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Capa: Foto de um macho do bicudinho-do-brejo-paulista, uma nova espécie de ave do gênero *Formicivora* (Thamnophilidae; foto de Robson Silva e Silva) já considerada ameaçada de extinção e associada com brejos nos municípios de Biritiba-Mirim, Mogi das Cruzes, Santa Isabel, Salesópolis e São José dos Campos no leste do estado de São Paulo; descrita nesta edição por Buzzetti *et al.*.

Cover: Picture of a male São Paulo Marsh Antwren, a new species belonging to the genus *Formicivora* (Thamnophilidae; photo by Robson Silva e Silva) already regarded as endagered and associated with marshes in the municipalities of Biritiba-Mirim, Mogi das Cruzes, Santa Isabel, Salesópolis, and São José dos Campos in eastern State of São Paulo; described herein by Buzzetti *et al.*.

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SUMÁRIO / CONTENTS

ARTIGOS / PAPERS

NOTAS / SHORT-COMMUNICATIONS

Instructions to Authors

Revista Brasileira de Ornitologia, 21(4), 217-220
December 2013

Peregrine falcons capture fish in Brazil

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ABSTRACT: This note first describes two instances of Peregrine falcons (*Falco peregrinus tundrius*) capturing fish in different places in Brazil. The first record was in the Ibirapuera Park, municipality of São Paulo, where an adult male swept and captured a fish on the lake's surface, as a typical fishing raptor's strategy. The second one was an adult female catching fish in a salty lagoon in the municipality of Florianopolis. She used vertical diving, surprisingly dipping into water. In both circumstances, falcons had the opportunity to capture birds but they still opted to fish. Although Peregrine falcons mostly prey on birds, there are already some records of feeding on mammals, reptiles, and insects. There are some possible reasons why Peregrine falcons would go fishing, but advanced studies are necessary to test them.

KEY-WORDS: behavior; diet; *Falco peregrinus tundrius*; foraging habits; hunting strategy.

INTRODUCTION

According to Cramp & Simons (1980), the diet of falcons is related to prey availability and habitat quality. Thereby it is expected that the Peregrine Falcon (*Falco peregrinus* Tunstall, 1771) would have a greatly varied diet since it occurs from urbanized to uninhabited areas, sometimes being found even in the middle of the ocean (Voous 1961, Cramp & Simons 1980, Del Hoyo *et al.* 1994). At first, this statement causes strangeness once it is a bird-eating specialist. On the other hand, there are already some prey variation recorded for this species, which also eats small mammals (see Cade & Digby 1982, Thiollay 1982, Byre 1990, Silva 1997, Wells 1999, Serra *et al.* 2001, Kulic 2005, Castellanos *et al.* 2006, Pereira *et al.* 2006, Brown 2007, Probst *et al.* 2007, Bagyura *et al.* 2008, Drewitt & Dixon 2008, Moshkin 2009), insects (see Layard & Layard 1882, Herbert & Herbert 1965, Cade & Digby 1982, White & Brimm 1990, Amies 1997, Collar 2002, Pereira *et al.* 2006), and reptiles (see Layard & Layard 1882, Cade & Digby 1982, Pereira *et al.* 2006).

Peregrine falcons main hunting behaviors include pursuit, vertical dive, swoop, and attack from perch (Beebe 1960, Craddock & Carlson 1970, Rogers & Leatherwood 1981, Cade & Digby 1982, Vasina & Straneck 1984, Fox 2003, Zoratto *et al.* 2010). This species prefers surprise attacks (Herbert & Herbert 1965, Cade & Digby 1982, Dekker 2009), adapting place, time, and strategy to achieve its preys, in an opportunistic behavior (Beebe 1960, Sick 1961, Sick 1997, Silva 1997, Serra *et al.* 2001, Pereira *et al.* 2006, Verdari 2011). Between Peregrine falcons migratory subspecies, *Falco peregrinus tundrius* comes from northern hemisphere to winter in southern hemisphere (Ratcliffe 1980, Cade & Digby 1982, Del Hoyo *et al.* 1994). In Brazil, the high expression of this species' opportunistic hunting behavior, suiting itself according to the chosen habitat, has already been reported by some studies (see Sick 1961, Sick 1997, Silva 1997, Serra *et al.* 2001, Pereira *et al.* 2006).

Fishes as prey of Peregrine falcons are very rare (Cramp & Simons 1980, Ratcliffe 1980, Cade & Digby 1982, Del Hoyo *et al.* 1994). The hunting behavior to capture fishes is mostly speculated. Therefore, this paper describes two observed strategies of fishing used by *Falco peregrinus tundrius* in Brazil, with the first record of intentional full diving into water.

MATERIALS AND METHODS

Both records were opportunistic. First record occurred in the Ibirapuera Park's urban lake (23º35'08.6"S; 46º39'34.4"W; elev. ±760 m), municipality of São Paulo, state of São Paulo. The Ibirapuera Park has 110 ha and is located at a highly urbanized area. This park has two lakes connected with a depth between 0.5 to 2.5 m.

The second record was in the Ponta das Canas' salty lagoon (27º24'29.8"S; 48º25'37.9"W; elev. ±2 m), municipality of Florianopolis, and coastline of the state of Santa Catarina. The Ponta das Canas' salty lagoon has 28 ha bordered with mangrove forests and *restinga*. Because of tidal influence in the Ponta das Canas' salty lagoon, depth varies between -10 and 3 m.

RESULTS

On 21 November 2007, J. A. B. M. observed an adult male Peregrine Falcon swooping and capturing a silvery-grey fish with his talons in the urban lake of Ibirapuera Park (Figure 1). The male is known to winter around the park at least since 2005 (J. A. B. M. *pers. obs.*). As soon as the male got height, the fish slipped and fell into the lake. The falcon swooped and captured it again but the fish slipped for the second time. The male gave up on the prey which was probably a Cichlidae, with 15–20 cm in length. Soon after the hunt, he killed a blue-and-white swallow *Pygochelidon cyanoleuca* (Vieillot, 1817), which was flying around.

On 27 January 2012, B. P. V. saw an adult female doing a vertical dive at high speed and getting into the water of the Ponta das Canas' salty lagoon (Figure 2). The impact caused a loud noise and, almost one second later, she emerged with one fish in her talons, probably a Cichlidae or Mugilidae. Then, the female flew toward some buildings where she probably had a roost.

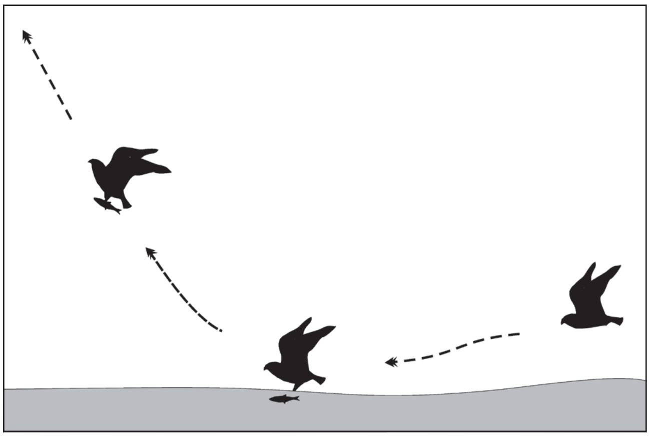

FIGURE 1. Male of *Falco peregrinus tundrius* fishing by swooping on 21 November 2007 at Ibirapuera Park, São Paulo, Brazil. Author: B. P. V.

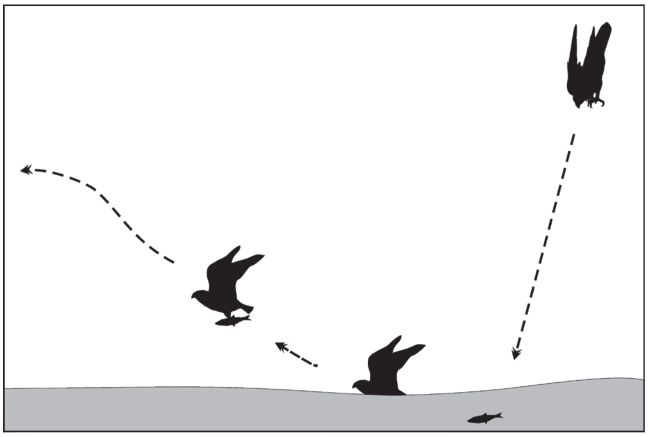

FIGURE 2. Female of *Falco peregrinus tundrius* fishing by vertical dive on 27 January 2012 at the Ponta das Canas' salty lagoon, Florianopolis, Brazil. Author: B. P. V.

DISCUSSION

Both areas were used by many Passeriformes and aquatic birds. At the Ibirapuera Park, the same male was seen hunting birds, such as Great Kiskadee (*Pitangus sulphuratus* (Linnaeus, 1766)) and Snowy Egret (*Egretta thula* (Molina, 1782)) (J. A. B. M. *pers. obs.*). Also, there were flocks with hundreds of individuals of Black Skimmer (*Rynchops niger* Linnaeus, 1758), Cabot's Tern (*Thalasseus acuflavidus* (Cabot, 1847)), Lesser Yellowlegs (*Tringa flavipes* (Gmelin, 1789)), Greater Yellowlegs (*Tringa melanoleuca* (Gmelin, 1789)), and Semipalmated Plover (*Charadrius semipalmatus* Bonaparte, 1825) at the Ponta das Canas' salty lagoon (B. P. V. *pers. obs.*). Therefore, there was no lack of avian prey. Also, we discarded the possibility of the falcon being confused and striking the water rather than the sky because during both attacks reported herein the water was visibly darker than the sky.

Some studies had previously found fish as an exceptional prey for Peregrine falcons (Cade 1960, Weir 1979, Tatum 1981, Hardy 1992, Barnes & Garwood 1995, Wheeler 2003, Moshkin 2009). Even though it is rare, this exception has been reported worldwide. For different reasons, fish consumption was not seen either in São Paulo nor Florianopolis. However, Weir (1979) and Moshkin (2009) had already confirmed fish consumption by this species, including remains in nests, which also suggests the feeding of the young.

Both records were of adults yet of different sexes. Dekker (2009) indicates that Peregrine falcons' hunting behavior seems to be innate without difference between males and females, though individuals can become more proficient with age, as also evidenced by Dekker (1980). There are some tactics that can increase hunting success, leading the falcon to ignore its common type of prey in order to get alternatives (Silva 1997). It is possible that falcons could have learned how to fish by observing sympatric fish-eating raptors such as Ospreys (*Pandion haliaetus* (Linnaeus, 1758)) and Bald Eagles (*Haliaeetus leucocephalus* (Linnaeus, 1766)) in their breeding sites in the northern hemisphere. But more detailed studies are necessary to prove that. In particular cases, hunting behaviors employed to get exceptional prey are different from the ones used to capture birds, such as the capture with beak described by Sick (1997).

Until now, the most speculated behavior to justify fish as prey was kleptoparasitism over Ospreys (Barnes & Garwood 1995, Wheeler 2003, Moshkin 2009), since Peregrine falcons would have "*an innate fear of water*" (Beebe 1960). Nevertheless, Heredia & Clark (1984) and Dekker (2009) support that kleptoparasitism is rare in Peregrine falcons. Also, Dekker (2009) highlights a size ratio whereby Peregrine falcons tend to parasitize smaller birds, being parasitized by bigger ones, both intra- and inter-specifically.

Cade (1960) observed direct hunting with a male swooping and grabbing a fish that leaped from the water. Tatum (1981) also reported an individual performing repeated swoops at sea, until it finally snatched a fish. In addition, Hardy (1992) described another male capturing two fishes with parachuted flight, as Kestrel's maneuver. On the other hand, the tactics described here are somewhat similar to those used by raptors adapted to fish. For example, the diving tactic used in Florianopolis was similar to the Osprey's feet-first plunging (Wheeler 2003, Gwyne *et al.* 2010). Nevertheless, these behaviors could also be viewed as simple adaptations of hunting flights already performed by Peregrine falcons in other situations (see strategies in Beebe 1960, Craddock & Carlson 1970, Fox 2003).

Despite its reported "*fear*", it is well known that Peregrine falcons use habitats strictly associated with water (Beebe 1960, Cade 1960). Foraging in Brazilian wintering areas, for example, is commonly performed in aquatic habitats, including shorebirds migratory routes (Sick 1997, Silva 1997, Pereira *et al.* 2006). In fact, our second record happened in a migratory coastal route. The hunting with intentional and complete dive into the lagoon provides more evidence that Peregrine falcons indeed have a strict fearless relation with water or at least does not avoid it.

The interaction with water, the adaptation of strategies, and the greater diet flexibility in wintering areas probably could culminate in fishing strategies as an alternative foraging behavior. In terms of wildlife management, knowing the physiological effects of dietary breadth on health and longevity of Peregrine falcons could also influence how rehabilitation and falconry are done today.

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December 2013

The structure of bird communities in areas revegetated after mining in southern Brazil

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ABSTRACT: Mined areas undergo physical changes and profound alterations in the structure and composition of the vegetation. Hence, the fauna cannot return to these areas without human intervention, usually through revegetation. In the state of Paraná, southern Brazil, we assessed the structure of bird communities (species richness, composition, trophic guilds, and forest dependence) in areas of different ages (5, 10, and 20 years) that were revegetated after mining with a single species of native tree (*Mimosa scabrella*). These areas were compared with a forest area with no mining influence (control). The areas differed in species richness and species composition. Birds of some foraging guilds (*e.g.*, frugivores) were absent from 10- and 5-year-old areas. The occurrence of forest-dependent birds increased, whereas forest-independent birds decreased with increasing area age. The death of *Mimosa scabrella* trees between 10 and 20 years after planting reduced vegetation complexity and affected the bird fauna. To avoid such an effect, and to assure the presence of frugivorous birds that are important to restore the vegetation through seed dispersal, we recommend the use of a high diversity of plant species in the initial planting, including plants with fleshy fruits that attract frugivorous birds.

KEY-WORDS: Araucaria Forest, foraging guilds, forest dependence, forest restoration, mining areas, restored areas.

INTRODUCTION

An often dramatic example of human interference in the environment is mining, which frequently results in decreased habitat complexity and changes in community composition (Wray *et al.* 1982). These changes may negatively affect the fauna, leading to decreasing populations (Scott & Zimmerman 1984). In an attempt to revert those negative effects, worldwide mining companies are often obliged by law to restore the vegetation in previously mined areas.

One of the techniques used to restore previously mined areas begins with the flattening of the local topography, followed by the deposition of soil with a seed bank and the planting of pioneer exotic and/or native plants (Tischew & Kimer 2007). The planting of tree species to recover degraded mining areas has been made in Brazil since the 1970s, mainly by planting exotic species such as eucalyptus (*Eucalyptus* spp.), and native species such as *bracatinga* (*Mimosa scabrella*) (Willians 1984). This restoration strategy results in an apparently well-developed vegetation in less than a decade. Nevertheless, the real effectiveness of this type of management in promoting the return of the fauna to restored mining areas is still unknown (Barth 1989).

The return of birds to regenerating forests is important to the local or regional maintenance of bird populations and the ecological roles played by birds (*e.g.*, predation, pollination, seed dispersal, and pest control) (Sekercioglu 2006). Seed-dispersing birds, for example, contribute directly to the regeneration of degraded areas (Walker & Del Moral 2003).

In Brazil, there are no studies that evaluated the effectiveness of post-mining management for the recovery of bird communities (but see Parrotta *et al.* 1997). However, mining activities are common in Brazil, which has one of the most diverse bird faunas in the world. In this study, we assessed the structure of bird communities in areas within the Araucaria Forest domain in southern Brazil. Such areas were previously mined and began to be restored at different times. Our main objective was to evaluate the effects of post-mining management on the richness and species composition of the bird community as a whole, as well as on specific foraging guilds and forest dependence categories. Since birds are sensitive to vegetation structure (MacArthur & MacArthur 1961, Whitman *et al.* 1998), the complexity and heterogeneity of the vegetation were assessed in the studied areas and related to the occurrence of birds.

MATERIAL AND METHODS

Study areas

We carried out the present study in São Mateus do Sul, state of Paraná, Brazil (25°52'S; 50°23'W; Figure 1). This municipality is located on the Paraná Plateau at 800 m a.s.l. The regional climate is type Cfb of Köppen (1948), subtropical humid with no dry season. The average annual rainfall varies between 1,400 and 1,500 mm. The average temperature of the warmest month is below 22°C and the average temperature of the coldest month is above 10°C, with more than five frosts per year. The vegetation of the region is the Araucaria forest, characterized by the dominance of *Araucaria angustifolia* (Bertol.) Kuntze (Araucariaceae) (Veloso *et al.* 1991).

