazil.

KEY-WORDS: *Charitospiza eucosma*, *Coryphaspsiza melanotis*, *Cypsnagra hirundinacea*, *Porphyrospiza caerulescens*, Rio Grande do Norte, threatened species.

INTRODUCTION

The *Cerrado* is the largest savanna in South America, encompassing approximately 1.8 million km² of its central part (Oliveira-Filho & Ratter 2002, Silva & Santos 2005). It is rich in fauna and flora and considered a biodiversity hotspot (Mittermeier *et al.* 1999, Silva & Bates 2002, Klink & Machado 2005, Proença *et al.* 2010). It has undergone rapid transformations primarily due to increased agriculture, with only 20% of the original area still intact (Myers *et al.* 2000, Ritter *et al.* 2010). The evolution of its biota was influenced by the expansion and retraction of forest caused by past climatic changes (Prado & Gibbs 1993, Pennington *et al.* 2000, Prado 2000, Fernandes 2003), where gallery forests played a key role in dispersing and altering biodiversity (Rodrigues 2005, Silva & Santos 2005). The current result is a complex region of dry and humid forests, arboreal savannas, bushy areas and

fields (Eiten 1993, Ratter *et al.* 2003). Its contact with the surrounding Amazon, Atlantic Forest and *Caatinga* is irregular, forming large diffuse ecotones in some regions and disjointed patches in others (Eiten 1972, Capobianco *et al.* 2001). Islands of *Cerrado* in the Amazon contain relatively well studied avifauna (*e.g.*, Silva *et al.* 1997, Brace *et al.* 1997, Henriques & Oren 1997, Sanaiotti & Cintra 2001, Aleixo & Poletto 2007, Mittermeier *et al.* 2010), but little is known about isolated *Cerrado* areas in the Atlantic Forest and *Caatinga*. In northeastern Brazil savanna formations occur at low altitudes near the coast (Castro 1999, Sarmiento & Soares 1971, Tavares 1988, Oliveira-Filho & Carvalho 1993, Figueiredo 1989, Costa *et al.* 2004, Oliveira *et al.* 2012). These areas have received scant attention in terms of conservation and biogeographic investigation, and are currently significantly impacted. This article presents information on the composition of bird communities in a savanna formation on the coast of

the northernmost portion of northeast Brazil and discusses the need for conservation. In the area that we studied we confirmed the presence of birds endemic to the *Cerrado* and threatened with extinction, broadened the knowledge on the distribution of other taxa and suggested biogeographic studies to better understand the current distribution of *Cerrado* forest patches on the northeast coast of Brazil.

METHODS

The main sampling site (5° 23' 25" S and 35° 30' 25" W) is located near Punaú in the township of Rio do Fogo. We investigated an area within a 10 km radius, encompassing the cities of Pureza and Touros in Rio Grande do Norte state, northeastern Brazil (Figure 1). This consists of a flat area (~30,000 ha) near the coast at an altitude ranging between ~30 and 100 m in the east-west direction. The soil is sandy and derived from the *Barreiras* Group formation (IDEMA 2002). The vegetation is primarily herbaceous/sub-bushy, harboring species of the families Poaceae, Fabaceae, Cyperaceae, Rubiaceae and Convolvulaceae, with sparse bushy-arboreal components composed of Fabaceae, Myrtaceae, Chrysobalanaceae and Rubiaceae, where genera often associated with *Cerrado* vegetation are found (e.g., *Byrsonima*, *Eugenia*, *Anacardium*, *Erythroxylum* and *Tocoyena*) (Oliveira *et al.* 2012).

Between October 2006 and August 2013 we visited the area 17 times (2006 - 9, 20-21, 28-29 Oct, 11-12 Nov, 21 Dec; 2007 - 17 Jan, 1 May, 10-11 Aug, 10-11 Nov; 2008 - 1-2 Mar, 16 Aug; 2009 - 1-2 May, 15-16 Aug; 2012 - 10 Jun; 2013 - 21 Apr, 9-11 Aug, 16 Nov). We used conventional bird survey methods (active search, playback, listening points and occasional mist nets). The observations were made through binoculars (10 x 42), scope (60 x), and a camera fitted with a 500 mm lens. We also recorded a number of songs and calls with a Marantz PMD-661. The number of individuals sighted, type of recording (audio or visual) and signs of reproduction such as nests and/or immature birds being fed by their parents were also registered. We concentrated the surveys in the *Cerrado*, with marginal investigations in the lagoons and gallery forest. The taxonomy and nomenclature of the species follow *Comitê Brasileiro de Registros Ornitológicos* (CBRO 2014).

RESULTS

We recorded 87 bird species distributed into 32 families, Tyrannidae being the most represented (15 species) followed by Thraupidae (11 species) (Appendix). As endemic *Cerrado* species we recorded *Porphyrospiza caerulescens* and *Charitospiza eucoisma* (following Silva 1997, Silva & Santos 2005). Other species distributed

mainly in the *Cerrado* region were *Heliactin bilophus*, *Cypsnagra hirundinacea* and *Coryphaspiza melanotis*. These records are the first in the northernmost portion of northeastern Brazil. Some of these are distributed more than 1,000 km from their previously known localities. Among the species recorded, *Coryphaspiza melanotis* is considered vulnerable and *Charitospiza eucoisma* as near threatened (BirdLife International 2014). All these species were recorded in an open physiognomy *Cerrado* with herbaceous or sub-bushy vegetation characterized mainly as Poaceae, Fabaceae, Cyperaceae (Figure 2, see Oliveira *et al.* 2012). The details of the most important records are described below.

Peach-fronted Parakeet - *Eupsittula aurea*. Recorded on 29 October and 21 December 2006, and 11 November 2007. On all occasions we saw two specimens in flight and vocalizing. This species is mainly recorded in southeastern and central Brazil, Paraguay and Bolivia (Stotz *et al.* 1996). In the *Caatinga* it occurs marginally, mainly in transition areas with the *Cerrado* (Pacheco 2004, Santos 2004, Vasconcelos *et al.* 2012, Schunck *et al.* 2012). It has recently been recorded along a thin strip of the northeast coast from Bahia to Pernambuco (WikiAves 2014), and there are two records on the south coast of Rio Grande do Norte (Duarte 2013, Silva 2011). Our records extend the distribution of the species ~150 km northwards. We did not observe any sign of reproduction in the area, but on 16 May 2009 we witnessed a young specimen being sold at a street fair in the city of Macaíba, near Natal, Rio Grande do Norte. The species is listed under CITES Appendix II and has been heavily traded (BirdLife International 2014).

Horned Sunbeam - *Heliactin bilophus*. Recorded on 21 October and 12 November 2006 and 17 January 2007. Only one male was sighted on each occasion. This species is common in central Brazil, extending to Bolivia in the west (BirdLife International 2014), but there have been recent records on the coast of Bahia, Sergipe and Paraíba (Lima & Buzzetti 2006, Sonntag 2011, Mendonça 2013, Silva 2013). Our records extend the distribution of the species ~200 km northwards.

Rusty-backed Antwren - *Formicivora rufa*. Recorded on 13 occasions between 2006 and 2013 in January, March, May, August, October and November, where at least one couple was observed (Appendix). On 5 May 2009 we observed a couple followed by a possible fledgling, indicating the breeding period in the region. This species occurs mainly in central and southeast Brazil, Bolivia, Paraguay and some disjunct populations around the Amazon (BirdLife International 2014). There are also some recent records along the coastline of northeast Brazil (França 2008, Holderbaum 2012, Sonntag 2012, Beleza 2013, Jones 2014a). Our observations widen the knowledge on species distribution and indicate that it is resident in the study area.

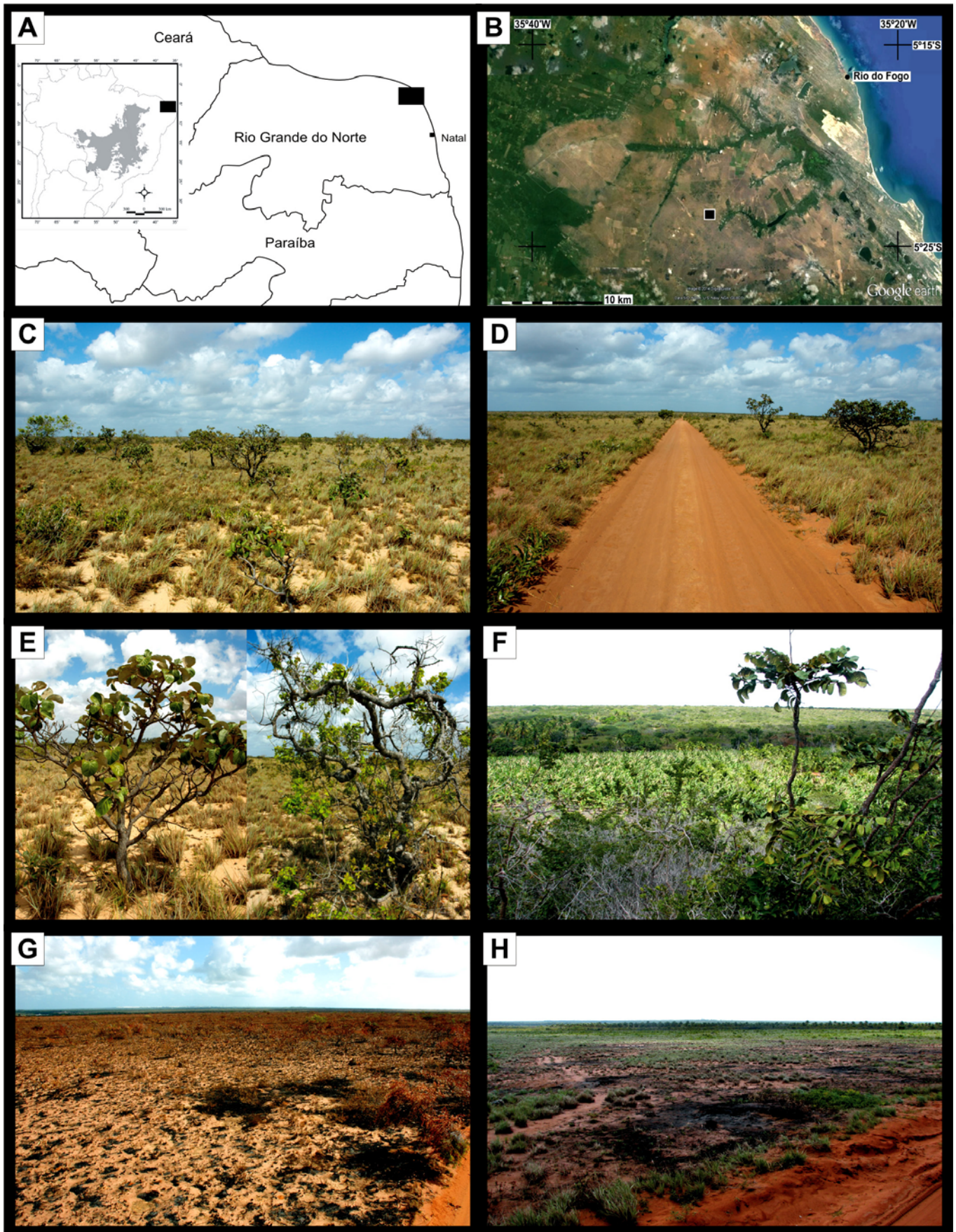


FIGURE 1. *Cerrado* area surveyed for birds in northeastern Brazil. A: localization in South America and northeastern Brazil (the grey polygon represents the core area of *Cerrado*). B: Aerial image of the studied site (the black square represents the core of the studied area, which was samples within a 10 km radius). C and D: general aspects of the vegetation. E: some typical tree species. F: Gallery forest vegetation impacted by agriculture. G: recent burned areas. H: impacted area by fire and coconut plantation in the background. Photos by Mauro Pichorim.