We selected four study areas forming a regeneration gradient from areas at initial successional stages to areas at advanced successional stages (Table 1). Three areas, coded based on their succession stage as A05 (recovering for five years), A10 (recovering for ten years), and A20 (recovering for 20 years) were located at the Unidade de Superintendência de Industrialização de Xisto of Petrobrás. These are mining areas under restoration. The restoration began with the topographic flattening and covering of the exposed soil with humus, and then the planting of *bracatinga* (*Mimosa scabrella* Benth, Leguminosae), an evergreen tree native from southeastern and southern Brazil that varies from 4 to 18 m in height and 20 to 30 cm in diameter at breast height. It may reach up to 30 m in height and 50 cm or more in diameter at breast height when adult. It is a fast-growing pioneer species regardless of the physical conditions of the soil, being frequently used in the restoration of degraded areas (Mattos & Mattos 1980, Lorenzi 2002).

The youngest managed area (A05) was composed exclusively of *bracatingas* and was at an initial successional stage (Table 1). The area A10 had only *bracatinga* as a tree species, and had an herbaceous understory composed of pioneer species and a high undergrowth cover. In A20 there was an input of different tree species at initial and intermediate life stages, *i.e.*, seedlings, young, and subadult individuals (Table 1). The fourth study area was a forest fragment located at the south of the managed areas that has never been mined, but underwent selective logging of *erva-mate* (*Ilex paraguariensis* St. Hil., Aquifoliaceae) in the 1960s. This area, coded as A50 (approximately 50 years of succession), corresponded to a control area in the present study (Figure 1, Table 1). The control area had a dense and continuous canopy. The emergent stratum was composed of *araucárias* (*Araucaria angustifolia*) with a developing understory, *i.e.*, composed of young and subadult trees, a herbaceous stratum of intermediate height (ca. 30 cm) compared to other areas, and a sparse undergrowth. With the exception of the urban area at the south of the restored areas, the matrix surrounding all the study areas was similar, composed of a mosaic of agricultural fields and small forest fragments (Figure 1).

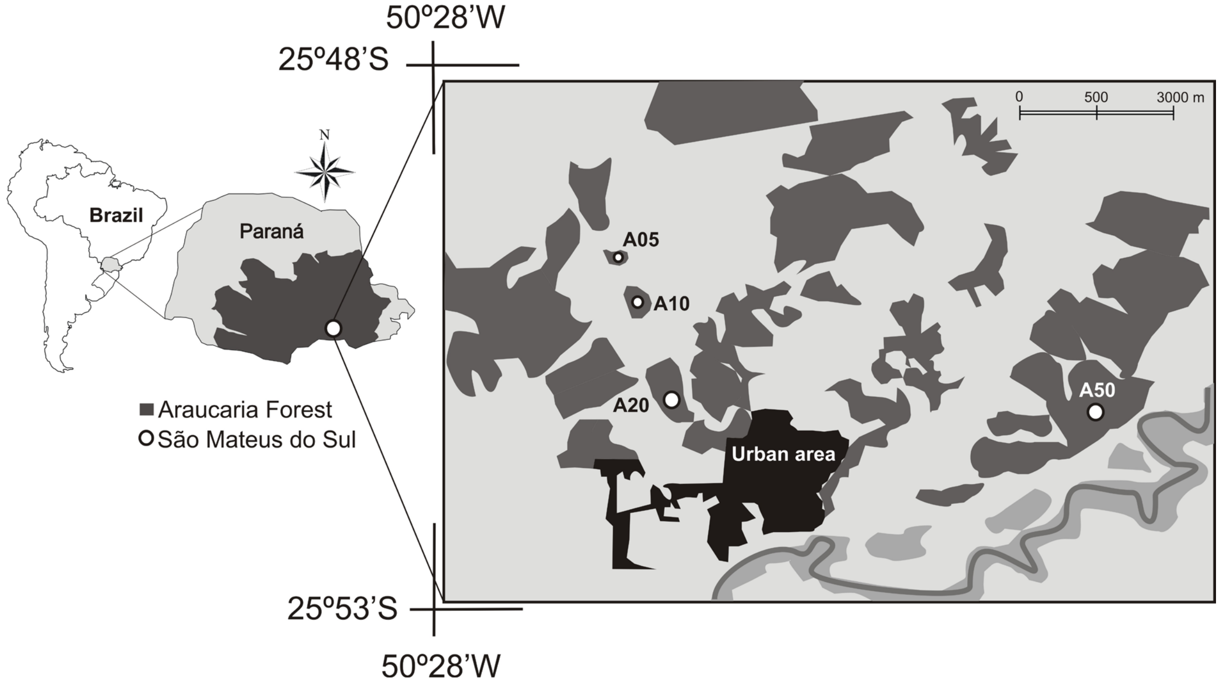

FIGURE 1. The restored mining areas (A05, A10, and A20) and control area (A50) located in São Mateus do Sul, state of Paraná, southern Brazil.

TABLE 1. Summary of the main characteristics and vegetation of the study areas in São Mateus do Sul, state of Paraná, southern Brazil. The abbreviations correspond to the years after the beginning of regeneration (*e.g.*, A20 is under regeneration for twenty years).

Area	Size (ha)	Type of exploration	Year when disturbance ceased	Most common species *
A50 (Control)	50	Extraction of mate plant (*Ilex paraguariensis*)	Has never been mined	*Lithraea brasiliensis*, *Rollinia sylvatica*, *Aspidosperma parvifolium*, *Araucaria angustifolia*, *Ocotea porosa*, *Sloanea monosperma*, *Cedrela fissilis*, *Jacaranda micrantha*, *Casearia decandra*, *Cupania vernalis*, *Campomanesia xanthocarpa*, *Podocarpus lambertii*, *Schinus terebinthifolius*, *Ilex paraguariensis*, *Psidium longipetiolatum, Syagrus romanzoffiana*, *Allophylus edulis*, and *Eugenia* cf. *Involucrata.*
A20	15	Mining	1985	*Mimosa scabrella*, *Casearia decandra*, *Cupania vernalis*, *Campomanesia xanthocarpa*, *Schinus terebinthifolius*, *Ilex paraguariensis*, *Syagrus romanzoffiana*, *Allophylus edulis*, and *Eugenia* cf. *Involucrata.*
A10	5	Mining	1995	Mainly *Mimosa scabrella* and individuals of *Baccharis* sp., Euphorbiaceae, *Bauhinia candicans*, and *Schinus terebinthifolius*.
A05	2	Mining	2001	Understory composed solely by saplings of *Mimosa.Scabrella*

* Barbieri & Heiden (2009). Plant nomenclature follows APG II - Angiosperm Phylogeny Group II (2003).

Vegetation structure

We established three plots of 10 x 30 m in each sampling area inside which we measured six structural parameters to characterize the vegetation: (i) the stem girth at breast height of all tree species with circumference ≥ 15 cm; (ii) the height of these trees measured with a 1-m graduated ruler; (iii) the undergrowth cover estimated with a 1-m^2 grid divided into 100 squares of 10 x 10 cm placed in 15 random sites within each plot; (iv) the understory height (plants > 1 m) with girth at breast height ≤ 15 cm; and (v) the absolute maximum height of the herbaceous vegetation (height < 1 m) at 15 random points in the plot. In addition, we also measured (vi) the percentage of canopy cover measured with a spherical densiometer in five points at each plot, four of which were located at the vertex and one in the center of the plot. At each of these points, we took four measurements of canopy cover to obtain an average value that characterized each point (Lemmon 1956).

Bird sampling

We sampled birds from January to December 2006 using the point count method with unlimited distance (Bibby *et al.*1992), always taking care to avoid double counting of the same bird and not counting birds outside the sampling areas. We sampled ten points at each area once in each season of the year, totaling 40 random sampling points within each study area, with a minimum distance of 100 m among sampling points. We remained for 10 min at each sampling point, moving among them at an interval shorter than 20 min to optimize the sampling time and assure independence among sampling points

(Bibby *et al.* 1992, Lynch 1995). The nomenclature followed Comitê Brasileiro de Registros Ornitológicos (CRBO 2011).

Data analysis

We tested for differences between average values of each vegetation structure parameter with a one-way analysis of variance (ANOVA). When such differences were significant, we used a Tukey post-hoc test (Zar 1996). In addition, to interpret these variables we used a principal component analysis (PCA). Through the interpretation of the PCA axis 1 (PC1), we obtained indexes of structural complexity and heterogeneity of the vegetation for each area (August 1983). We calculated the structural complexity of the areas as the average of the scores of axis 1, which concentrates all the variation of the original variables of each sample and outlines a space defined by the highest variation observed in the raw data (August 1983). Hence, structurally more complex areas were pointed out by high averages of these scores. We calculated the structural heterogeneity of the areas as the standard deviation of the scores of axis 1. Hence, heterogeneous areas were those with high variance in these scores. For these analyses, we transformed proportions to the arcsine of the square root (Zar 1996).

We analyzed sampling completeness with species accumulation curves made for each area (Krebs 1999). To compare richness between areas, we used a rarefaction analysis (Gotelli & Colwell 2001). This analysis is a non-biased way to compare areas, because it is not influenced by variations in the density of individuals per area (Colwell & Coddington 1994, Gotelli & Colwell 2001), which is expected in areas of different sizes. For building the rarefaction curve we used the program EstimateS® 7.5 (Colwell 1997).

To test for spatial autocorrelation among areas in species composition, we used a Mantel test with Bray-Curtis distances (dissimilarity) calculated based on the matrix of species records across areas and distances (m) among areas (Quinn & Keough 2002). We performed this Mantel test in the software PCord 4.20 (McCune & Mefford 1999), using 1,000 permutations.

We tested for differences in the composition of the bird fauna between areas through a clustering analysis based on the Bray-Curtis distance with the simple connection algorithm in the program MVSP (Kovach 2003). For analyzing foraging guilds, we grouped the species in six categories following Willis (1979), Sick (1997), and Sigrist (2006): CA (carnivores), FR (frugivores), NC (nectarivores), IN (insectivores), ON (omnivores), and GR (granivores). This analysis allows identifying the presence of some diet categories, so it indirectly allows assessing resource availability in the area. Forest dependence categories followed Silva (1995) with modifications based on the experience of the authors. The following forest dependence categories were considered: dependent (species found mainly in forest habitats), semi-dependent (species that occur in the forest but are frequently found in open habitats), and independent (species that occur in open vegetation such as pastures, grasslands, and marshes).

Although we are aware of a possible spatial dependence among point counts in each area (pseudo-replication *sensu* Hurlbert 1984), we assumed each point count to be an independent sample. Hence, to minimize this effect, we used a resampling statistic calculated in the program Resampling Stats® for Excel (Simon 1997, Blank *et al.* 2001), with 10,000 randomizations, in order to test for differences among areas in rarefied richness, number of records of each species (*i.e.*, abundances), and Bray-Curtis index. When the variances were significantly different ($\alpha \leq 0.05$), we adjusted them *a posteriori* to avoid the error type I due to the multiple interactions between average values, thus following the correction proposed by Holm (1979).

RESULTS

Vegetation structure

The study areas differed in several parameters of vegetation structure (Table 2). We observed an increase in tree girth and canopy cover with area age, but this gradient was not observed for other parameters, such as tree height (Table 2). Area A10 was more similar to A50 in tree height than to A20 due to the death of *bracatingas* that occurred 10 to 20 years after planting. Hence, A10 was broadly dominated by high individuals of *bracatinga*, whereas A20 had a low canopy with other tree species at initial and intermediate life stages. As a result, A50 had the highest complexity and heterogeneity of vegetation, followed by A10 and not by A20, as we expected (Table 2).

The youngest area (A05) had no well-developed canopy stratum; it presented an understory with average height higher than other managed areas, but formed only by *bracatingas* at initial life stage, with high herbaceous vegetation. This area had a homogeneous and less complex vegetation structure when compared to the other areas (Table 2).

Bird communities

We obtained a total of 3,454 records of 120 bird species (34 families, 12 orders) during 1,600 min of sampling (Appendix). The species accumulation curves for the four study areas stabilized at the end of the study soon after an increase in early spring (Figure 2). We had a higher absolute richness in A50 with 81 species, followed by A10 with 66 species, A20 with 54 species, and A05 with 39 species. The average rarefied species richness differed between A50 (mean ± 95% confidence interval = 52.1 ± 3,89 species) and A20 (41.4 ± 3,02 species), whereas A10 (46.6 ± 3,34 species) did not differ significantly from A50 or A20. The lowest richness was estimated for A05 (27.3 species), which differed significantly from all other areas (Table 3).

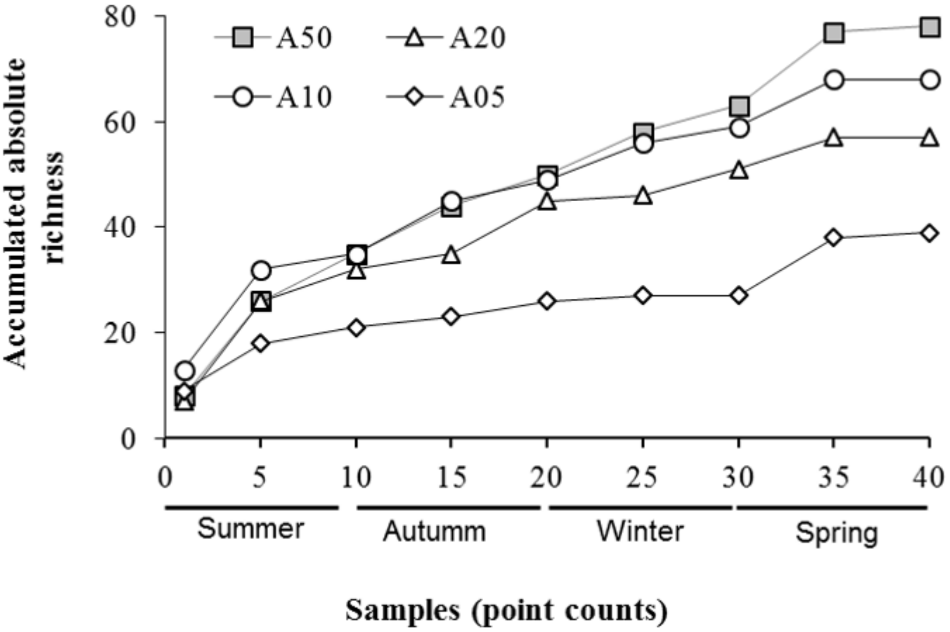

FIGURE 2. Species accumulation curves of the restored mining areas (A05, A10, and A20) and the non-mined control area (A50) at different seasons. Sampling dates were Summer (4-19 January 2006); Autumm (15-25 April 2006); Winter (16-29 July 2006); and Spring (10-18 November 2006).

TABLE 2. Vegetation structure parameters in three restored mining areas (A05, A10, and A20) and one non-mined control area (A50). We present average values and standard errors based on three 10 x 30 m plots sampled in each area. The same letters indicate similar variances among areas. The indexes of vegetation complexity and heterogeneity correspond, respectively, to the average and standard deviation of the scores of the axis 1 obtained from a PCA calculated with the structural parameters listed in the table (see text for details about this analysis).

Vegetation parameters	A50	A20	A10	A05
Girth at breast height (m)	0.43 ± 0.07^{a}	0.38 ± 0.02$^{a.b}$	0.30 ± 0.01^{b}	0.00 ± 0.00^{c}
Tree height (m)	10.62 ± 0.64^{a}	4.91 ± 0.16^{b}	10.00 ± 0.14^{a}	0.00 ± 0.00^{c}
Height of herbaceous vegetation (m)	0.30 ± 0.02^{a}	0.19 ± 0.02^{b}	0.29 ± 0.04^{a}	0.38 ± 0.02^{c}
Undergrowth cover (%)	24.10 ± 5.10^{a}	88.97 ± 3.58^{b}	88.47 ± 5.31^{b}	59.50 ± 6.80^{c}
Understory height (m)	3.36 ± 0.16^{a}	1.59 ± 0.22^{b}	1.39 ± 0.16^{b}	2.93 ± 0.17^{c}
Canopy cover (%)	96.10 ± 0.46^{a}	91.24 ± 1.68^{b}	73.16 ± 2.73^{c}	0.00 ± 0,00^{d}
Complexity	0.80	0.18	0.43	-1.40
Heterogeneity	0.90	0.36	0.45	0.23

TABLE 3. Average differences in rarefied species richness and corrections of the significance level (following the method proposed by Holm, 1979) between pairs of study areas.

Areas	Average differences	P-value	Adjusted P 0.05/(N+1-1)	Significant
A50 x A20	10.79	0.001	0.008	Yes
A50 x A05	24.86	0.001	0.010	Yes
A20 x A05	14.06	0.001	0.013	Yes
A10 x A05	19.29	0.001	0.017	Yes
A50 x A10	5.56	0.036	0.025	No
A20 x A10	-5.23	0.066	0.050	No

The compositions of the avifauna were significantly different for all between-area comparisons, but the control (A50) and the youngest (A05) areas had the most dissimilar avifaunas, while A20 and A10 had 70% of similarity (Table 4). There was no spatial autocorrelation in species occurrence among areas (Mantel r = 0.298; P = 0.173),

Overall, most bird species were insectivorous or omnivorous. Only the older areas (A50 and A20) had members of all six foraging guilds, while A05 had the lowest number of such guilds: only granivores, omnivores, and insectivores with the noteworthy absences of frugivorous and nectarivorous species (Figure 3A). There were more granivores in the youngest areas, A10 and A05. (Figure 3A).

There was a decrease in the proportion of forest-dependent species from the control to younger areas, whereas the opposite pattern was observed for forest-independent birds (Figure 3B). Semi-dependent species were more evenly distributed among areas, varying from 27.5% to 33.3% of all species recorded in each area (Figure 3B).

TABLE 4. Bray-Curtis dissimilarity indexes and corrections of the significance level (following the method proposed by Holm, 1979) used to compare species composition between study areas.

Areas	Bray-Curtis dissimilarity index	P value	Adjusted P 0.05/(N+1-1)	Significant
A20 x A10	0.315	0.000	0.008	Yes
A50 x A10	0.684	0.000	0.010	Yes
A20 x A05	0.670	0.001	0.013	Yes
A50 x A05	0.926	0.007	0.017	Yes
A50 x A20	0.695	0.011	0.025	Yes
A10 x A05	0.588	0.015	0.050	Yes

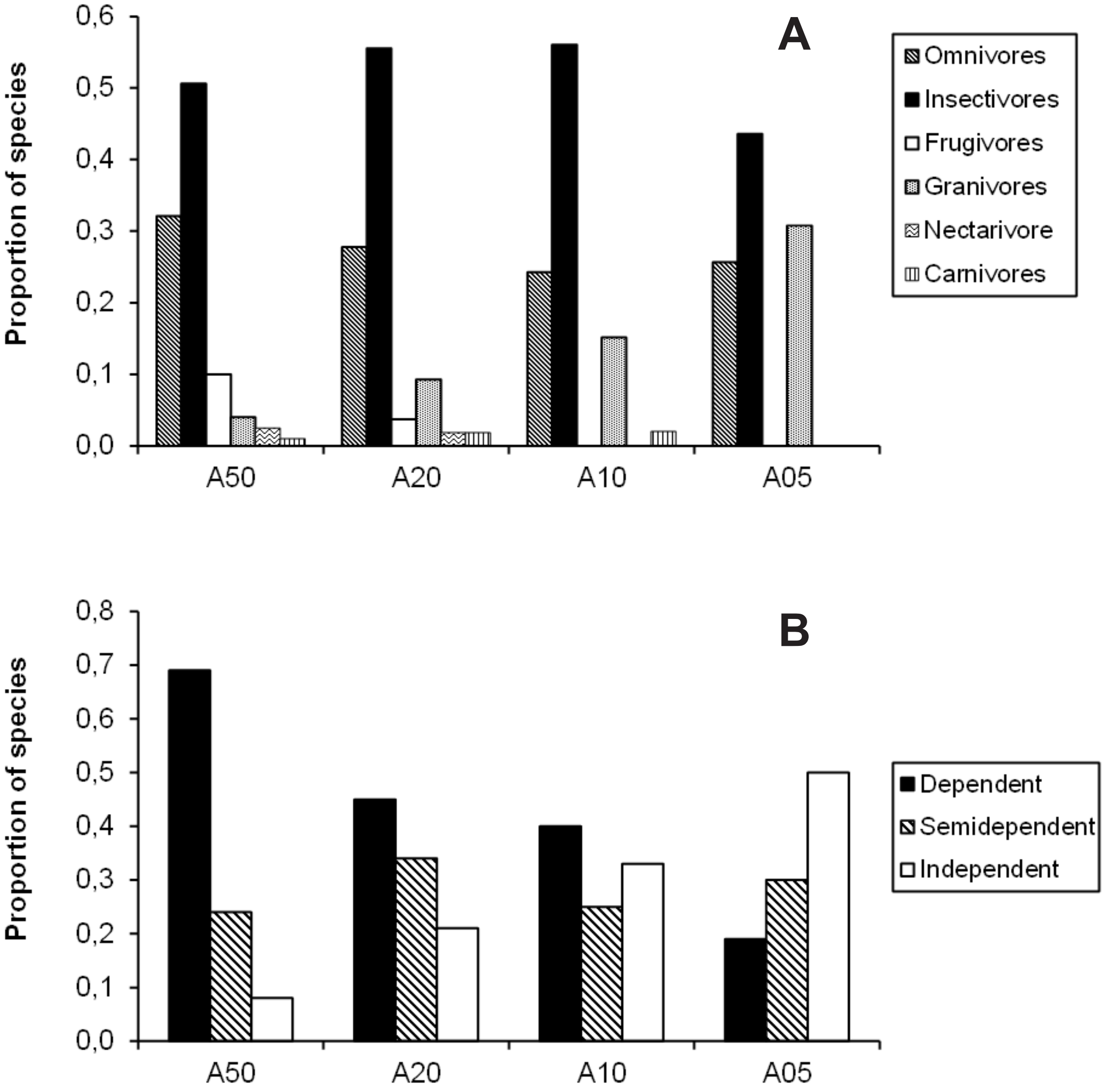

FIGURE 3. Percentage of species in each diet (A) and forest dependence (B) categories recorded in restored mining areas (A05, A10, and A20) and in a non-mined control area (A50). The numbers of bird species recorded in A05, A10, A20, and A50 were 39, 66, 54, and 80, respectively.

DISCUSSION

We observed a significant change in bird species richness and composition a few years after post-mining management, a result that corroborates with other studies in restored mined areas in forest environments (Brewer 1958, Krementz & Sauer 1982, Armstrong & Nichols 2000, Passell 2000, Nichols & Nichols 2003). It should be noted, however, that in the present study we lack replicates of age categories for the areas sampled, which call for caution in the interpretation and generalization of results. Notwithstanding, we believe that some results are good indicatives of the effects of the restoration strategy adopted upon the bird community.

Based on the species-area relationship (reviewed by Rosenzweig 1995), we expected a decreasing gradient of species richness from the older and larger to the smaller and younger area. Such gradient, however, did not exactly occurred because areas A10 and A20 did not differed from each other in species richness, likely because the death of *bracatingas* 10 to 20 years after planting reduced the complexity and heterogeneity of the vegetation at A20. Moreover, the area A10 showed similar species richness to the control area. The presence of forest-independent granivores species (such as *Zonotrichia capensis, Sicalis flaveola,* and *Lanio cucullatus*) together with forest-dependent species (such as *Trogon surrucura* and *Crypturellus obsoletus*) likely contributed to increase the species richness in A10, making it similar to the richness observed in the control area. However, differently from A10, the control area harbors species that are more sensitive to human disturbance, such as some Dendrocolaptidae and Formicariidae (Stotz *et al.* 1996), which were not recorded in the managed areas. Therefore, although the species richness of a 10-yr old area is comparable to an area that has never been mined, it has less disturbance-sensitive species, regardless of their dependence on forested habitats.

We did not record frugivorous or nectarivorous species at A05 but only insectivorous, omnivorous, and granivores species. This functional composition probably reflects the initial stage of regeneration of the vegetation at A05. Motta-Júnior (1990) reported that in degraded habitats there is a larger number of omnivorous birds, and possibly less specialized insectivorous birds. Indeed, likely as a result of the low structural complexity of A05, which was typical of initial successional stages (D'Angelo Neto *et al.* 1998), we did not record top predators (*e.g.*, Accipitridae and Falconidae), intermediate and large frugivores (*e.g.*, families Tinamidae, Trogonidae, and Ramphastidae), soil insectivores (species of the family Formicariidae), large bark insectivores (*e.g.*,Dendrocolaptidae), and several other frugivores (*e.g.*,Thraupidae). It is important to note that the flowers of *bracatinga*, the dominant species in A05, are pollinated by bees (Catharino *et al.* 1982), thus not attracting nectarivorous birds. Likewise, it does not produce fleshy fruits and, hence, does not represent a food source for frugivores. Therefore, if the objective is to speed up forest succession and quickly restore a mining area, it is important to include plants with fleshy fruits at the initial planting to attract frugivorous birds (Parrotta *et al.* 1997, Barbosa & Pizo 2006).

In conclusion, for the purpose of avifauna recovery we suggest that it is undesirable to adopt uniform plantations of *Mimosa scabrella* as a restoration strategy in mined areas because forest specialists and frugivorous birds lose suitable refuges for several decades until the planted forest regenerates and can thus disappear from the area. The initial planting of a high diversity of species is important not only to ensure the persistence of the restored forest (Rodrigues *et al.* 2010) but also to speed up the recovery of the bird fauna.

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APPENDIX.

Number of records of bird species in each of the study areas in São Mateus do Sul, state of Paraná, Brazil. Abbreviations: A50 (area with no mining history, at least 50 years with no disturbances), A20 (mined area under recovery for 20 years), A10 (mined area under recovery for 10 years), and A05 (mined area under recovery for 5 years). Diet categories: C (carnivores), F (frugivores), N (nectarivores), I (insectivores), O (omnivores), and G (granivores). Forest dependence categories: D (dependent), S (semi-dependent), I (independent). See text for definition of categories.

Families/species	Diet	Forest dependence	Areas			
			A50	A20	A10	A05
Tinamidae						
Crypturellus obsoletus (Temminck, 1815)	F	D	4	7	0	0
Crypturellus tataupa (Temminck, 1815)	F	D	3	0	0	0
Nothura maculosa (Temminck, 1815)	I	I	0	0	0	9
Cracidae						
Penelope obscura Temminck, 1815	F	D	4	0	0	0
Odontophoridae						
Odontophorus capueira (Spix, 1825)	I	D	4	0	0	0
Accipitridae						
Rupornis magnirostris (Gmelin, 1788)	C	I	0	1	1	0
Falconidae						
Micrastur semitorquatus (Vieillot, 1817)	C	S	2	0	0	0
Rallidae						
Aramides saracura (Spix, 1825)	I	S	2	0	1	2
Columbidae						
Columbina talpacoti (Temminck, 1811)	G	I	0	0	6	0
Columbina picui (Temminck, 1813)	G	I	0	0	7	9
Columbina squammata (Lesson, 1831)	G	I	0	0	3	0
Zenaida auriculata (Des Murs, 1847)	G	I	0	0	1	1
Leptotila verreauxi Bonaparte, 1855	G	S	18	3	8	1
Leptotila rufaxilla (Richard e Bernard, 1792)	G	D	6	0	5	0
Patagioenas picazuro (Temminck, 1813)	G	S	19	0	2	0
Psittacidae						
Pyrrhura frontalis (Vieillot, 1817)	F	D	15	0	0	0
Triclaria malachitacea (Spix, 1824)	F	D	2	0	0	0
Cuculidae						
Coccyzus melacoryphus Vieillot, 1817	I	D	0	0	1	0
Piaya cayana (Linnaeus, 1766)	I	S	0	4	7	0

Families/species	**Diet**	**Forest dependence**	**Areas**			
			A50	**A20**	**A10**	**A05**
Guira guira (Gmelin, 1788)	I	I	0	0	3	9
Tapera naevia (Linnaeus, 1766)	I	S	0	1	0	0
Trochilidae						
Chlorostilbon lucidus (Shaw, 1812)	NC	S	1	3	0	0
Leucochloris albicollis (Vieillot, 1818)	NC	D	1	0	0	0
Trogonidae						
Trogon surrucura Vieillot, 1817	O	D	36	1	18	0
Ramphastidae						
Ramphastos dicolorus Linnaeus, 1766	F	D	4	0	0	0
Picidae						
Picumnus temminckii Lafresnaye, 1845	I	D	0	1	6	0
Colaptes melanochloros (Gmelin, 1788)	I	S	1	1	4	0
Colaptes campestris (Vieillot, 1818)	I	I	0	0	0	10
Veniliornis spilogaster (Wagler, 1827)	I	S	9	5	21	2
Piculus aurulentus (Temminck, 1821)	I	D	4	2	1	0
Dryocopus lineatus (Linnaeus, 1766)	I	S	1	0	0	0
Campephilus robustus (Lichtenstein, 1818)	I	D	4	0	0	0
Thamnophilidae						
Thamnophilus caerulescens Vieillot, 1816	I	D	2	3	12	1
Thamnophilus ruficapillus Vieillot, 1816	I	I	0	3	1	26
Dysithamnus mentalis (Temminck, 1823)	I	D	22	0	0	0
Drymophila malura (Temminck, 1825)	I	D	0	0	4	0
Conopophagidae						
Conopophaga lineata (Wied, 1831)	I	D	13	0	0	0
Grallariidae						
Hylopezus nattereri (Pinto, 1937)	I	D	1	0	0	0
Formicariidae						
Chamaeza campanisona (Lichtenstein, 1823)	I	D	115	0	0	0
Scleruridae						
Sclerurus scansor (Menetries, 1835)	I	D	36	0	0	0
Dendrocolaptidae						
Sittasomus griseicapillus (Vieillot, 1818)	I	D	31	0	3	0
Xiphocolaptes albicollis (Vieillot, 1818)	I	D	2	1	5	0
Dendrocolaptes platyrostris Spix, 1825	I	D	3	0	3	0

Families/species	**Diet**	**Forest dependence**	**Areas**			
			A50	**A20**	**A10**	**A05**
Xiphorhynchus fuscus (Vieillot, 1818)	I	D	3	0	0	0
Lepidocolaptes falcinellus (Cabanis& Heine, 1859)	I	D	6	0	1	0
Furnariidae						
Leptasthenura setaria (Temminck, 1824)	I	D	26	0	0	0
Synallaxis ruficapilla Vieillot, 1819	I	D	0	12	0	0
Synallaxis cinerascens Temminck, 1823	I	D	7	13	13	1
Synallaxis spixi Sclater, 1856	I	S	0	20	25	10
Cranioleuca obsoleta (Reichenbach, 1853)	I	D	2	0	0	0
Syndactyla rufosuperciliata (Lafresnaye, 1832)	I	D	1	20	5	1
Heliobletus contaminates Berlepsch, 1885	I	D	20	0	0	0
Furnarius rufus (Gmelin, 1788)	I	I	0	0	4	5
Incertae sedis						
Xenops rutilans Temminck, 1821	I	D	0	1	0	0
Rhynchocyclidae						
Mionectes rufiventris Cabanis, 1846	I	D	3	0	0	0
Phylloscartes ventralis (Temminck, 1824)	I	D	15	0	2	0
Tolmomyias sulphurescens (Spix, 1825)	I	D	25	0	1	0
Poecilotriccus plumbeiceps (Lafresnaye, 1846)	I	D	0	1	4	9
Incertaesedis						
*Platyrinchus mystaceus*Vieillot, 1819	I	D	12	0	0	0
Tyrannidae						
Phyllomyias fasciatus (Thunberg, 1822)	I	S	0	0	0	0
Elaenia sp,	O		3	0	0	0
Elaenia flavogaster (Thunberg, 1822)	O	S	2	0	0	0
Elaenia spectabilis Pelzeln, 1868	O	D	2	0	0	0
Elaenia parvirostris Pelzeln, 1868	O	I	0	0	1	0
Elaenia mesoleuca (Deppe, 1830)	O	D	8	1	0	0
Camptostoma obsoletum (Temminck, 1824)	O	I	2	28	34	21
Serpophaga subcristata (Vieillot, 1817)	I	S	0	9	10	48
Euscarthmus meloryphus Wied, 1831	I	S	0	2	34	16
Myiophobus fasciatus (Statius Muller, 1776)	I	I	0	1	0	1
Lathrotriccus euleri (Cabanis, 1868)	I	D	4	0	3	0
Machetornis rixosa (Vieillot, 1819)	I	I	0	0	1	0
Legatus leucophaius (Vieillot, 1818)	I	S	6	2	0	0