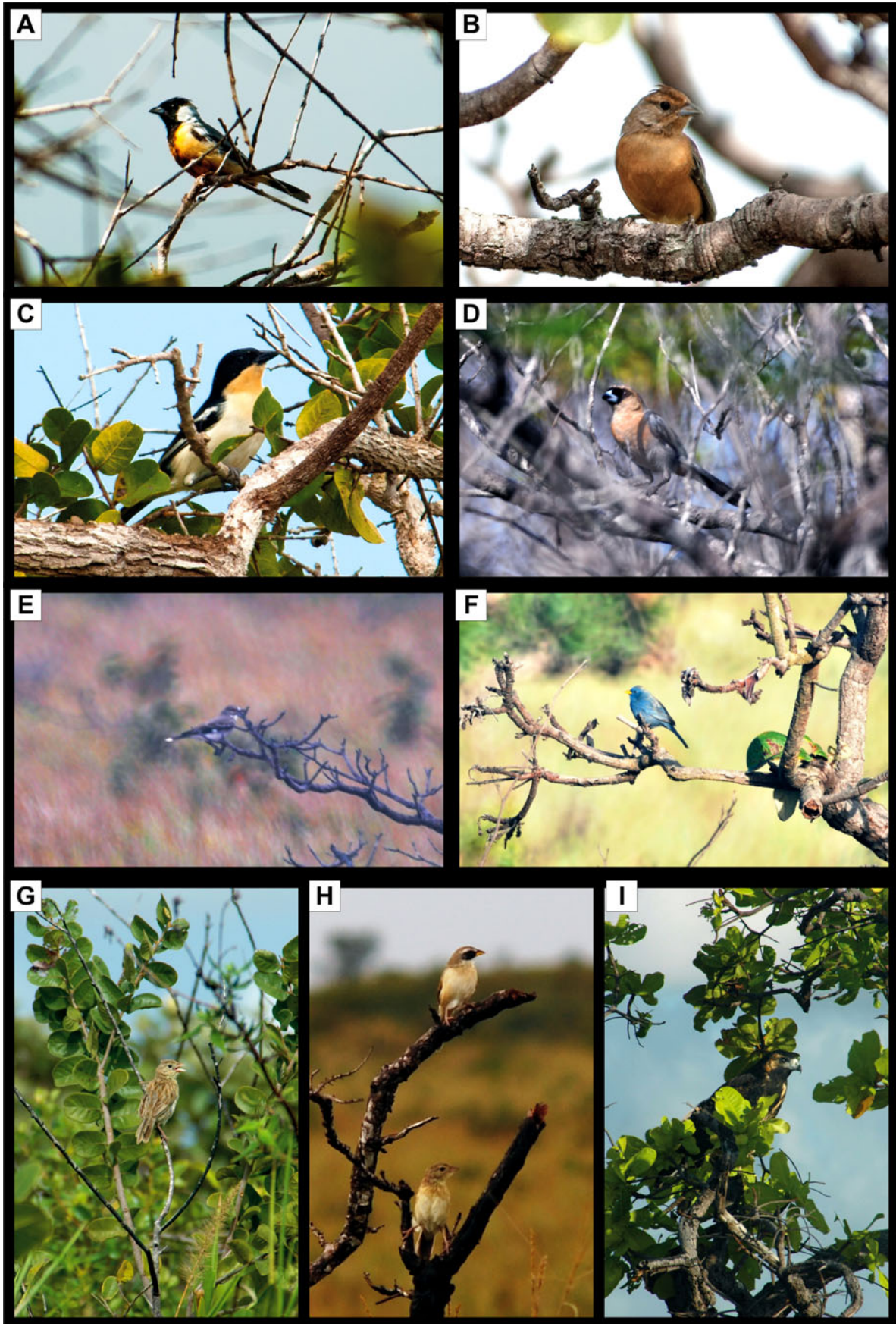


FIGURE 2. Some bird species recorded at the study site between 2006 and 2013. A and B: Male and female of the Near Threatened Coal-crested Finch - *Charitospiza eucosma*. C: White-rumped Tanager - *Cypsnagra hirundinacea*. D: Cinnamon Tanager - *Schistochlamys ruficapillus*. E: Grey Monjita - *Xolmis cinereus*. F and G: Male and female of the Near Threatened Blue Finch - *Porphyrospiza caerulescens*. H: Male and female of the Vulnerable Black-masked Finch - *Coryphospiza melanotis*. I: White-tailed Hawk - *Geranoaetus albicaudatus* (young). Photos by Ricardo Duarte de Araújo, Bruno Rodrigo de Albuquerque França and Mauro Pichorim.

Lesser Elaenia - *Elaenia chiriquensis*. Visual and sound records were made on 12 November and 21 December 2006, 11 November 2007, 16 August 2008, 1 May 2009 and 10 June 2012. This species seems to undertake seasonal movements in the region since it occurs from late spring through fall. We saw no sign of reproduction during our observations, perhaps because the species is only transient in the study area. This species is common in the *Cerrado* of central Brazil and Bolivia, and in northern South America with well-known south-north movements (Stotz *et al.* 1996, BirdLife International 2014). It is poorly known in the *Caatinga* and the northeastern portion of the Atlantic Rainforest. The records nearest to our area were in Paraíba (Medcraft 2009, Holderbaum 2013), but the photographs and songs shown by these authors are more similar to *Elaenia chilensis*. Our records extend the knowledge on this species' distribution and the time of occurrence in the northernmost portion of northeastern Brazil.

Gray Monjita - *Xolmis cinereus*. Single individuals were recorded on 29 October and 21 December 2006, 16 August 2008 and 16 November 2013 in recently burned areas. This species is common in central and southeastern Brazil, and open areas of Argentina, Paraguay, Uruguay and Bolivia (Ridgely & Tudor 1994, BirdLife International 2014). It has recently been observed on the west coast of Ceará (Lopes 2012, Teixeira 2012), and the north coast of Bahia (Lima 2006). Our records are noteworthy because they extend species distribution at least 650 km to the northeast. The short period of occurrence in our area may indicate some movement, perhaps as a result of winter migration to the south.

Cinnamon Tanager - *Schistochlamys ruficapillus*. A common resident species recorded in 16 expeditions with more than three specimens per day observed (Appendix). This species is common in the *Cerrado*, but also occurs at the edge of the *Caatinga* and Atlantic Forest (BirdLife International 2014). In northeastern Brazil it is known in the south of Ceará, south coast of Paraíba, eastern Pernambuco, Alagoas and Bahia (Lima 2006, Albano 2009, Hilty 2011, Fernandes 2013, Jones 2014b). Recent records in Rio Grande do Norte state extend this species' distribution ~200 km northward. The individuals observed had light plumage in line with the subspecies *S. r. capistrata*. Additional morphological studies are needed to determine possible differences between coastal and inland specimens.

White-rumped Tanager - *Cypsnagra hirundinacea*. Pairs were recorded on 14 expeditions between 2006 and 2013 in January, March, April, May, June, August, October, November and December (Appendix, Figure 2). On 2 March 2008 and 1 May 2009, we observed groups of four specimens possibly involving family groups, since they were flying and foraging together. Thus, the

breeding period of the species in the region may occur from summer to fall. This species is common in the *Cerrado* of central Brazil, but it was also recorded on the north coast of Bahia (Lima 2006, Cedraz 2012) and cited without any information on the south coast of Sergipe (Bencke *et al.* 2006), the nearest point to our records (~650 km). The specimens observed were tape recorded and photographed, exhibiting a pale chin and throat, similar to *C. b. pallidigula* (Figure 2). We have captured a number of individuals to measure and record their songs to determine possible taxonomic differences in the Rio Grande do Norte population. These analyses are currently underway and the results will be released shortly.