Families/species	**Diet**	**Forest dependence**	**Areas**			
			A50	**A20**	**A10**	**A05**
Pitangus sulphuratus (Linnaeus, 1766)	O	I	24	29	49	21
Myiodynastes maculatus (Statius Muller, 1776)	O	S	7	9	3	0
Megarynchus pitangua (Linnaeus, 1766)	O	S	0	2	0	0
Empidonomus varius (Vieillot, 1818)	I	S	4	2	0	0
Tyrannus melancholicus Vieillot, 1821	I	I	2	2	7	0
Myiarchus swainsoni Cabanis e Heine, 1859	I	I	8	0	2	0
Attila phoenicurus Pelzeln, 1868	I	D	49	0	0	0
Pipridae						
Chiroxiphia caudata (Shaw e Nodder, 1793)	O	D	36	1	18	0
Tityridae						
Schiffornis virescens (Lafresnaye, 1838)	F	D	16	0	0	0
Pachyramphus polychopterus (Vieillot, 1818)	I	D	15	3	2	1
Vireonidae						
Cyclarhis gujanensis (Gmelin, 1789)	I	S	9	13	27	1
Vireo olivaceus (Linnaeus, 1766)	I	D	0	9	0	0
Corvidae						
Cyanocorax caeruleus (Vieillot, 1818)	O	D	12	0	0	0
Cyanocorax chrysops (Vieillot, 1818)	O	S	43	5	19	3
Troglodytidae						
Troglodytes musculus Naumann, 1823	I	I	2	35	25	30
Turdidae						
*Turdus rufiventri*s Vieillot, 1818	O	S	75	16	25	12
Turdus leucomelas Vieillot, 1818	O	S	4	0	0	0
Turdus amaurochalinus Cabanis, 1850	O	S	36	0	5	1
*Turdus subalari*s (Seebohm, 1887)	O	D	3	0	0	0
Turdus albicollis Vieillot, 1818	O	D	11	0	0	0
Thraupidae						
Saltator similis d'Orbigny e Lafresnaye, 1837	O	D	12	26	47	2
Lanio melanops (Vieillot, 1818)	O	D	6	0	0	0
Tachyphonus coronatus (Vieillot, 1822)	O	D	1	3	0	0
Tangara sayaca (Linnaeus, 1766)	O	S	4	23	22	0
Pyrrhocoma ruficeps (Strickland, 1844)	I	D	4	3	11	0
Pipraeidea melanonota (Vieillot, 1819)	O	D	3	2	0	0
Conirostrum speciosum (Temminck, 1824)	I	S	3	41	42	0

Families/species	**Diet**	**Forest dependence**	**Areas**			
			A50	**A20**	**A10**	**A05**
Emberizidae						
Zonotrichia capensis (Statius Muller, 1776)	G	I	10	91	130	212
Ammodramus humeralis (Bosc, 1792)	G	I	0	0	0	37
Poospiza cabanisi (Bonaparte, 1850)	O	D	4	20	5	0
Sicalis flaveola (Linnaeus, 1766)	G	I	0	0	2	5
Lanio cucullatus (Statius Muller, 1776)	G	I	0	18	48	133
Sporophila caerulescens (Vieillot, 1823)	G	I	0	2	7	42
Volatinia jacarina (Linnaeus, 1766)	G	I	0	1	0	110
Cardinalidae						
Cyanoloxia glaucocaerulea (d'Orbigny&Lafresnaye, 1837)	G	S	0	0	0	12
Cyanoloxia brissonii (Lichtenstein, 1823)	G	S	0	0	9	1
Parulidae						
Parula pitiayumi (Vieillot, 1817)	I	D	23	9	20	6
Geothlypis aequinoctialis (Gmelin, 1789)	I	I	0	0	11	14
Basileuterus culicivorus (Deppe, 1830)	I	D	53	41	38	0
Basileuterus leucoblepharus (Vieillot, 1817)	I	D	68	60	54	0
Icteridae						
Cacicus chrysopterus (Vigors, 1825)	O	D	3	2	7	0
Cacicus haemorrhous (Linnaeus, 1766)	O	D	6	17	6	0
Gnorimopsar chopi (Vieillot, 1819)	O	I	0	0	6	0
Pseudoleistes guirahuro (Vieillot, 1819)	O	I	0	0	1	0
Molothrus bonariensis (Gmelin, 1789)	O	I	0	0	0	1
Fringillidae						
Sporagra magellanica (Vieillot, 1805)	G	I	0	0	0	4
Euphonia pectoralis (Latham, 1801)	O	D	9	0	0	0
Euphonia chalybea (Mikan, 1825)	O	D	7	0	0	0

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ARTICLE

Stomach contents of Brazilian non-passerine birds

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ABSTRACT: We report on the stomach contents of 70 individuals belonging to 36 species and 12 families of non-passerine birds of the Ornithological Collection Marcelo Bagno, University of Brasilia, Brazil. The stomachs, mostly collected during the rainy season and in the Cerrado area, were opened and their food items sorted to the nearest taxonomic level. Virtually all stomachs contained food items consistent with the literature. *Galbula ruficauda*, however, had plant material in its stomach, although it is considered insectivorous. It is interesting to mention that species considered omnivorous, such as *Rhynchotus rufescens*, *Nothura maculosa* and *Ramphastos toco*, contained only animal material in their stomachs. *Columbina talpacoti, Leptotila verreauxi* and *Leptotila rufaxilla*, which can supplement their diet with arthropods, ate only vegetable material, reinforcing items of animal origin as unusual in their diet. *Geotrygon montana, C. talpacoti, L. verreauxi, N. maculosa, Aratinga aurea* and *Aratinga cactorum* had stones in their stomachs, which can help to macerate food items. This study covers non-passerines poorly sampled in the literature and can assist in improving the knowledge about the diet of these species.

KEY-WORDS: arthropod, Cerrado, diet, feeding, food item, seed.

Diet study is an important research line that may help to understand ecological, evolutionary and conservation questions about birds (Durães & Marini 2005). Field observations, even though easier to get for some species, may provide erroneous data (Hempel 1949), a problem that is avoided with the examination of stomach contents. However, there is very limited data about diet based on stomach contents of large birds, most of them non-Passeriformes. Classic studies, such as Moojen *et al.* (1941), Hempel (1949), and Schubart *et al.* (1965), describe the diet of only 36% of Brazilian non-passerine birds. The difficulty to capture large-bodied species with usually low population densities complicates the study of their stomach contents. Therefore there is still a poor knowledge to be supplemented on Brazilian non-passerine diet. In this study we describe the stomach contents from 36 species of non-passerine birds from a bird collection from central Brazil.

MATERIAL AND METHODS

Stomachs (N = 70) from 36 species of non-passerine birds were collected between 1987 and 2012, although mostly in the years of 1988 and 1989 (67.5%). The samples are from the Cerrado region, specifically from the states of Bahia, Goiás, Minas Gerais, Mato Grosso, Rondônia, Tocantins and the Federal District (Table 1).

The stomachs, preserved in alcohol 70%, were cut open and had the contents identified by Y. B. and M. R. F. The contents were examined under a stereomicroscope and analyzed in relation to the food type (animal or vegetal material). Seeds were separated in morphotypes, counted and measured to the nearest 0.1 mm. Arthropod fragments were identified to the nearest taxonomic level as possible and grouped, when possible, in families or orders (insects) and classes (other arthropods). Other animal fragments (vertebrates) were identified to the nearest taxonomic level as possible. All stomachs studied are from Coleção Ornitológica Marcelo Bagno (COMB/ML) - Universidade de Brasília, Brasília, DF, Brazil. Species names, collection date and locality are listed in the Appendix. Bird taxonomy follows Remsen *et al.* (2013).

RESULTS AND DISCUSSION

The 70 stomachs examined contained food items. Below we briefly describe and discuss the diet of each species. Detailed results are presented in the Appendix.

Tinamidae

Species of Tinamidae are considered omnivore, feeding on seeds, leaves, dry fruits, small arthropods and mollusks (Sick 1997). *Crypturellus undulatus* (N = 1) and

C. parvirostris (N = 1) ingested arthropods and vegetal material, which is consistent with an omnivore diet. The stomach of *Rhynchotus rufescens* (N = 1) analyzed contained two insect orders. No vegetal material was found, even though it may also be consumed besides arthropods (Sick 1997). The stomachs of *Nothura maculosa* (N = 3) contained four insect orders and stones, which may have been ingested accidentally or to help digestion (Beaune *et al*. 2009). Although no vegetal material was found, this species is known to feed on seeds, leaves, dry fruits, small arthropods and mollusks (Sick 1997).

Ardeidae

Nycticorax nycticorax (N = 1) contained insect fragments in its stomach, even though it is known that the species can feed on a variety of food items, as fish, aquatic insects, arthropods, mollusks and vertebrates such as frogs, lizards, and dead fledglings found on the ground (Sick 1997).

Accipitridae

The *Geranospiza caerulescens* (N = 1) stomach was composed by one insect order. *Rupornis magnirostris* (N = 3) stomachs contained seven insect genera, a lizard and an arachnid. The *R. magnirostris* (N = 1) sample from the wet season had a higher insect diversity, probably because insects are more abundant at this time of the year (Pinheiro *et al.* 2003). *Geranospiza caerulescens* and *R. magnirostris* are carnivores, feeding on arthropods and small vertebrates such as lizards, snakes, frogs, birds, bats and rodents (Mader 1981, Sick 1997, Sutter *et al.* 2001, Ramos *et al.* 2011, Camacho *et al.* 2012).

Falconidae

The stomachs of *Milvago chimachima* (N = 2) were composed of Coleoptera insects and arachnids. No other animal or vegetal material was found even though they are known to feed also on small vertebrates and carrion

TABLE 1. Collection sites of stomach samples analyzed in this study.

Code	Locality	Municipality	State
FAA	Fazenda Alegre	Correntina	Bahia
FIG	Fazenda Integrada	Correntina	Bahia
SMV	Santa Maria da Vitória	Santa Maria da Vitória	Bahia
AED	E.E. Águas Emendadas	Brasília	Distrito Federal
ASA	Asa Norte	Brasília	Distrito Federal
COU	Centro Olímpico-UnB	Brasília	Distrito Federal
DFE	DF 190, Km 14.1	Brasília	Distrito Federal
FAL	Fazenda Água Limpa	Brasília	Distrito Federal
FMB	Fazenda Mocambinho	Brasília	Distrito Federal
SHI	SHIS QI 23	Brasília	Distrito Federal
FDD	Fazenda do Delfino	São João da Aliança	Goiás
EFL	EFLEX	Silvânia	Goiás
FML	Fazenda Monalisa	Catalão	Goiás
FGA	Fazenda Graúna	Guarda-Mor	Minas Gerais
IBI	Ibiá	Ibiá	Minas Gerais
FAG	Fazenda Acangaú	Paracatu	Minas Gerais
FRT	Fazenda Rosato	Paracatu	Minas Gerais
FSB	Fazenda Sulbrasil	Paracatu	Minas Gerais
UHE	UHE Manso	Chapada dos Guimarães	Mato Grosso
BRE	BR 364, Km 180	Pimenta Bueno	Rondônia
FNI	Fazenda Nova Iguaçu	Dianópolis	Tocantins

(Sick 1997, Olmos *et al.* 2006). The insect orders found in the *Falco sparverius* (N = 1) stomach were the most common items reported for its diet in the Cerrado region (Cabral *et al.* 2006). However, this species also feeds on small vertebrates such as lizards, birds, rodents and bats (Sick 1997, Cabral *et al.* 2006, Zilio 2006).

Columbidae

This family is composed of frugivorous and granivorous species that can complement their diet with arthropods and mollusks (Sick 1997). *Columbina talpacoti* (N = 10) ingested during the wet season (N = 5) and the dry season (N = 5) seeds and grass seeds. Although Piratelli & Pereira (2002) considered it omnivore, no animal material was found in the samples, indicating that this could be a casual food item. *Leptotila verreauxi* (N = 3) and *L. rufaxilla* (N = 1) had seeds of varying sizes in their stomachs, which is consistent with the literature, as they feed mostly on fruits and also on seeds and arthropods (Moojen *et al.* 1941, Sick 1997, Gondim 2001, Piratelli & Pereira 2002). We also found stones in one of the four *L. verreauxi* stomachs. *Claravis pretiosa* (N = 2) and *Patagioenas speciosa* (N = 1), which are mostly frugivorous (Sick 1997), had stomachs with seeds and grass seeds. *Geotrygon Montana* (N = 1), another frugivore (Cruz 1974, Sick 1997), had nothing but 10 stones in its stomach, which may help digestion by macerating fruits and seeds. *Columbina squammata* (N = 2) had seeds and grass seeds of medium size in its stomachs, as expected, as it is mostly granivore (Sick 1997, Santos 2004). *Patagioenas cayennensis* (N = 2), also a granivore (Pizo 2004), contained seed of varying sizes in their stomachs. It is noteworthy the consumption of corn grains by one of the birds.

Psittacidae

The *Orthopsittaca manilata* (N = 1) and the *Amazona amazonica* (N = 1) stomachs analyzed contained large seeds, corroborating their diet as frugivores specialized on palm fruits and also on some non-palm fruits (Bonadie & Bacon 2000). The stomachs of *Aratinga aurea* (N = 7) analyzed contained seeds, fruit pulp and three of them had stones. The stomachs of *Aratinga cactorum* (N = 2) also had stones. The diet of *A. aurea*, *A. cactorum*, *Aratinga leucophthalma* (N = 1) and *Aratinga solstitialis* (N = 1) is composed mostly of seeds and fruit pulp, flowers and leaf sprout (Sick 1997, Paranhos *et al.* 2009, Peixoto 2010). *Aratinga aurea* eats also termites (de Faria 2007) and *A. cactorum* can feed on latex (Barros & Marcondes-Machado 2000). The seeds found in its stomach are consistent with this description. No animal material was found, corroborating conclusions that arthropods are a complementary food item for this species (Costa 2006). *Brotogeris versicolurus* (N = 1) has a similar diet to *A. aurea*, but it also consumes insects (Costa 2006). The stomach sample of *Pionus maximiliani* (N = 1), collected in the rainy season, was composed by fruit pulp. This species eats mostly seeds, and also flowers and fruits in a lesser amount. In the dry season, however, depending on the availability of the food items, the proportion of its diet may change and it can feed on flower and fruit in greater proportion (Galetti 1993).

Caprimulgidae

The *Nyctidromus albicollis* (N = 1) stomach sample contained 73 food items (60 flying insects and 13 non-flying insects) from five insect orders. This agrees with the large stomach capacity reported for Caprimulgidae (Sick 1997) and the species' flying insectivore hunting behavior (Thurber 2003).

Alcedinidae

All species from this family feed mainly on fish. *Megaceryle torquata* (N = 3) is the largest Brazilian Alcedinidae, and was able to ingest a 10 cm Characiformes fish. *Megaceryle torquata* may sometimes feed on small birds and some arthropods as insects and crustaceans (Willard 1985, Sick 1997, Jackson 2006). All the stomachs of *Chloroceryle amazona* (N = 2) analyzed contained only fish, but it also feeds on arthropods as insects and crustaceans (Willard 1985, Sick 1997). The samples of *Chloroceryle americana* (N = 2) contained only fish, including Chareidae, an abundant shallow water fish in the Cerrado region (P. Podestá, pers. comm.). However, this species sometimes feeds on aquatic insects or even lizards (Willard 1985, Sick 1997, Luz *et al.* 2008).

Galbulidae

Even though *Galbula ruficauda* (N = 1) is insectivorous (Chai 1986, Poulin *et al.* 1994, Pinheiro *et al.* 2003), the sample analyzed was composed by unidentified vegetal material.

Bucconidae

The *Nystalus maculatus* (N = 2) stomachs contained four orders of flying insects, probably due to the fact that it hunts insects in flight or wait on perches (Sick 1997). No other arthropod or vegetal material was found even if it is known to feed on these food items (Sick 1997).

Ramphastidae

Ramphastos toco (N = 1) is considered omnivore (Remsen *et al.* 1993, Sick 1997), but the stomach analyzed had only arthropods. Differently from *R. toco*, *Pteroglossus inscriptus* (N = 2) is basically frugivorous, feeding on a variety of fruits (Remsen *et al.* 1993, Sick 1997). We confirmed this by finding only seeds on the stomachs, including *Rapanea* seeds, an important food source for birds during the dry season (Pineschi 1990). *Pteroglossus castanotis* (N = 2) fed only on fruits of variable sizes and flowers, but had no arthropods as reported in the literature (Remsen *et al.* 1993).