Blue Finch - *Porphyrospiza caerulescens*. A common resident species recorded in all surveys conducted between 2006 and 2013 (Appendix, Figure 2). We sighted lone individuals, pairs and family groups. On 1 May 2007 we recorded a pair and a fledgling with low flight capacity. On 16 August 2009 we observed a couple with one offspring and on 10 August 2013 we sighted two immature males, four males and six females. Thus, the local breeding period likely occurs from March to August. There is probably no species movement in the area since it was observed during all seasons. This species was also recorded on the north coast of Bahia and in southern Sergipe (Lima 2006, Lima & Buzzetti 2006, Sousa 2011). Our observations are ~650 km north of the nearest previously known location. The specimens observed were quite similar to those from other sites, but we are investigating possible morphological and biological differences in this new population. This near threatened species has become rare in many areas, owing to the conversion of its *Cerrado* habitats to agriculture (Jaramillo 2011a, BirdLife International 2014).

Coal-crested Finch - *Charitospiza eucosma*. Recorded in 15 surveys conducted between 2006 and 2013 (Appendix, Figure 1). The species seems relatively abundant in the area, and is normally encountered in flocks of 4-10 individuals (possibly involving family groups). On some occasions we observed lone individuals and on 21 December 2006 we recorded a group of 15 individuals. On 1 May 2007 and on 10 August 2013 we recorded pairs with one offspring each. The breeding period in the area likely occurs from March to August. Local migrations do not occur since specimens were observed during all seasons. This is a near threatened species that occurs mainly in the *Cerrado* of Brazil (BirdLife International 2014). It was also recently recorded in the *Caatinga* in northern Bahia and eastern Piauí (Nascimento 2011, Mota 2012, Santos 2012, Melo 2013, Caranha 2013). These are the nearest records to our observations (~650 km). There are no apparent morphological differences between the specimens from Rio Grande do Norte and central Brazil, but this deserves further investigation. This species is declining due to

habitat loss (conversion of *Cerrado* to agriculture) and the illegal bird trade (Jaramillo 2011b).

Black-masked Finch - *Coryphaspiza melanotis*. This species was observed mainly in couples and is relatively abundant in the area, since it was observed in all surveys (Appendix, Figure 2). On 16 August 2008, 1 May 2009 and 10 August 2013 we recorded three, four and five pairs respectively, and on each of these occasions one pair had a fledgling. The breeding period in the area likely occurs from March to August. Species movement does not occur given that it was observed in all seasons. This is a vulnerable species that occurs mainly in the *Cerrado* of Brazil, Peru, Bolivia, Paraguay and Argentina (BirdLife International 2014). In Brazil there is an isolated population at the mouth of the Amazon River described as *C. m. marajoara* (Sick 1967), with recent photographic records in eastern Pará (Lees 2011, Thompson 2011). The northernmost records of *C. m. melanotis* are from northern Goiás (Braz 2008, Cavalcante 2013, Timm 2013). These previous distribution limits are more than 1,600 km from our records. We are studying the morphology and ecology of this new population, focusing on possible geographic variations. This species is uncommon to rare and has experienced habitat destruction (Jaramillo 2011c).

DISCUSSION

Our results broaden the knowledge on the distribution of various species, indicate the seasonality and reproduction of some and reveal a lack of information on the composition of the communities in little or unstudied areas of Brazil. Birds from the *Cerrado* have been studied in the core region and a number of Amazon enclaves (e.g., Henriques & Oren 1997, Silva *et al.* 1997, Tubelis & Cavalcanti 2000, Aleixo & Poletto 2007, Mittermeier *et al.* 2010), but little or no attention has been given to *Cerrado* enclaves in the *Caatinga* and Atlantic Forest. Distribution projections using niche modeling show low or medium probability of the occurrence of a number of *Cerrado* birds (e.g., *C. hirundinacea*, *Neothraupis fasciata*, *Saltatricula atricollis*, *Melanopareia torquata*, *Cyanocorax cristatellus*) for part of the northeast coast of Brazil (Leite 2006, Corrêa *et al.* 2010). Our records confirm the presence of at least one of these species in the region. Even though these projections have been considered flaws in the models generated (see Corrêa *et al.* 2010), we believe that there are concrete indications of environmental similarities among the open areas on the northeast coast and the *Cerrado* of central Brazil. The lack of records for some species may be due to inadequate samplings of these formations on the northeastern coast. It is important to underscore that a number of species that we recorded have been linked to highland areas of central Brazil (Parker *et al.* 1996, Sick

1997). *P. caeruleus* is recognized as a riparian species from highland areas (BirdLife International 2014). The occurrence of these species on the coast of northeastern Brazil reveals they have a higher niche range than previously thought. Thus, it is important to reconstruct these potential distribution models with the addition of all the occurrence points on the northeastern coast of Brazil. These techniques are essential for optimizing the search effort of new occurrence areas for the species, as well as for understanding the biogeographic processes that led to their current distribution.

Considering the five structural types of *Cerrado* recognized by botanists (see Eiten 1972, 1993), the species we recorded are more common in open physiognomies known as “*campo limpo*” (grassland with few or no shrubs or tall woody plants) and “*campo sujo*” (grassland with scattered shrubs). Elements of “*Cerrado sensu stricto*”, “*cerradão*” and “*matas de galeria* (riparian forests)” are lacking (e.g., *Cyanocorax cristatellus*, *Antilophia galeata*, *Myiothlypis leucophrys*, *Herpsilochmus longirostris*). This is likely due to the fact that our study site has a physiognomy with a low density of typical *Cerrado* trees (Oliveira *et al.* 2012), decreasing the availability of structure and resources for a number of birds, in addition to the absence of gallery forests, border streams and lagoons in the region with typical “*veredas*” (tall gallery forests with stands of a species of palm, *Mauritia flexuosa*). In the study area the forests near rivers and lagoons are different from those of Central Brazil, in that they are mainly tropical semideciduous forests associated with the Atlantic Forest. Moreover, they are significantly affected by subsistence agriculture or coconut plantations. Thus, the lack of birds typical of *Cerrado* forest areas may be a result of environmental restrictions, due to differences in composition and/or local extinctions caused by the use of these areas.