Picidae

The stomachs of *Colaptes melanochloros* (N = 1) and *Colaptes campestris* (N = 1) contained only insects, confirming their highly insectivorous diet (Beltzer *et al.* 1994, Raw 1997). No vegetal material was found, even though they can also feed on fruit (de la Peña & Pensiero 2003, Tubelis 2007, Francisco & Galetti 2011).

Almost all the species analyzed in this study ingested food items consistent with diet descriptions found in the literature. However, *Galbula ruficauda* had vegetal material in its stomach even though it is considered insectivorous. This study provides information about the diet of non-passerines in the Cerrado, which can be compared with samples of the same species in other biomes. Moreover, as it is reported the month of collection for 69 of the 70 samples, this study may contribute to future investigations about possible seasonal variations in the diet of these species. Studies such as Moojen *et al.* (1941), Hempel (1949) and Schubart *et al.* (1965), which are the most comprehensive studies on Brazilian non-passerine bird diets based on stomach contents, described together only 292 of 809 species of Brazilian non-passerine birds. Furthermore, the number of stomachs analyzed per species is rarely superior to five. The small sample size found in the literature can exclude possible casual food items, thus studies like this are important to complement the knowledge about the diets of Brazilian non-passerine birds.

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APPENDIX

Qualitative and quantitative analysis of the food items observed in 70 stomachs of 36 non-passerine birds. Taxonomy of species follows Remsen *et al.* (2013). The samples were identified with the initials of the area where they were collected as shown in Table 1. The food items were abbreviated in the following way: Orthoptera (Ort.), Mantodea (Man.), Blattaria (Bla.), Isoptera (Iso.), Hemiptera (Hem.), Hymenoptera (Hym.), Araneae (Ara.).

TINAMIDAE

Crypturellus undulatus (Undulated Tinamou)
UHE/May, 1988 = 9 insect legs, unident. veg. material.

Crypturellus parvirostris (Small-billed Tinamou)
UHE/July, 1988 = 1 Ort.

Rhynchotus rufescens (Red-winged Tinamou)
FGA/November, 2001 = 1 Hem. (Heteroptera), 1 Hem. (Auchenorrhyncha), 9 Col., 1 Col. larva.

Nothura maculosa (Spotted Nothura)
FAL/July, 1989 = 1 Ort. (Acrididae), 3 Ort., 1 Iso., 5 Col., 1 Hym. (Formicidae), 1 Hym.
FSB/November, 2001 = 1 Ort. (Gryllidae), 1 Ort., 11 Col., 6 Hym. (Formicidae), stones.
FML/November, 2001 = 1 Col., stones.

ARDEIDAE

Nycticorax nycticorax (Black-crowned Night-heron)
UHE/May, 1988 = insect legs.

ACCIPITRIDAE

Geranospiza caerulescens (Crane Hawk)
FAG/March, 1989 = 6 Blat.

Rupornis magnirostris (Roadside Hawk)
DFE/April, 2010 = 1 Man., 1 Ort., 2 Hym. (Formicidae sp.1), 1 Hym. (Formicidae sp.2), 1 Hym., 1 lizard.
FAG/February, 1989 = 1 feather.
FNI/September, 2003 = 2 Iso., 1 Col., 1 Ara.

FALCONIDAE

Milvago chimachima (Yellow-headed Caracara)
EFL/March, 1989 = 5 Col., 2 Ara.
FAG/February, 1989 = 2 Col. (Scarabaeidae), 1 Ara.

Falco sparverius (American Kestrel)
EFL/March, 1989 = 1 Man., 1 Blat., 4 Ort., 1 Ara.

COLUMBIDAE

Columbina talpacoti (Ruddy Ground Dove)
UHE/November, 1988 = 1 seed (2.5 mm), 2 grass seeds (2.8 mm), 50 grass seeds (4.0 mm).
UHE/November, 1988 = 40 seeds (1.3 mm), 10 grass seeds (4.0 mm), 20 *Davilla* seeds (4.0 mm).
UHE/May, 1988 = 100 *Miconia* seeds (0.8 mm).
SHI/April, 1989 = 7 seeds (1.1 mm), 6 seeds (2.0 mm), 9 seeds (2.5 mm), 5 grass seeds (3.6 mm), 15 grass seeds (5.5 mm).
UHE/November, 1988 = 2 seeds (2.5 mm), 30 grass seeds (2.8 mm), 11 *Davilla* seeds (4.0 mm), 125 grass seeds (4.0 mm).
UHE/November, 1988 = 5 grass seeds (2.8 mm), 5 grass seeds (4.0 mm), 25 *Davilla* seeds (4.0 mm).
BRE/May, 2002 = 100 seeds (1.0 mm), 1 stone.
FRT/November, 2001 = 40 seeds (0.9 mm).
FAA/July, 2011 = 3 grass seeds (3.1 mm), 12 grass seeds (3.8 mm), 10 grass seeds (5.6 mm), 10 stones.
SMV/July, 2011 = 5 seeds (0.9 mm), 33 seeds (1.4 mm), 8 seeds (1.9 mm), 1 seed (3.2 mm).

Columbina squammata (Scaled Dove)
FMB/January, 1989 = 30 seeds (1.0 mm), 5 seeds (2.3 mm), 5 seeds (2.7 mm), 4 grass seeds (3.6 mm), 30 seeds (3.9 mm), 5 grass seeds (4.0 mm).
FAG/February, 1989 = 100 grass seeds (4.0 mm).

Claravis pretiosa (Blue Ground Dove)
FAG/February, 1989 = 15 grass seeds (4.0 mm).
FAG/February, 1989 = 20 seeds (2.5 mm).

Patagioenas speciosa (Scaled Pigeon)
UHE/November, 1988 = 2 seeds (1.6 mm), 7 seeds (2.3 mm).

Patagioenas cayennensis (Pale-vented Pigeon)
FDD/July, 1987 = 10 grass seeds (8.5 mm), 3 corn grains (11.5 mm).
FGA/November, 2001 = 500 seeds (1.4 mm), 3 seeds (12.2 mm).

Leptotila verreauxi (White-tipped Dove)
FMB/February, 1989 = 10 grass seeds (2.4 mm), 20 grass seeds (2.5 mm).
AED/July, 2007 = 100 seeds (2.0 mm), 22 seeds (3.1 mm), 8 grass seeds (3.8 mm), 9 seeds (7.9 mm), 13 seeds (8.8 mm).
SMV/July, 2011 = 20 seeds (1.6 mm), 5 seeds (2.2 mm), 3 seeds (3.0 mm), 1 seed (3.1 mm), 2 seeds (3.4 mm), 1 seed (15.3 mm), 50 stones.

Leptotila rufaxilla (Gray-fronted Dove)
UHE/November, 1988 = 2 seeds (1.7 mm), 4 seeds (2.6 mm), 3 seeds (2.7 mm), 3 seeds (9.6 mm).

Geotrygon montana (Ruddy Quail-dove)
UHE/November, 1988 = 10 stones.

PSITTACIDAE
Orthopsittaca manilata (Red-bellied Macaw)
UHE/November, 1988 = 8 seeds (4.7 mm), 8 seeds (3.6 mm).

Aratinga leucophthalma (White-eyed Parakeet)
EFL/March, 1989 = macerated seed.

Aratinga solstitialis (Sun Parakeet)
IBI/January, 1989 = 30 seeds (3.3 mm).

Aratinga aurea (Peach-fronted Parakeet)
EFL/March, 1989 = 21 seeds (2.5 mm).
EFL/March, 1989 = 1 seed (1.4 mm), 10 seeds (1.8 mm), 1 seed (3.0 mm).
FAG/February, 1989 = 100 seeds (2.3 mm), 4 stones.
FAG/February, 1989 = 50 seeds (2.3 mm), 3 stones.
FAG/February, 1989 = fruit pulp, stones.
FNI/September, 2003 = fruit pulp.
FAA/July, 2011 = 9 seeds (1.9 mm), 1 seed (2.0 mm), 2 seeds (2.6 mm), 10 seeds (2.8 mm).

Aratinga cactorum (Cactus Parakeet)
FAA/July, 2011 = 20 seeds (2.1 mm), 200 seeds (2.9 mm), 20 seeds (4.9 mm).
SMV/July, 2011 = 2 seeds (1.6 mm), 400 seeds (2.9 mm), stones.

Brotogeris versicolurus (Canary-winged Parakeet)
UHE/July, 1988 = 5 seeds (2.4 mm).

Pionus maximiliani (Scaly-headed Parrot)
FGA/November, 2001 = fruit pulp.

Amazona amazonica (Orange-winged Parrot)
UHE/November, 1988 = 50 Melastomataceae seeds (2.2 mm), 4 *Davilla* seeds (4.0 mm), 4 seeds (7.9 mm).

CAPRIMULGIDAE
Nyctidromus albicollis (Common Pauraque)
FNI/September, 2003 = 1 Blat., 11 Ort., 2 Hem (Heteroptera), 11 Col. (Scarabaeidae), 5 Col. (Elateridae), 24 Col. (sp.1), 5 Col. (sp.2), 11 Hym. (Formicidae - *Atta*), 2 Hym. (Formicidae), 1 Hym. (Vespidae).

ALCEDINIDAE
Megaceryle torquata (Ringed Kingfisher)
COU/Ind., 1998 = 1 fish.
COU/March, 1989 = 1 fish (10 cm) (Characiforme).
COU/March, 1989 = Soil clod.

Chloroceryle amazona (Amazon Kingfisher)
UHE/November, 1988 = 1 fish.
UHE/November, 1988 = 1 fish.

Choroceryle americana (Green Kingfisher)
AED/April, 1989 = 1 fish.
UHE/November, 1988 = 1 fish.
UHE/November, 1988 = 1 fish (5 cm) (Characiforme, Chareidae).

GALBULIDAE
Galbula ruficauda (Rufous-tailed Jacamar)
AED/April, 1989 = unident. veg. material.

BUCCONIDAE
Nystalus maculatus (Spot-backed Puffbird)
FAA/July, 2011 = 2 Ort., 1 Col., 2 Hym. (Apidae)
FAA/July, 2011 = 3 Ort. (Acrididae), 1 Hem. (Heteroptera).

RAMPHASTIDAE
Ramphastos toco (Toco Toucan)
ASA/March, 2012 = 1 Ara., 2 membranous wings.

Pteroglossus inscriptus (Lettered Aracari)
UHE/November, 1988 = 7 Rubiaceae seeds (9.6 mm).
UHE/November, 1988 = 100 seeds (2.7 mm), 25 *Rapanea* seeds (3.1 mm).

Pteroglossus castanotis (Chestnut-eared Aracari)
UHE/July, 1988 = 100 *Rapanea* seeds (3.1 mm).
UHE/November, 1988 = 60 seeds (1.8 mm), 4 seeds (12.3 mm), 2 flowers.

PICIDAE
Colaptes melanochloros (Green-barred Woodpecker)
FIG/July, 2011 = 102 Hym. (Formicidae sp.1), 45 Hym. (Formicidae sp.2), 15 Hym. (Formicidae sp.3).

Colaptes campestris (Campo Flicker)
FAA/July, 2011 = 150 Iso.

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ARTICLE

Avian composition and distribution in a mosaic of cerrado habitats (RPPN Parque Ecológico João Basso) in Rondonópolis, Mato Grosso, Brazil

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ABSTRACT: The birds of cerrado in Mato Grosso are poorly studied and although the RPPN Parque Ecológico João Basso is a natural cerrado remnant, there are no studies of fauna in this area. Thus, we conducted the first bird survey in this area to describe the avifauna composition and to analyze the spatial distribution among three habitats (gallery forest, cerradão and cerrado *stricto sensu*). We adopted the transect method (100 m) in 56 h of sampling. We recorded 191 species (2.865 contacts). The Shannon-Wiener index was 4,258 and equity 0,819. We detected only two endangered species, five endemic species to the cerrado, and 31 migratory species. We recorded 101 species in gallery forests (29 only in this habitat), 107 in cerradão (22 exclusive) and 115 in cerrado *stricto sensu* (50 exclusive). The cerradão was intermediate between gallery forest and cerrado *stricto sensu* in terms of both horizontal and vertical distribution of species, being slightly more similar to the gallery forest and the cerrado *stricto sensu.* High indices of richness and evenness detected among bird communities of different habitat types reinforce the importance of the study area for the conservation of the cerrado avifauna.

KEY-WORDS: bird community; conservation; habitat selection; savanna; vertical and horizontal distribution.

INTRODUCTION

The cerrado domain is a mosaic of vegetation ranging from grassland (savanna) to forested environments, such as cerradão, riparian vegetation and gallery forest (Coutinho 2006, Batalha 2011). This heterogeneity in the cerrado increases the species richness and provides high biodiversity (Klink & Machado 2005). However, it has been one of the most modified biomes by human actions (Myers *et al.* 2000, Goldstein *et al.* 2008). With regards to the Mato Grosso state, the native cerrado vegetation has been quickly replaced by monocultures, particularly soybean and cotton plantations due to the fertile soil and favorable topography. As a result, the remaining cerrado is now largely fragmented and isolated. In this way, the relictual biodiversity of cerrado can be found only in these fragments (Vialou 2006, Durigan *et al.* 2007).

The cerrado in Mato Grosso has been little studied in relation to birds. There have been only short periods studies performed by Naumburg (1930), Willis (1976), Allen (1981, 1982, 1983a e b), Silva & Oniki (1988), Willis & Oniki (1990), Silveira & D'Horta (2002), Vasconcelos *et al.* (2008) and Lopes *et al.* (2009). As noted, more extensive studies on birds in the remaining areas in Mato Grosso are needed, particularly in protected areas where there are best oportunities for bird conservation (Rylands & Brandon 2005). In addition, there are no studies focused on the spatial distribution on birds of cerrado in the Mato Grosso state.

Thus, we conducted this study to describe the composition of the local avifauna and to analyze their horizontal and vertical distributions on three distinct vegetation types occurring at the study site (cerradão, gallery forest and cerrado *stricto sensu*).

MATERIALS AND METHODS

Study site

Although the RPPN Parque Ecológico João Basso (hereafter JB) is a protected area of cerrado, no wildlife studies have been conducted there. The JB (16°31'40.48 "S; 54°49'56.80" W) is located 71 km from Rondonopolis / MT and has 3,624.57 ha (Figure 1). Its relief in form of ruins lies in a valley located between plateaus with sandstones and siltstones from the Devonian Furnas Formation. The soil is predominantly made of sandstone-quartz (Nardes 2005). The climate is tropical, with annual temperatures and rainfall averages of 25C ° and 1000 to 2000 mm, respectively (Sette 2000). Two major rivers (Vermelho and Ribeirão Ponte de Pedra) limit the JB in its northeastern portion, with several streams occurring within the area (Figure 1). The altitude varies between 200 and 600 m with plateaus at various locations (Nardes 2005).