We also did not find birds typical of open areas (e.g., *M. torquata*, *N. fasciata*, *S. atricollis* and *Poospiza cinerea*). The reasons for this are difficult to ascertain at the moment, and more field surveys and increased knowledge of species biology are needed. In general, the study area seems to be relictual, representing the distribution limit of the *Cerrado* formation with low richness, likely related to historical extinction processes. However, this characteristic does not diminish the importance of the area, since it reveals clues of evolutionary processes in central and northeastern Brazil, in addition to harboring endemic species and those near or threatened with extinction. It is also important to consider that open physiognomies of the *Cerrado* must be more protected due to their increased vulnerability to agriculture, pastures and biological invasions (Tubelis & Cavalcanti 2000). The conservation of open habitats is essential in protecting threatened or little known Brazilian grassland birds (Marini & Garcia 2005, Lopes *et al.* 2010).

These *Cerrado* formations along the coast of Brazil seem to be distributed from the north coast of Bahia to Rio Grande do Norte. Some typical species of the *Cerrado*, such as *C. hirundinacea* and *P. caerulescens*, were previously cited for this narrow strip in the states of Bahia and Sergipe (Bencke *et al.* 2006, Lima & Buzzetti 2006, Sousa 2011). These formations occur on sandy soils originating in the *Arenito Barreira* outcrop, which extends over a large part of northeastern Brazil.

Considering the sea-level variation through the Late Pleistocene and Holocene, these areas may have undergone a series of expansion and coalescence. Most biogeographic patterns of the biotic diversity of the *Cerrado* occurred during the Pleistocene (Cracraft 1985, Silva 1995a, b, Silva 1997, Silva & Bates 2002). It is known that the sea level in the Late Pleistocene was ~100 m below current levels (Hearty 1998). For the coast of Rio Grande do Norte state, which is shallow and has a wide continental shelf, these events may have expanded the shoreline 50 km to the east, widening the coastal strip of open formations. The biogeography of savannas in the northern and southern Amazon has been studied in recent years (Haffer 1967, 1974, Webb 1991, Silva 1995b, c, Henriques & Oren 1997, Silva *et al.* 1997, Silva 1998), suggesting an Atlantic coast savanna corridor (Silva & Bates 2002). A similar process may have occurred on the northeast coast of Brazil. This process and the age of these *Cerrado* relicts need to be better understood and these areas must be protected, since they preserve the memory of the evolution of these biotas and the dynamics of the environments involved.

We observed that the study area has been affected by fire, agriculture and military activities. Although fires are uncommon, they must be controlled, since several *Cerrado* grassland species are highly sensitive to regular fires (Tubelis & Cavalcanti 2000). Agriculture has had a greater impact, completely altering the local physiognomy. At the margins of watercourses vegetation has been almost completely altered. Moreover, in recent years a number of monocultures have been established in the northern portion of the area, including irrigated agriculture (Figure 1). Some extensive coconut plantations (*Cocos nucifera*) have recently appeared (Figure 1). The major threats to Brazilian birds are habitat loss, degradation and fragmentation (Marini & Garcia 2005). Controlling these impacts is essential in maintaining the threatened endemic species that we found in the area. Therefore, new agriculture projects should be temporarily banned until their impacts on the flora and fauna can be assessed and conservation measures implemented. Furthermore, an Integral Protection Conservation Unit (ICU) must be urgently established to guarantee effective conservation. This ICU should be large (~20,000 ha) in order to protect viable populations, given that it is an open isolated area

where species have low density and occupy an extensive area. There are still areas available to create an ICU of this size, including a section used as a military area and other conserved areas. However, decisions must be made immediately, since this situation will not continue for long. The parks and ecological stations in the *Cerrado* are vital to the conservation of this habitat (Silva & Bates 2002).

It is unknown whether the species found are totally isolated from the central areas of Brazil. Isolation is most likely be taking place since there is no indication of seasonal displacement, with most species found throughout the year. The time of this possible isolation cannot be estimated yet. For this reason, and considering the distance of these records, some geographic variation (morphological and/or genetic) probably occurred in these populations from the northernmost portion of the northeast. We observed some plumage variation in *C. hirundinacea* and *C. melanotis* and are acquiring more data on the subject. However, extensive morphological, bioacoustics and molecular studies are needed for these species, in order to clarify all the taxonomic and phylogeographic aspects in the region. Some of these initiatives are underway and we will present more information on *Cerrado* fragments on the northeast coast shortly. However, we cannot wait for this information to protect these *Cerrado* fragments on the northeastern coast; conservation measures must be immediate.

With respect to endemism in the *Cerrado*, we found *C. eucosma* and *P. caerulescens* (following Silva & Bates 2002, Silva & Santos 2005). However, the criteria adopted by Silva & Santos (2005) to define endemism in this region were the overlap between geographic distribution of the species and the central region of the *Cerrado* (minimum of 95%) and isolated populations in savanna-like habitats up to 430 km from the *Cerrado*. Considering this last criterion, these species must no longer be considered endemic to the *Cerrado*, given that new records presented here are farther than those previously established. Vasconcelos (2008) considered the "430-km rule" inaccurate and biased and its application can create unrealistic or obscure biogeographic patterns. We agree with this idea mainly due to the peculiarities of species distribution in open areas and the fragmented pattern of the relictual occurrence of *Cerrado* patches in the Amazon, Atlantic Forest and *Caatinga* at large distances from the central region. As such, we suggest adopting only distribution overlapping with the central area as criterion, that is, the first criterion proposed by Silva & Santos (2005). Therefore, the aforementioned species are endemic and others have regained this status (*e.g.*, *N. fasciata* and *C. hirundinacea*). It is important to underscore that Vasconcelos (2008) also suggested not considering some species restricted to the eastern Brazilian highlands as endemic to the *Cerrado* (*e.g.*, *Augastes scutatus*,

Asthenes luizae, *Polystictus superciliaris*, and *Embernagra longicauda*) because rupestrian field vegetation seems to have been subjected to an independent evolutionary process. Thus, considering these proposals, the Cerrado currently has 28 endemic birds (*Nothura minor*, *Taoniscus nanus*, *Penelope ochrogaster*, *Columbina cyanopis*, *Pyrrhura pfrimeri*, *Alipiopsitta xanthops*, *Hydropsalis candidans*, *H. longirostris*, *Cercomacra ferdinandi*, *M. torquata*, *Scytalopus novacapitalis*, *Geositta poeciloptera*, *Clibanornis rectirostris*, *Syndactyla dimidiata*, *Synallaxis simoni*, *A. galeata*, *Suiriri islerorum*, *Phyllomyias reiseri*, *Knipolegus franciscanus*, *C. cristatellus*, *M. leucophrys*, *S. atricollis*, *C. hirundinacea*, *N. fasciata*, *Paroaria baeri*, *P. caerulescens*, *P. cinerea*, and *C. eucosma*).