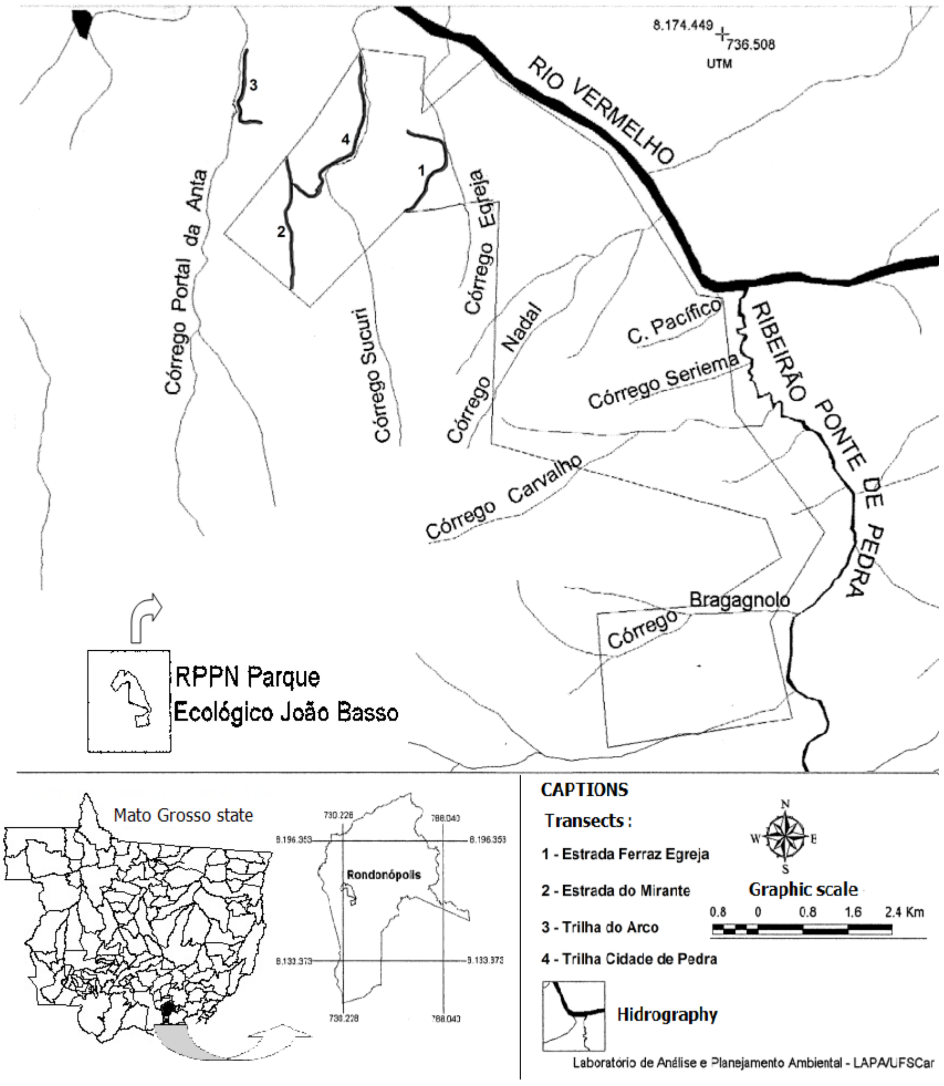

FIGURE 1. Map with location, boundaries and hydrography of RPPN Parque Ecológico João Basso (modified from Nardes, 2005), with the locations of transects sampled (bold and numbered lines: 1, 2, 3 e 4).

According to Batalha's (2011) definition, there are two main habitats in the cerrado *sensu lato*: a) semideciduous forest: cerradão and gallery forests at lower altitudes and; b) savanna: cerrado *stricto sensu* in the intermediate altitudes and cerrado campo sujo (scrubs) in the higher altitude areas ("chapadões"). Thus, we sampled four pre-existing paths (Figure 1) for each of the following habitats: a) cerrado *stricto sensu*: Ferraz Egreja and Mirante; and b) cerradão and gallery forests: Cidade de Pedra (córrego da Sucuri) and Arco (córrego Portal da Anta), the latter outside the legal boundaries of JB (Nardes 2005).

Bird surveys

The study was conducted from November 2006 to October 2007, except February and April 2007 when we did not have access to the study area because of intense rainfall. We used linear transects (Bibby *et al.* 1992) with a radius of 100 m on each side and two hours of uninterrupted observations for each survey. The sampling units (replicated surveys) were four trails (see Fig. 1), with trails 1 and 2 located in the savanna (cerrado *stricto sensu*) and trails 3 and 4 cutting the semideciduous forest types (cerradão and gallery forest). We run a total of 28 transects surveys during 56 h distributed in the following sampling units: seven transect surveys in each trails 3 and 4 (12 h during the dry season and 16 h in the wet season), and seven transect surveys in each trails 1 and 2 (16 h during the dry period and 12 h in the wet season). Birds were counted only if detected in a specific habitat (cerradão, gallery forest and cerrado *stricto sensu*). Flying over birds were not counted, except for the Apodiformes.

We analyzed bird community distribution according to habitat type (cerradão, gallery forest and cerrado *stricto sensu*), and also vertical distribution (whether primarily associated with the ground, understory and canopy) at each habitat type. Birds were considered canopy dwellers if they were detected within or at terminal branches of tree crowns. Birds detected on or close (less than 0.5 m) to the ground were considered ground dwellers. Finally, birds often recorded above 0.5 m off the ground and bellow the tree crowns were treated as understory dwellers.

The data on migratory birds were determined consulting Sick (1997) for migrant birds within Brazil and Luna *et al.* (2003) within the South America.

Data analysis

We calculated the Shannon-Wiener index (H ') and the parameters that affect this index such as richness, relative abundance, frequency of occurrence (FO), and evenness (*sensu* Anjos *et al.* 2010). Differences in species richness among the three main habitats surveyed (cerradão, gallery forest, and cerrado *stricto sensu*, i.e., dependent variables) were calculated with the Student's t test. In addition, the sampling effort (number of samples) in different environments was evaluated by using cumulative curves of species estimated by the program PAST version 2.0 (Hammer *et al.* 2001).

The Sorensen similarity index was used to compare the avifauna among the sampled habitats. We performed the Pearson index to assess the correlation between richness and relative abundance in each habitat studied. These parameters were obtained by the software SYSTAT® 11th version (Wilkinson 2004) and we adopted the level of significance of ≤ .005.

We used an analysis of similarity (ANOSIM) to test for differences in bird species composition among transects of the habitat types sampled. The ANOSIM procedure uses Monte Carlo randomization of observed data to assess whether rank similarities within groups (transects) are greater than between groups (habitat types). The Bray-Curtis index was used to express similarities and 10.000 Monte Carlo permutations were conducted to generate a random test statistic. If the ANOSIM was significant, we conducted a non-metric multidimensional scaling (NMDS) ordination. This technique was also based on the Bray-Curtis similarity measure between any two sites. We performed this analysis to further explore within – and between – habitat differences in community structure at the level of transect. The abundance measure used in the ordination was the number of individuals observed at each transect. Transects from a given habitat type were thus positioned in ordination space according to their bird species composition and abundance.

RESULTS

We recorded 191 species, 101 in gallery forest (29 recorded only in this habitat), 107 in cerradão (22 exclusive) and 115 in cerrado *stricto sensu* (50 exclusive). Forty-two species were found in all habitats (Appendix), 25 between only gallery forest and cerradão, 18 between cerradão and cerrado *stricto sensu* and only five species between gallery forest and cerrado *stricto sensu*. Despite the richness variation observed among habitat types, bird species richness exhibited no significant difference among habitats (t = - 0099, df = 222, p = 092) (Figure 2). Rarefaction curves (Figure 3) for the three habitats / sites indicate a tendency towards stability within the 95% confidence interval.

We contacted 2,865 birds, including 937 in gallery forest, 950 in cerradão and 978 in cerrado *stricto sensu*. *Ara ararauna* showed the highest relative abundance (88 contacts; AI = 0.045), followed by *Ramphocelus carbo* (72; 0.037), *Turdus leucomelas* (65; 0.033), *Basileuterus flaveolus* (55; 0.028), *Pitangus sulphuratus* (53; 0.027), *Gnorimopsar chopi* (50; 0.026) and *Crypturellus undulatus* (44; 0.022) (Appendix).

The following species were more frequent: *T. leucomelas* (FO = 71.42); *B. flaveolus* (67.85); *P. sulphuratus* (60.71); *Thamnophilus pelzeni* (57.13), *C. undulatus* and *Leptotila verreauxi* (53.57); *A. ararauna*, *Cyclarhis gujanensis*, *R. carbo* and *G. chopi* (46.42); *Patagioenas picazuro*, *Piaya cayana*, *T. amaurochalinus* and *Momotus momota* (42.85) (Appendix).

We recorded 31 migratory species (Appendix), with 13 regarded as austral migrants (e.g., *Hirundinea ferruginea*, *Elaenia spectabilis*, *Serpophaga subcristata*, *Myiarchus swainsoni*, *Myiodynastes maculatus*, *Pyrocephalus rubinus*, *Tyrannus savanna*, and *T. melancholicus*), whereas *Vireo olivaceus* migrates throughout the Americas.

The Shannon-Wiener index (H') of the studied area was 4258 and evenness (J') 0819. The Sorensen Similarity Index (ISS) between semideciduous forest (gallery forest and cerradão) and savanna (cerrado *stricto sensu*) was 0519, being 0798 between gallery forest and cerradão, 0571 between cerradão and cerrado *stricto sensu* and 0390 between gallery forest and cerrado *stricto sensu*.

Differences in bird species composition were higher between than within habitats classes (ANOSIM, *r* = 054, *P* < 0004). This result reflected the coherence of transect dispersion in the ordination plot according to bird species composition in each habitat type (Figure 4). Some species were entirely restricted to a given habitat type, which shared different complements of its avifauna with other sites (Appendix). The most marked contrast in species composition was therefore between the bird assemblages of cerrado *stricto sensu* and gallery forest with only 47 species in common (Appendix). These observations are supported by the NMDS ordination (stress = 0163, Figure 4). It is clear that cerrado *stricto sensu* and gallery forest diverged considerably in their bird assemblage composition, being distinctly separated

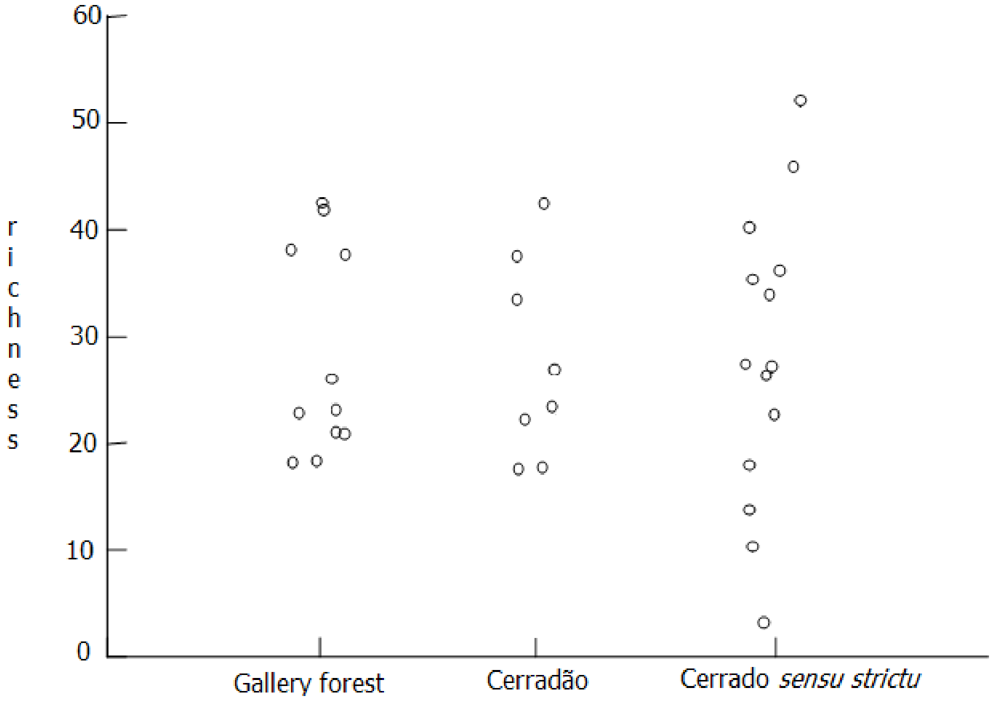

FIGURE 2. Richness distribution of survey samples obtained in gallery forest, cerradão and cerrado *stricto sensu* habitats of the RPPN Parque Ecológico João Basso.

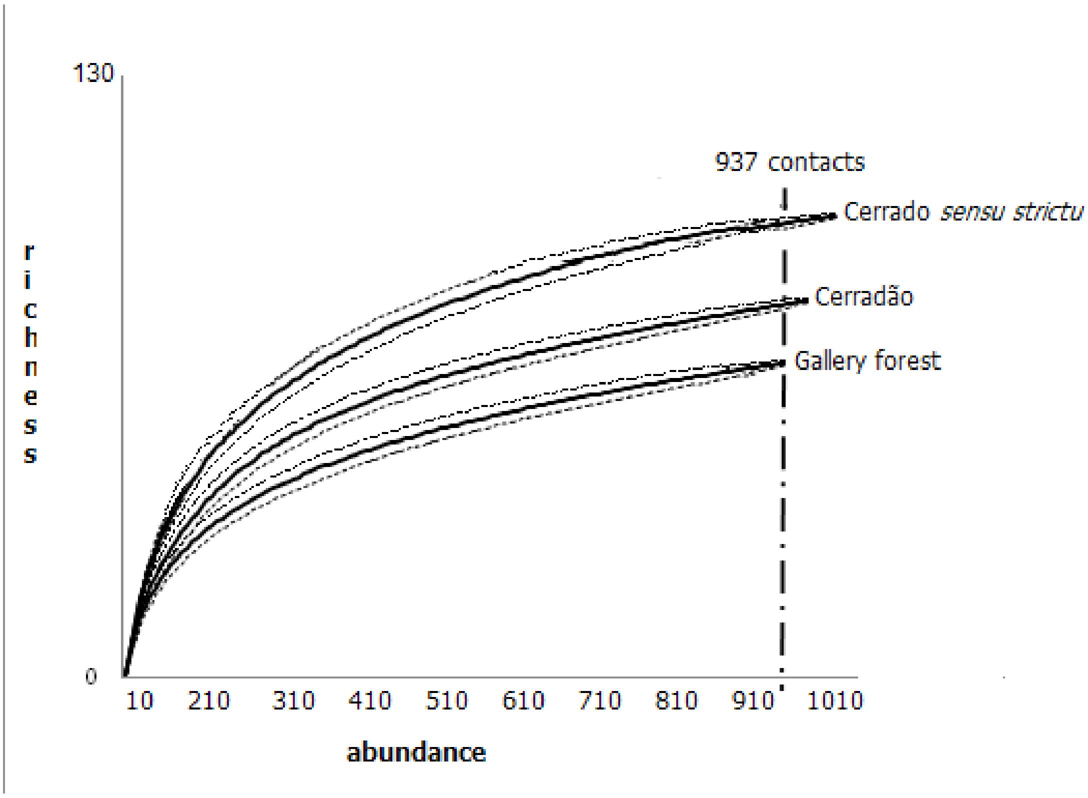

FIGURE 3. Rarefaction curves plotting species richness against the cumulative number of contacts obtained in gallery forest, cerradão and cerrado *stricto sensu* habitats of the RPPN Parque Ecológico João Basso. Confidence intervals (95%) are denoted with dashed lines.

at opposite ends of the ordination diagram. The cerradão sites were similarly distinct, with 85 species in common with gallery forest and/or cerrado *stricto sensu* (Appendix), appearing to cluster between cerrado *stricto sensu* and gallery forest (Figure 4).

Differences in bird species composition also emerged according to vertical distribution of bird species in the habitat types, which were greater between than within habitat classes (ANOSIM, $r = 088$, $P < .00001$). According to vertical distribution, transect groups were highly coherent, so that canopy and ground bird assemblages were positioned in opposite extremes of the ordination plot (NMDS, stress = 020, Figure 5). Also in this case, gallery forest and cerrado *stricto sensu* diverged substantially in respect to either canopy or ground bird assemblages (Figure 5). As expected, the dense cerradão, which shared traits with both habitat types, figured as intermediate between ground and canopy assemblages. Understory assemblages of both cerradão and gallery forest, besides being very similar, equally diverged from canopy and ground assemblages, mainly due to the presence of several insectivorous bird species.

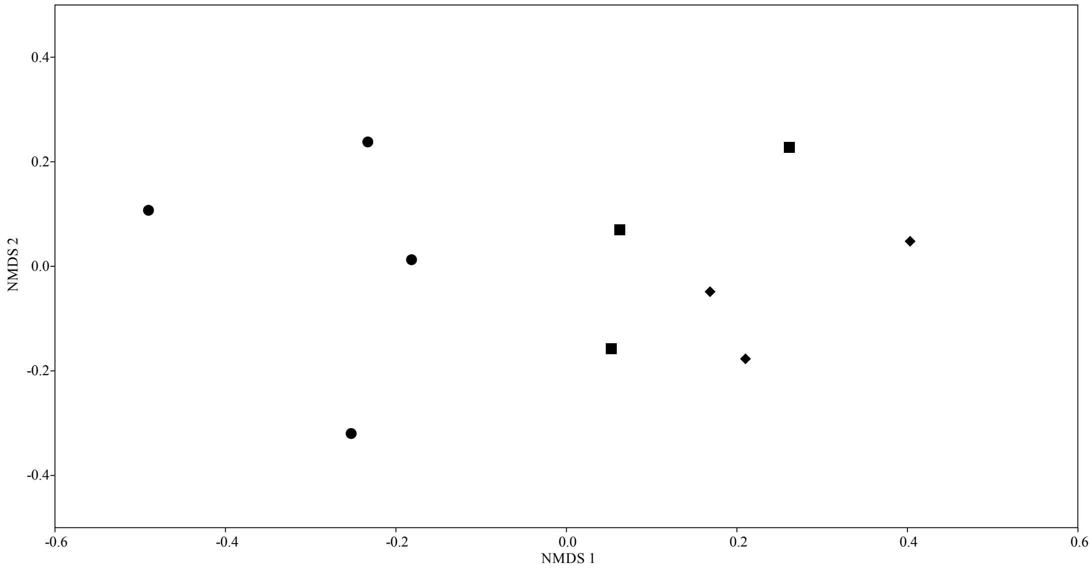

FIGURE 4. Non-metric multi-dimensional scaling (NMDS; stress = 0.163) ordination of horizontal (inter-habitat) distribution of the bird communities recorded along transects in cerrado *stricto sensu* (circles), cerradão (squares) and gallery forest (diamonds), in the RPPN João Basso.

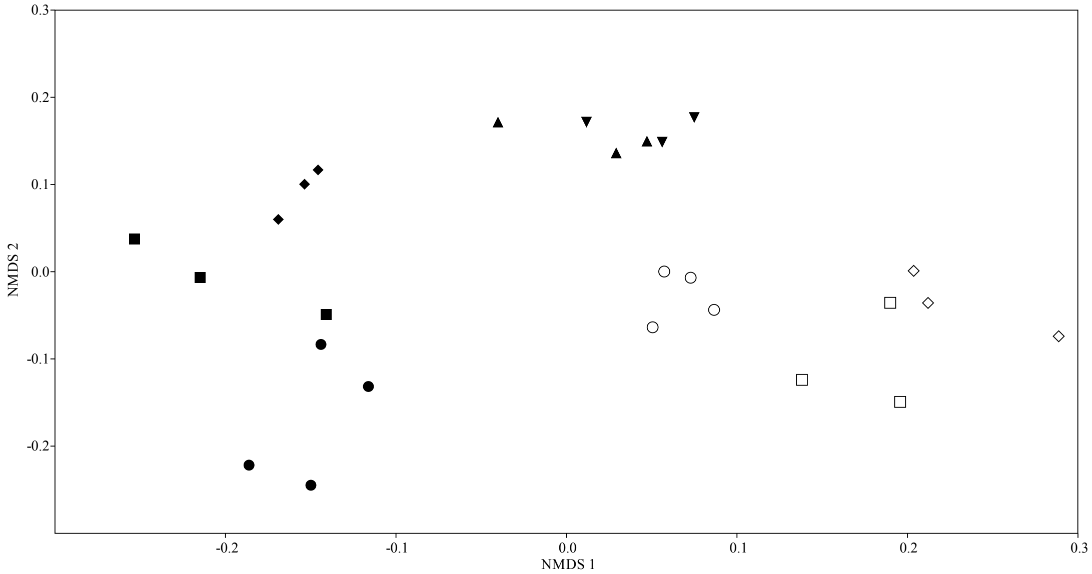

FIGURE 5. Non-metric multi-dimensional scaling (NMDS; stress = 0.200) ordination of vertical (preferential foraging stratum) distribution of bird communities recorded along transects in cerrado *stricto sensu*, cerradão, and gallery forest in the RPPN João Basso. Avifauna of cerrado *stricto sensu*: ground = full circles, understory = open circles; Avifauna of cerradão: ground = full squares, understory = full triangles, canopy = open squares; Avifauna of gallery forest: ground = full diamonds, understory = full upside-down triangles, canopy = open diamonds.

DISCUSSION

Avifauna composition

According to Silva (1995), 837 species are found in the cerrado biome, so the species recorded at JB correspond to 22,82% of the cerrado avifauna. In addition, the Shannon-Wiener index points out towards a high avian diversity. This is probably due to the fact that the JB is a recently isolated area by extensive monocultures, and also to the presence of riparian and gallery forests, which connect this area with other fragments, allowing a wider range species movement. In this respect, about 23% of birds occurring in the cerrado are threatened (Silva 1995), and only 4% endemic (Myers *et al.* 2000). From the 191 species recorded during this study, only two are endangered (IUCN 2010): *Primolius maracana* and *Rhea americana* and five are endemic to the cerrado: *Herpsilochmus longirostris*, *Saltatricula atricollis*, *Basileuterus leucophrys*, *Antilophia galeata*, and *Cyanocorax cristatellus* (Silva & Bates 2002).

The high relative abundance recovered for *A. ararauna* might be explained by the presence of dormitories and nesting places of this species in the study area (S. R. Posso, *pers. obs.*). On the other hand, the relative high abundance of other species potentially mirrors the ability to exploit wide niches (Gregory & Gaston 2000), as seems to be the case of *T. leucomelas* and *P. sulphuratus*. Moreover, some birds show frequent and loud vocalizations (*C. undulatus*) and/or are gregarious (*Brotogeris chiriri*, *C. chrysops, R. carbo* and *G. chopi*), which increase their detection index. However, it is important to remember that relative abundance does not necessarily reflect true abundance (Anjos *et al.* 2010).

About 10% of birds occurring in the cerrado are migratory (Silva 1995), so a total of 16.23% species recorded during the study were migratory, with 6.8% of all species considered austral migrants. These percentages indicate the importance of the JB for migratory species, particularly those from southern South America. The remaining migrants (13,1%) are mostly passerines, with the predominance of austral flycatchers, a well-known migratory group (Sick 1997).

The data above suggest that the JB harbors a rich avifauna, presumably as consequence of reduced anthropization, in spite of being located within a highly disturbed Brazilian region due to intensive agriculture. This reinforces the importance of this cerrado mosaic for birdlife conservation.

Spatial distribution

Animal diversity is directly affected by the heterogeneity of the local vegetation (Veech & Crist 2007). According to Tubelis & Cavalcanti (2001) the bird species composition of the cerrado is associated with the floristic and structural characteristics of the habitat. Structurally complex environments have a richer variety of niches and more possibilities for resource exploitation, enabling the existence of a higher diversity of species (Poulsen 2002).

The most pronounced difference in species composition between habitats was that between cerrado *stricto sensu* and gallery forest. This is not surprising given the spatial configuration of the gallery forest, which formed a narrow corridor across the cerradão matrix, and includes dense and evergreen trees along a major perennial river (Figure 1). On the other hand, the cerrado *stricto sensu* is a semi-open habitat in which trees are interspersed with open grassy areas. In fact, gallery forest transects exhibited enhanced coherence in comparison with cerrado *stricto sensu* transects in which were present a highly diverse avifauna ranging from the large *Rhea americana* to small canopy species such as *Elaenia cristata*. This result is well within the environmental heterogeneity hypothesis (Poulsen 2002). The contrasting structural and seasonal differences between dense and semi-open habitats are expressed in richness patterns observed throughout the year (Cavalcanti 1992). For example, the higher densities of tree trunks on which they forage, might explain the higher richness of Dendrocolaptidae in the cerradão and gallery forests. According to the vertical distribution, both cerradão and gallery forest shared a high number of understory insectivorous bird species (Figure 5). Often, understory insectivorous birds are less prone to travel across open areas due to the reduced variability in arthropods availability they prey upon (Yabe & Marques 2001). This is particularly consistent in dense woodland and forest corridors that support higher richness and abundance of arthropods (Ramirez-Alborez 2006). Tubelis & Cavalcanti (2000) observed that the increase in floristic composition results in a higher number of associated invertebrates, which allows the establishment of insectivorous birds.

Nevertheless, in addition to an abundant and perennial water supply, gallery forests also harbors specific foods items associated to the occurrence of birds dependent on this habitat, such as *Chloroceryle amazona*, *Megaceryle torquata, Eurypyga helias*, *A. galeata* and *B. leucophrys*. According to Tubelis *et al.* (2004), the particular seasonal and structural traits of the gallery forest favor a rich bird community in spite of the reduced area in comparison to the other cerrado habitats. Therefore, denser habitats such as gallery forests and cerradão seem to play a very important role in maintaining high levels of bird richness throughout the seasonal cycle.

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APPENDIX.

Check-list of bird species recorded at the RPPN Parque Ecológico João Basso, Rondonópolis, Mato Grosso, between 2006 and 2007. Systematics and nomenclature follow CBRO (2011).

Species	**Total of contacts**	**AI(Pi)[1]**	**FO[2]**	**Habitat**	**Status of Migration**
Struthioniformes Latham, 1790					
Rheidae Bonaparte, 1849					
Rhea americana (Linnaeus, 1758)	6	0,0031	7,14	CS	-
Tinamiformes Huxley, 1872					
Tinamidae Gray, 1840					
Crypturellus soui (Hermann, 1783)	2	0,001	7,14	C, GF	-
Crypturellus obsoletus (Temminck, 1815)	11	0,0057	28,57	C, CS	-
Crypturellus undulatus (Temminck, 1815)	44	0,0229	53,57	C/ GF, CS	-
Crypturellus parvirostris (Wagler, 1827)	10	0,0052	28,57	C, CS	-
Rhynchotus rufescens (Temminck, 1815)	5	0,0026	14,28	CS	-
Nothura maculosa (Temminck, 1815)	1	0,0005	3,37	CS	-
Galliformes Linnaeus, 1758					
Cracidae Rafinesque, 1815					
Penelope superciliaris Temminck, 1815	20	0,0104	28,57	C/ GF, CS	-
Pelecaniformes Sharpe, 1891					
Ardeidae Leach, 1820					
Syrigma sibilatrix (Temminck, 1824)	1	0,0005	3,57	CS	-
Threskiornithidae Poche, 1904					
Mesembrinibis cayennensis (Gmelin, 1789) [*A]	4	0,002	7,14	CS	-
Theristicus caudatus (Boddaert, 1783)	14	0,0073	25	CS	-
Cathartiformes Seebohm, 1890					
Cathartidae Lafresnaye, 1839					
Cathartes aura (Linnaeus, 1758)	8	0,0041	7,14	C, CS	-
Cathartes burrovianus Cassin, 1845	5	0,0026	7,14	CS	-
Coragyps atratus (Bechstein, 1793)	29	0,0151	35,71	C/ GF, CS	-
Sarcoramphus papa (Linnaeus, 1758)	5	0,0026	17,85	C, CS	-
Accipitriformes Bonaparte, 1831					
Accipitridae Vigors, 1824					
Elanoides forficatus (Linnaeus, 1758)	8	0,0041	14,28	CS	-
Gampsonyx swainsonii Vigors, 1825	1	0,0005	3,57	C	-
Ictinia plumbea (Gmelin, 1788)	2	0,001	7,14	C, CS	-
Rupornis magnirostris (Gmelin, 1788)	4	0,002	14,28	CS	-
Pseudastur albicollis (Latham, 1790)	4	0,002	10,71	GF	-
Falconiformes Bonaparte, 1831					
Falconidae Leach, 1820					
Caracara plancus (Miller, 1777)	5	0,0026	3,57	CS	-
Milvago chimachima (Vieillot, 1816)	3	0,0015	10,71	CS	-

Species	**Total of contacts**	**AI(Pi)[1]**	**FO[2]**	**Habitat**	**Status of Migration**
Herpetotheres cachinnans (Linnaeus, 1758)	4	0,002	14,28	GF, CS	-
Falco rufigularis Daudin, 1800	1	0,0005	3,57	CS	-
Falco femoralis Temminck, 1822*B	2	0,001	7,14	CS	-
Eurypygiformes Furbringer, 1888					
Eurypygidae Selby, 1840					
Eurypyga helias (Pallas, 1781)	3	0,0015	7,14	GF	-
Gruiformes Bonaparte, 1854					
Rallidae Rafinesque, 1815					
Porzana albicollis (Vieillot, 1819)	2	0,001	7,14	GF	-
Cariamiformes Furbringer, 1888					
Cariamidae Bonaparte, 1850					
Cariama cristata (Linnaeus, 1766)	15	0,0078	21,42	CS	-
Charadriiformes Huxley, 1867					
Charadriidae Leach, 1820					
Vanellus chilensis (Molina, 1782)	12	0,0062	14,28	CS	-
Columbiformes Latham, 1790					
Columbidae Leach, 1820					
Columbina talpacoti (Temminck, 1811)	41	0,0214	25	C,CS	-
Columbina squammata (Lesson, 1831)	29	0,0151	17,85	C, CS	-
Claravis pretiosa (Ferrari-Perez, 1886) *A	4	0,002	10,71	C, GF, CS	R
Patagioenas speciosa (Gmelin, 1789)	7	0,0036	14,28	C, GF	-
Patagioenas picazuro (Temminck, 1813) *A	30	0,0156	42,85	C, GF, CS	-
Patagioenas cayennensis (Bonnaterre, 1792)	2	0,001	7,14	GF	-
Zenaida auriculata (Des Murs, 1847)	13	0,0067	14,28	CS	
Leptotila verreauxi Bonaparte, 1855	24	0,0125	53,57	C/ GF, CS	-
Leptotila rufaxilla (Richard & Bernard, 1792)	18	0,0093	28,57	C/ GF, CS	-
Psittaciformes Wagler, 1830					
Psittacidae Rafinesque, 1815					
Ara ararauna (Linnaeus, 1758)	88	0,0459	46,42	C/ GF, CS	-
Ara severus (Linnaeus, 1758)	1	0,0005	3,57	C	-
Primolius maracana (Vieillot, 1816)	23	0,012	21,42	C, GF, CS	-
Primolius auricollis (Cassin, 1853)	10	0,0052	17,85	C, GF	-
Diopsittaca nobilis (Linnaeus, 1758)	32	0,0167	25	C, GF	-
Aratinga acuticaudata (Vieillot, 1818)	2	0,001	3,57	C	-
Aratinga leucophthalma (Statius Muller, 1776)	27	0,014	28,57	C, GF, CS	-
Aratinga aurea (Gmelin, 1788)	38	0,0198	21,42	C, GF, CS	-
Pyrrhura snethlageae Joseph & Bates, 2002	8	0,0041	7,14	C,GF	-
Myiopsitta monachus (Boddaert, 1783)	10	0,0052	10,71	CS	-
Forpus xanthopterygius (Spix, 1824)	12	0,0062	3,57	C, GF	-
Brotogeris versicolurus (Statius Muller, 1776)	41	0,0214	32,14	C, GF, CS	-
Amazona aestiva (Linnaeus, 1758)	10	0,0052	10,71	C/ GF, CS	-

Species	**Total of contacts**	**AI(Pi)[1]**	**FO[2]**	**Habitat**	**Status of Migration**
Cuculiformes Wagler, 1830					
Cuculidae Leach, 1820					
Piaya cayana (Linnaeus, 1766)	14	0,0073	42,85	C/ GF, CS	-
Crotophaga ani Linnaeus, 1758	18	0,0093	7,14	CS	-
Guira guira (Gmelin, 1788)	12	0,0062	7,14	CS	-
Tapera naevia (Linnaeus, 1766)	2	0,001	7,14	C	-
Dromococcyx phasianellus (Spix, 1824)	8	0,0041	25	C, CS	-
Strigiformes Wagler, 1830					
Strigidae Leach, 1820					
Megascops choliba (Vieillot, 1817)	1	0,0005	3,57	CS	-
Glaucidium brasilianum (Gmelin, 1788)	4	0,002	14,28	C, CS	-
Athene cunicularia (Molina, 1782)	2	0,001	3,57	CS	-
Caprimulgiformes Ridgway, 1881					
Caprimulgidae Vigors, 1825					
Hydropsalis albicollis (Gmelin, 1789)	15	0,0078	25	C, GF CS	-
Apodiformes Peters, 1940					
Apodidae Olphe-Galliard, 1887					
Panyptila cayennensis (Gmelin, 1789)	28	0,0146	3,57	CS	-
Trochilidae Vigors, 1825					
Phaethornis pretrei (Lesson & Delattre, 1839)	6	0,0031	10,71	C, GF	-
Eupetomena macroura (Gmelin, 1788)	2	0,001	7,14	CS	-
Anthracothorax nigricollis (Vieillot, 1817) [*B]	5	0,0026	14,28	CS	-
Chlorostilbon lucidus (Shaw, 1812)	5	0,0015	10,71	C,GF	-
Trogoniformes A. O. U., 1886					
Trogonidae Lesson, 1828					
Trogon surrucura Vieillot, 1817	4	0,002	14,28	C, GF	-
Trogon curucui Linnaeus, 1766	12	0,0062	35,71	C, GF	-
Coraciiformes Forbes, 1844					
Alcedinidae Rafinesque, 1815					
Megaceryle torquata (Linnaeus, 1766)	1	0,0005	3,57	GF	-
Chloroceryle americana (Gmelin, 1788)	1	0,0005	3,57	GF	-
Momotidae Gray, 1840					
Momotus momota (Linnaeus, 1766)	19	0,0099	42,85	C, GF	-
Galbuliformes Fürbringer, 1888					
Galbulidae Vigors, 1825					
Brachygalba lugubris (Swainson, 1838)	1	0,0005	3,57	C, GF	-
Galbula ruficauda Cuvier, 1816	8	0,0041	14,28	C, GF	-
Bucconidae Horsfield, 1821					
Bucco tamatia Gmelin, 1788	1	0,0005	3,57	GF	-
Nystalus chacuru (Vieillot, 1816)	2	0,001	7,14	C, CS	-
Nystalus maculatus (Gmelin, 1788)	1	0,0005	3,57	CS	-