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APPENDIX

Birds recorded in the *Cerrado* area near Punaú, Rio do Fogo, Rio Grande do Norte, Northeastern Brazil between 2006 and 2013. The taxonomy follows CBRO (2014).

Families and species	Records (date and between parentheses the amount of individuals observed in each occasion)
TINAMIDAE	
<i>Crypturellus parvirostris</i> Small-billed Tinamou	17Jan2007(2), 02Mar2008(2), 01May2007(2), 01May2009(3), 10Aug2013(1)
<i>Nothura maculosa</i> Spotted Nothura	17Jan2007(1), 02Mar2008(2), 16Aug2008(1), 01May2009(3), 16Nov2013(1)
ANATIDAE	
<i>Dendrocygna viduata</i> White-faced Whistling-duck	21Oct2006(~500), 10Aug2013(5)
ARDEIDAE	
<i>Butorides striata</i> Striated Heron	21Oct2006(1)
CATHARTIDAE	
<i>Cathartes aura</i> Turkey Vulture	21Oct2006(2), 12Nov2006(2), 01May2007(2), 01May2009(1), 15Aug2009(2), 15Aug2009(2), 10Jun2012(1), 21Apr2013(2), 10Aug2013(2)
<i>Cathartes burrovianus</i> Lesser Yellow-headed Vulture	21Oct2006(5), 16Aug2009(1), 16Aug2009(1), 10Aug2013(2), 16Nov2013(1)
<i>Coragyps atratus</i> Black Vulture	09Oct2006(2), 21Oct2006(5), 17Jan2007(2), 01May2007(5), 11Aug2007(1), 11Nov2007(2), 15Aug2009(10), 15Aug2009(3), 10Jun2012(5), 21Apr2013(6), 10Aug2013(5), 16Nov2013(2)
ACCIPITRIDAE	
<i>Heterospizias meridionalis</i> Savanna Hawk	15Aug2009(1)
<i>Rupornis magnirostris</i> Roadside Hawk	21Oct2006(3), 01May2007(1), 01May2009(2)
<i>Geranoaetus albicaudatus</i> White-tailed Hawk	21Oct2006(2), 29Oct2006(3), 29Oct2006(1), 12Nov2006(2), 21Dec2006(1), 17Jan2007(2), 01May2007(3), 11Aug2007(3), 10Nov2007(2), 11Nov2007(1), 02Mar2008(3), 01May2009(2), 10Jun2012(2), 10Aug2013(1), 16Nov2013(1)
<i>Buteo brachyurus</i> Short-tailed Hawk	15Aug2009(2)
CHARADRIIDAE	
<i>Vanellus chilensis</i> Southern Lapwing	21Oct2006(1)
COLUMBIDAE	
<i>Columbina passerina</i> Common Ground-dove	01May2009(2), 10Aug2013(3)

Families and species	Records (date and between parentheses the amount of individuals observed in each occasion)
<i>Columbina minuta</i> Plain-breasted Ground-dove	09Oct2006(2), 21Oct2006(9), 29Oct2006(2), 12Nov2006(6), 01May2007(2), 11Nov2007(1), 02Mar2008(2), 16Aug2009(1), 10Jun2012(1), 16Nov2013(1)
<i>Columbina squammata</i> Scaled Dove	11Nov2007(2)
<i>Patagioenas picazuro</i> Picazuro Pigeon	21Oct2006(1), 29Oct2006(1), 10Aug2013(1)
<i>Zenaida auriculata</i> Eared Dove	21Apr2013(2)
CUCULIDAE	
<i>Piaya cayana</i> Squirrel Cuckoo	21Oct2006(1), 10Aug2013(1)
<i>Crotophaga ani</i> Smooth-billed Ani	21Oct2006(1)
STRIGIDAE	
<i>Glaucidium brasilianum</i> Ferruginous Pygmy-owl	10Aug2013(1)
<i>Athene cunicularia</i> Burrowing Owl	09Oct2006(3), 01May2007(2), 10Jun2012(1), 10Aug2013(2)
CAPRIMULGIDAE	
<i>Hydropsalis parvula</i> Little Nightjar	21Oct2006(2), 21Dec2006(1), 17Jan2007(1), 11Aug2007(1), 16Nov2013(1)
<i>Hydropsalis torquata</i> Scissor-tailed Nightjar	16Aug2009(1)
<i>Chordeiles pusillus</i> Least Nighthawk	21Dec2006(1), 17Jan2007(20), 01May2007(8), 11Aug2007(3), 10Nov2007(1), 11Nov2007(3), 02Mar2008(7), 16Aug2008(2), 01May2009(5), 15Aug2009(2), 16Aug2009(4), 10Aug2013(8)
TROCHILIDAE	
<i>Eupetomena macroura</i> Swallow-tailed Hummingbird	21Dec2006(3), 17Jan2007(1), 01May2007(2), 11Nov2007(1), 02Mar2008(3), 16Aug2008(1), 15Aug2009(3), 16Aug2009(1), 10Aug2013(1)
<i>Polytmus guainumbi</i> White-tailed Goldenthrout	21Apr2013(1), 10Aug2013(1)
<i>Heliactin bilophus</i> Horned Sungem	21Oct2006(1), 12Nov2006(1), 17Jan2007(1)
ALCEDINIDAE	
<i>Megaceryle torquata</i> Ringed Kingfisher	21Apr2013(2)
BUCCONIDAE	
<i>Nystalus maculatus</i> Spot-backed Puffbird	21Oct2006(7), 12Nov2006(2), 11Nov2007(2), 02Mar2008(2), 15Aug2009(2), 16Aug2009(2), 21Apr2013(2), 10Aug2013(1)
PICIDAE	
<i>Veniliornis passerinus</i> Little Woodpecker	10Aug2013(2)

Families and species	Records (date and between parentheses the amount of individuals observed in each occasion)
CARIAMIDAE	
<i>Cariama cristata</i> Red-legged Seriema	21Oct2006(3), 21Dec2006(6), 01May2007(3), 11Aug2007(1), 11Nov2007(2), 02Mar2008(2), 01May2009(2), 16Aug2009(4), 10Jun2012(2), 21Apr2013(1), 10Aug2013(4)
FALCONIDAE	
<i>Caracara plancus</i> Southern Caracara	21Dec2006(8), 17Jan2007(2), 02Mar2008(1), 01May2009(2), 15Aug2009(1), 16Aug2009(1), 10Jun2012(5), 21Apr2013(3), 10Aug2013(2)
<i>Milvago chimachima</i> Yellow-headed Caracara	29Oct2006(1), 12Nov2006(1), 21Dec2006(1), 02Mar2008(1), 21Apr2013(1), 10Aug2013(1)
<i>Falco sparverius</i> American Kestrel	09Oct2006(1), 02Mar2008(1)
<i>Falco femoralis</i> Aplomado Falcon	01May2007(3), 15Aug2009(2), 16Aug2009(1), 21Apr2013(1)
PSITTACIDAE	
<i>Eupsittula aurea</i> Peach-fronted Parakeet	29Oct2006(2), 21Dec2006(2), 11Nov2007(2)
<i>Eupsittula cactorum</i> Cactus Parakeet	10Aug2013(2)
THAMNOPHILIDAE	
<i>Formicivora grisea</i> White-fringed Antwren	21Oct2006(2), 01May2007(2), 11Aug2007(1), 11Nov2007(2), 02Mar2008(2), 16Aug2008(2), 16Aug2009(1)
<i>Formicivora melanogaster</i> Black-bellied Antwren	15Aug2009(1)
<i>Formicivora rufa</i> Rusty-backed Antwren	09Oct2006(4), 21Oct2006(4), 12Nov2006(2), 17Jan2007(4), 01May2007(2), 11Nov2007(1), 02Mar2008(6), 16Aug2008(3), 01May2009(3), 15Aug2009(1), 16Aug2009(3), 10Jun2012(1), 10Aug2013(1)
<i>Thamnophilus torquatus</i> Rufous-winged Antshrike	21Oct2006(4), 17Jan2007(1), 11Nov2007(1), 16Aug2008(2), 15Aug2009(1), 16Aug2009(2), 10Jun2012(1), 10Aug2013(1)
FURNARIIDAE	
<i>Synallaxis frontalis</i> Sooty-fronted Spinetail	11Nov2007(1)
<i>Synallaxis albescens</i> Pale-breasted Spinetail	01May2007(6), 10Nov2007(2), 11Nov2007(1), 02Mar2008(1), 16Aug2008(1), 16Aug2009(3), 10Aug2013(1)
<i>Synallaxis scutata</i> Ochre-cheeked Spinetail	21Apr2013(1)
RHYNCHOCYCLIDAE	
<i>Todirostrum cinereum</i> Common Tody-flycatcher	12Nov2006(1), 01May2007(2), 11Nov2007(1), 10Aug2013(1)
<i>Hemitriccus margaritaceiventer</i> Pearly-vented Tody-tyrant	21Oct2006(2), 11Nov2007(2), 02Mar2008(3), 16Aug2008(3), 01May2009(2), 15Aug2009(1), 10Jun2012(1), 21Apr2013(3), 10Aug2013(1)
TYRANNIDAE	
<i>Stigmatura napensis</i> Lesser Wagtail-tyrant	12Nov2006(1), 17Jan2007(1), 11Nov2007(4), 02Mar2008(2), 01May2009(2), 15Aug2009(2), 16Aug2009(1)

Families and species	Records (date and between parentheses the amount of individuals observed in each occasion)
<i>Euscarthmus meloryphus</i> Tawny-crowned Pygmy-tyrant	11Nov2007(1)
<i>Camptostoma obsoletum</i> Southern Beardless-tyrannulet	21Oct2006(2)
<i>Elaenia flavogaster</i> Yellow-bellied Elaenia	21Oct2006(2), 21Dec2006(1), 01May2007(2), 11Aug2007(3), 10Nov2007(1), 11Nov2007(4), 02Mar2008(3), 01May2009(4), 15Aug2009(1), 10Aug2013(2)
<i>Elaenia spectabilis</i> Large Elaenia	21Oct2006(1), 11Nov2007(1), 16Aug2008(2), 16Aug2009(2), 10Aug2013(3)
<i>Elaenia chilensis</i> Chilean Elaenia	17Jan2007(1), 10Aug2013(1)
<i>Elaenia cristata</i> Plain-crested Elaenia	12Nov2006(1), 21Dec2006(4), 11Nov2007(3), 02Mar2008(4), 16Aug2008(1), 01May2009(4), 15Aug2009(1), 16Aug2009(8), 21Apr2013(5), 10Aug2013(8), 16Nov2013(3)
<i>Elaenia chiriquensis</i> Lesser Elaenia	12Nov2006(4), 21Dec2006(1), 11Nov2007(1), 16Aug2008(2), 01May2009(2), 10Jun2012(2)
<i>Myiopagis viridicata</i> Greenish Elaenia	11Nov2007(1)
<i>Pitangus sulphuratus</i> Great Kiskadee	21Oct2006(1)
<i>Tyrannus melancholicus</i> Tropical Kingbird	21Oct2006(9), 12Nov2006(3), 21Dec2006(1), 17Jan2007(3), 01May2007(4), 10Nov2007(3), 11Nov2007(2), 02Mar2008(4), 16Aug2008(2), 01May2009(3), 15Aug2009(2), 16Aug2009(2), 10Jun2012(2), 21Apr2013(2), 10Aug2013(3)
<i>Tyrannus savana</i> Fork-tailed Flycatcher	29Oct2006(5), 12Nov2006(1), 21Dec2006(1), 21Apr2013(1)
<i>Sublegatus modestus</i> Southern Scrub-flycatcher	11Nov2007(1)
<i>Cnemotriccus fuscatus</i> Fuscous Flycatcher	21Oct2006(3)
<i>Xolmis cinereus</i> Gray Monjita	29Oct2006(2), 21Dec2006(1), 16Aug2008(1), 16Nov2013(1)
VIREONIDAE	
<i>Cyclarhis gujanensis</i> Rufous-browed Peppershrike	21Oct2006(2), 29Oct2006(1), 11Nov2007(2)
HIRUNDINIDAE	
<i>Stelgidopteryx ruficollis</i> Southern Rough-winged Swallow	21Apr2013(1)
<i>Progne chalybea</i> Gray-breasted Martin	02Mar2008(2)
<i>Tachycineta albiventer</i> White-winged Swallow	21Oct2006(2), 10Aug2013(2)
<i>Hirundo rustica</i> Barn Swallow	29Oct2006(4)
TROGLODYTIDAE	
<i>Troglodytes musculus</i> Southern House Wren	21Oct2006(2), 12Nov2006(1), 17Jan2007(1), 01May2007(1), 10Jun2012(1)
<i>Cantorchilus longirostris</i> Long-billed Wren	21Oct2006(1)

Families and species	Records (date and between parentheses the amount of individuals observed in each occasion)
POLIOPTILIDAE	
<i>Polioptila plumbea</i> Tropical Gnatcatcher	09Oct2006(2), 21Oct2006(4), 12Nov2006(1), 21Dec2006(1), 01May2007(2), 11Aug2007(3), 11Nov2007(1), 01May2009(2), 21Apr2013(2)
TURDIDAE	
<i>Turdus leucomelas</i> Pale-breasted Thrush	09Oct2006(1), 21Oct2006(2), 11Nov2007(2)
MIMIDAE	
<i>Mimus saturninus</i> Chalk-browed Mockingbird	21Oct2006(1), 12Nov2006(2), 21Dec2006(1), 15Aug2009(3), 15Aug2009(3), 10Jun2012(5), 10Aug2013(2)
MOTACILLIDAE	
<i>Anthus lutescens</i> Yellowish Pipit	10Jun2012(1)
PASSERELLIDAE	
<i>Ammodramus humeralis</i> Grassland Sparrow	09Oct2006(5), 21Oct2006(5), 12Nov2006(1), 21Dec2006(5), 17Jan2007(2), 01May2007(6), 11Nov2007(2), 02Mar2008(1), 01May2009(4), 15Aug2009(3), 16Aug2009(1), 10Jun2012(4), 10Aug2013(8)
ICTERIDAE	
<i>Procacicus solitarius</i> Solitary Black Cacique	17Jan2007(1), 11Nov2007(1)
<i>Molothrus bonariensis</i> Shiny Cowbird	21Apr2013(1)
THRAUPIDAE	
<i>Coereba flaveola</i> Bananaquit	21Dec2006(1), 02Mar2008(2), 01May2009(2), 15Aug2009(2)
<i>Cypsnagra hirundinacea</i> White-rumped Tanager	21Oct2006(7), 12Nov2006(7), 21Dec2006(3), 17Jan2007(2), 01May2007(6), 11Aug2007(4), 11Nov2007(4), 02Mar2008(4), 16Aug2008(2), 01May2009(4), 16Aug2009(4), 10Jun2012(2), 21Apr2013(2), 10Aug2013(4)
<i>Tachyphonus rufus</i> White-lined Tanager	21Oct2006(2), 10Jun2012(1)
<i>Tangara cayana</i> Burnished-buff Tanager	21Oct2006(4), 12Nov2006(1), 21Dec2006(3), 11Aug2007(1), 10Nov2007(2), 11Nov2007(2), 02Mar2008(1), 16Aug2008(1), 16Aug2009(2), 10Jun2012(1), 21Apr2013(1), 10Aug2013(4), 16Nov2013(2)
<i>Schistochlamys ruficapillus</i> Cinnamon Tanager	09Oct2006(4), 21Oct2006(5), 29Oct2006(3), 12Nov2006(3), 21Dec2006(3), 17Jan2007(4), 01May2007(3), 11Aug2007(3), 11Nov2007(5), 02Mar2008(5), 16Aug2008(3), 01May2009(5), 16Aug2009(3), 10Jun2012(3), 21Apr2013(3), 10Aug2013(4), 16Nov2013(1)
<i>Porphyrospiza caerulescens</i> Blue Finch	09Oct2006(2), 21Oct2006(8), 29Oct2006(1), 12Nov2006(3), 21Dec2006(1), 17Jan2007(1), 01May2007(3), 11Aug2007(1), 11Nov2007(2), 02Mar2008(2), 16Aug2008(2), 01May2009(3), 15Aug2009(3), 16Aug2009(6), 10Jun2012(1), 21Apr2013(2), 10Aug2013(12), 16Nov2013(1)
<i>Sicalis luteola</i> Grassland Yellow-finch	21Dec2006(14), 17Jan2007(15), 01May2007(25), 11Aug2007(3), 11Nov2007(2), 02Mar2008(5), 01May2009(5), 16Aug2009(1), 16Aug2009(1), 21Apr2013(5), 10Aug2013(6)

Families and species	Records (date and between parentheses the amount of individuals observed in each occasion)
<i>Emberizoides herbicola</i> Wedge-tailed Grass-finch	29Oct2006(5), 12Nov2006(2), 21Dec2006(2), 01May2007(3), 11Aug2007(2), 10Nov2007(2), 01May2009(3), 16Aug2009(1), 10Jun2012(3), 21Apr2013(2), 10Aug2013(1)
<i>Volatinia jacarina</i> Blue-black Grassquit	02Mar2008(1), 01May2009(3), 10Jun2012(1), 10Aug2013(5)
<i>Charitospiza eucosma</i> Coal-crested Finch	09Oct2006(8), 21Oct2006(15), 29Oct2006(1), 12Nov2006(4), 21Dec2006(15), 17Jan2007(5), 01May2007(3), 11Aug2007(3), 11Nov2007(2), 02Mar2008(1), 16Aug2008(1), 01May2009(3), 15Aug2009(1), 16Aug2009(14), 21Apr2013(1), 10Aug2013(13), 16Nov2013(2)
<i>Coryphospiza melanotis</i> Black-masked Finch	09Oct2006(1), 21Oct2006(4), 29Oct2006(1), 12Nov2006(1), 21Dec2006(2), 17Jan2007(3), 01May2007(3), 11Aug2007(3), 11Nov2007(2), 02Mar2008(2), 16Aug2008(7), 01May2009(9), 15Aug2009(1), 16Aug2009(10), 10Jun2012(6), 21Apr2013(1), 10Aug2013(10), 16Nov2013(3)
FRINGILLIDAE	
<i>Euphonia chlorotica</i> Purple-throated Euphonia	09Oct2006(1), 01May2009(2), 16Aug2009(1), 21Apr2013(2), 10Aug2013(1)