Species	**Total of contacts**	**AI(Pi)**^{1}	**FO**^{2}	**Habitat**	**Status of Migration**
Monasa nigrifrons (Spix, 1824)	31	0,0162	39,28	GF, CS	-
Chelidoptera tenebrosa (Pallas, 1782)	19	0,0099	21,42	C/ GF, CS	-
Piciformes Meyer & Wolf, 1810					
Ramphastidae Vigors, 1825					
Ramphastos toco Lichtenstein, 1823	1	0,0005	3,57	GF	-
Ramphastos vitellinus Lichtenstein, 1823	1	0,0005	3,57	C	-
Pteroglossus castanotis Gould, 1834	7	0,0036	14,28	C, GF, CS	-
Picidae Leach, 1820					
Veniliornis passerinus (Linnaeus, 1766)	8	0,0041	21,42	C, GF, CS	-
Colaptes campestris (Vieillot, 1818)	17	0,0088	10,71	CS	-
Celeus lugubris (Malherbe, 1851)	4	0,002	7,14	C	-
Dryocopus lineatus (Linnaeus, 1766)	2	0,001	7,14	GF	-
Passeriformes Linné, 1758					
Thamnophilidae Swainson, 1824					
Formicivora rufa (Wied, 1831)	3	0,0015	7,14	CS	-
Herpsilochmus longirostris Pelzeln, 1868	2	0,001	3,57	C, GF	-
Thamnophilus doliatus (Linnaeus, 1764)	12	0,0062	21,42	C/ GF, CS	-
Thamnophilus pelzeni (Hellmayr, 1924)	36	0,0187	57,13	C/ GF, CS	-
Thamnophilus caerulescens Vieillot, 1816	5	0,0026	14,28	C, GF, CS	-
Taraba major (Vieillot, 1816)	2	0,001	3,57	CS	-
Cercomacra melanaria (Ménétriès, 1835)	1	0,0005	3,57	GF	-
Dendrocolaptidae Gray, 1840					
Sittasomus griseicapillus (Vieillot, 1818)	22	0,0114	50	C, GF, CS	-
Xiphorhynchus guttatus (Lichtenstein, 1820)	10	0,0052	14,28	C, GF	-
Dendroplex picus (Gmelin, 1788)	1	0,0005	3,57	GF	-
Lepidocolaptes angustirostris (Vieillot, 1818)	13	0,0067	32,14	C, CS	-
Dendrocolaptes picumnus Lichtenstein, 1820	3	0,0015	10,71	C, GF	-
Dendrocolaptes platyrostris Spix, 1825	1	0,0005	3,57	C	-
Xiphocolaptes albicollis (Vieillot, 1818)	1	0,0005	3,57	GF	-
Furnariidae Gray, 1840					
Xenops rutilans Temminck, 1821	1	0,0005	3,57	GF	-
Furnarius rufus (Gmelin, 1788)	8	0,0041	7,14	CS	-
Hylocryptus rectirostris (Wied, 1831)	1	0,0005	3,57	GF	-
Syndactyla dimidiata (Pelzeln, 1859)	1	0,0005	3,57	GF	-
Phacellodomus ruber (Vieillot, 1817)	1	0,0005	3,57	GF	-
Certhiaxis cinnamomeus (Gmelin, 1788)	1	0,0005	3,57	GF	-
Synallaxis frontalis Pelzeln, 1859	5	0,0026	14,28	C, CS	-
Pipridae Rafinesque, 1815					-
Pipra fasciicauda Hellmayr, 1906	1	0,0005	3,57	GF	-
Antilophia galeata (Lichtenstein, 1823)	22	0,0114	32,14	GF	-

Species	**Total of contacts**	**AI(Pi)[1]**	**FO[2]**	**Habitat**	**Status of Migration**
Tityridae Gray, 1840					
Tityra inquisitor (Lichtenstein, 1823)	4	0,002	7,14	GF	-
Tityra cayana (Linnaeus, 1766)	6	0,0031	10,71	GF	-
Tityra semifasciata (Spix, 1825)	4	0,002	10,71	GF	-
Pachyramphus viridis (Vieillot, 1816)	3	0,0015	10,71	GF	-
Pachyramphus marginatus (Lichtenstein, 1823)	2	0,001	3,57	GF	-
Insertae sedis					
Platyrinchus mystaceus Vieillot, 1818	1	0,0005	3,57	C	-
Rynchocyclidae Berlepsch, 1907					
Leptopogon amaurocephalus Tschudi, 1846	1	0,0005	3,57	C	-
Tolmomyias sulphurescens (Spix, 1825)	1	0,0005	3,57	C/ GF	-
Poecilotriccus latirostris (Pelzeln, 1868)	14	0,0073	17,85	C, GF	-
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	13	0,0067	25	C	-
Tyrannidae Vigors, 1825					
Hirundinea ferruginea (Gmelin, 1788)	9	0,0046	17,85	CS	A
Camptostoma obsoletum (Temminck, 1824)	5	0,0026	14,28	CS	-
Elaenia flavogaster (Thunberg, 1822) [*A]	2	0,001	7,14	CS	A
Elaenia spectabilis Pelzeln, 1868	1	0,0005	3,57	CS	A
Elaenia cristata Pelzeln, 1868	2	0,001	7,14	C, CS	-
Myiopagis gaimardii (d'Orbigny, 1839)	1	0,0005	3,57	C	-
Myiopagis viridicata (Vieillot, 1817)	1	0,0005	3,57	C	-
Phaeomyias murina (Spix, 1825)	1	0,0005	3,57	C, GF	-
Serpophaga subcristata (Vieillot, 1817)	5	0,0026	7,14	CS	A
Attila phoenicurus Pelzeln, 1868	1	0,0005	3,57	C	A
*Legatus leucophaius (*Vieillot, 1818)	1	0,0005	3,57	C	-
Myiarchus swainsoni Cabanis & Heine, 1859	3	0,0015	7,14	CS	A
Myiarchus ferox (Gmelin, 1789)	15	0,0078	28,57	C, GF, CS	-
Myiarchus tyrannulus (Statius Muller, 1776) [*A, B]	7	0,0036	21,42	C, GF, CS	A
Sirystes sibilator (Vieillot, 1818) [*B]	11	0,0057	14,28	C	A
Pitangus sulphuratus (Linnaeus, 1766)	53	0,0276	60,71	C, GF, CS	-
Machetornis rixosa (Vieillot, 1819*)* [*A, B]	1	0,0005	3,57	CS	A
Myiodynastes maculatus (Statius Muller, 1776)	18	0,0093	31,24	C, GF, CS	A
Megarynchus pitangua (Linnaeus, 1766) [*B]	14	0,0073	39,28	C, GF, CS	A
Myiozetetes cayanensis (Linnaeus, 1766) [*A]	10	0,0052	17,85	GF	A
Myiozetetes similis (Spix, 1825) [*A]	11	0,0057	21,42	C, CS	A
Tyrannus melancholicus Vieillot, 1819	4	0,002	10,71	C, GF, CS	A
Tyrannus savana Vieillot, 1808	1	0,0005	3,57	CS	A
*Colonia colonus (*Vieillot, 1818) [*A, B]	2	0,001	7,14	GF	A
Pyrocephalus rubinus (Boddaert, 1783)	1	0,0005	3,57	CS	A
Cnemotriccus fuscatus (Wied, 1831*)*	5	0,0026	7,14	CS	-
Lathrotriccus euleri (Cabanis, 1868) [*B]	6	0,0031	21,42	C, CS	A

Species	**Total of contacts**	**AI(Pi)**[1]	**FO**[2]	**Habitat**	**Status of Migration**
Contopus cinereus (Spix, 1825) [*A]	2	0,001	7,14	C	A
Xolmis velatus (Lichtenstein, 1823) [*A]	1	0,0005	3,57	CS	A
Vireonidae Swainson, 1837					
Cyclarhis gujanensis (Gmelin, 1789)	41	0,0214	46,42	C, GF, CS	-
Vireo olivaceus (Linnaeus, 1766)	19	0,0099	35,71	C, GF, CS	N
Hylophilus hypoxanthus Pelzeln, 1868	6	0,0031	17,85	GF, CS	-
Corvidae Leach, 1820 (1,5%)					
Cyanocorax cyanomelas (Vieillot, 1818)	4	0,002	14,28	C, CS	-
Cyanocorax cristatellus (Temminck, 1823)	7	0,0036	7,14	CS	-
Cyanocorax chrysops (Vieillot, 1818)	38	0,0198	35,71	C, GF, CS	-
Troglodytidae Swainson, 1831					
Troglodytes musculus Naumann, 1823	6	0,0031	17,85	CS	-
Pheugopedius genibarbis Swainson, 1838	16	0,0083	25	GF	-
Polioptilidae Baird, 1858					
Polioptila plumbea (Gmelin, 1788)	2	0,001	3,57	CS	-
Polioptila dumicola (Vieillot, 1817)	1	0,0005	3,57	CS	-
Turdidae Rafinesque, 1815					
Turdus leucomelas Vieillot, 1818[*A]	65	0,0339	71,42	C, GF, CS	A
Turdus amaurochalinus Cabanis, 1850	25	0,013	42,85	C, GF, CS	A
Turdus fumigatus Lichtenstein, 1823	1	0,0005	3,57	CS	
Mimidae Bonaparte, 1853					
Mimus saturninus (Lichtenstein, 1823)	1	0,0005	3,57	CS	-
Coerebidae d'Orbigny & Lafresnaye, 1838					
Coereba flaveola (Linnaeus, 1758)	3	0,0015	10,71	C, GF, CS	-
Thraupidae Cabanis, 1847					
Saltator coerulescens Vieillot, 1817	7	0,0036	10,71	C	-
Saltator similis d'Orbigny & Lafresnaye, 1837	18	0,0093	39,28	C	-
Saltatricula atricollis Vieillot, 1817	6	0,0031	7,14	CS	-
Tachyphonus rufus (Boddaert, 1783)	11	0,0057	25	GF, CS	-
Ramphocelus carbo (Pallas, 1764)	72	0,0375	46,72	C, GF	-
Lanio luctuosus d'Orbigny & Lafresnaye, 1837	3	0,0015	7,14	GF, CS	-
Lanio cucullatus (Statius Muller, 1776)	19	0,0099	28,57	C, CS	-
Lanio penicillatus (Spix, 1825)	3	0,0015	10,71	C, GF	-
Tangara schrankii (Spix, 1825)	1	0,0005	3,57	GF	-
Tangara sayaca (Linnaeus, 1766)	9	0,0046	14,28	C, GF, CS	-
Tangara palmarum (Wied, 1823)	6	0,0031	10,71	C, GF	-
Tangara cayana (Linnaeus, 1766)	3	0,0015	3,57	C, GF, CS	-
Paroaria capitata (d'Orbigny & Lafresnaye, 1837)	1	0,0005	3,57	GF	-
Dacnis cayana (Linnaeus, 1766)	11	0,0057	21,42	C/ GF, CS	-
Cyanerpes cyaneus (Linnaeus, 1766)	1	0,0005	3,57	GF	-
Hemithraupis guira (Linnaeus, 1766)	2	0,001	7,14	C, CS	-

Species	**Total of contacts**	**AI(Pi)[1]**	**FO[2]**	**Habitat**	**Status of Migration**
Emberizidae Vigors, 1825					
Zonotrichia capensis (Statius Muller, 1776)	12	0,0062	25	CS	-
Volatinia jacarina (Linnaeus, 1766)	6	0,0031	17,85	CS	A
Cardinalidae Ridgway, 1901					
Piranga flava (Vieillot, 1822)	2	0,001	3,57	C	-
Parulidae Wetmore, Friedmann, Lincoln, Miller, Peters, van Rossem, Van Tyne & Zimmer 1947					
*Parula pitiayum*i (Vieillot, 1817)	1	0,0005	3,57	C	-
Basileuterus culicivorus (Deppe, 1830)	2	0,001	7,14	C	-
Basileuterus hypoleucus Bonaparte, 1830	3	0,0015	3,57	C	-
Basileuterus flaveolus (Baird, 1865)	55	0,028	67,85	C/ GF	-
Basileuterus leucophrys Pelzeln, 1868	3	0,0015	10,71	GF	-
Icteridae Vigors, 1825					
Cacicus cela (Linnaeus, 1758)	5	0,0026	14,28	C, GF	-
Gnorimopsar chopi (Vieillot, 1819)	50	0,0261	46,42	CS	-
Molothrus bonariensis (Gmelin, 1789)	12	0,0062	3,57	CS	-
Fringillidae Leach, 1820					
Euphonia chlorotica (Linnaeus, 1766)	9	0,0046	25	C, GF, CS	-
Euphonia violacea (Linnaeus, 1758)	1	0,0005	3,57	C, GF, CS	-

Captions: [1] **Abundance Index (AI;** calculated after Anjos *et al.* 2010) ; [2] **Frequency of occurrence (FO;** calculated after Anjos *et al.* 2010); **Habitat**: Cerradão (C), gallery forest (GF), and *cerrado stricto sensu* (CS); Status of **Migration:** (N) Neotropical - species arriving from North, Central and northern South America; (A) Austral- species arriving from southern South America.

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ARTICLE

Rediscovery of the Cryptic Forest-Falcon *Micrastur mintoni* Whittaker, 2002 (Falconidae) in the Atlantic forest of southeastern Brazil

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ABSTRACT: The population of *Micrastur gilvicollis* from eastern Brazil has been attributed to *Micrastur mintoni,* a forest raptor described in 2002 based primarily on a large series of specimens especially from Amazonian and only three historic specimens from the Atlantic rainforest. The last records of *M. mintoni* in Atlantic forest were obtained in 1972 (museum specimens) and the literature suggests that it could have been extinct from the easternmost part of its geographic distribution. Herein, we provide a recent documented record of *M. mintoni* for the Atlantic forest, confirming the rediscovery of the species from northern Espírito Santo, southeastern Brazil. Our record is documented by photographs and audio recording from Reserva Natural Vale, municipality of Linhares, obtained on 29 July 2012. The loss of habitat, the natural rarity and furtive behavior of this falcon seems to explain why it remained unrecorded for 40 years in the Atlantic forest.

KEY-WORDS: Amazonia; distribution; Espírito Santo; Linhares; *Micrastur gilvicollis*; new record; play-back; taxonomy.

INTRODUCTION

The Cryptic Forest-falcon, *Micrastur mintoni*, was described in the past decade based on a series of 53 specimens from Amazonia south of the Amazon and east of the Madeira rivers and northeastern Bolivia, and eastern Brazil from southern Bahia to northern Espírito Santo (Whittaker 2002). The holotype is an adult female collected at Caxiuanã, state of Pará, Brazil, deposited in the Museu Paraense Emílio Goeldi (MPEG 54849).

M. mintoni is a cryptic raptor of discrete habits and its vocalization is most often the best way of detection and the main feature that distinguish it from other species of the genus (Whittaker 2002). In describing *Micrastur mintoni*, Whittaker (2002) restricted the distribution of *M. gilvicollis* to the Amazon rainforest, north of the Amazon and west of the Madeira rivers in Brazil and neighboring countries (for example, Guiana, Venezuela, Ecuador and Peru). Hence, the previous records of *M. gilvicollis* from eastern Brazil were assigned to the new taxon described by him. The disjunct occurrence of *M. mintoni* in Atlantic forest was recognized by the author based on three specimens housed in scientific collections: two from southern Bahia and one from northern state of Espírito Santo. The old collecting dates of those specimens and the current scenario of the Atlantic rainforest devastation, prompted Whitakker (2002) to state that "the status of the disjunct population in eastern Brazil is critical, if not already extinct". Accordingly, the last record for this population was a specimen collected at Cachoeira Grande, Bahia, in 1933 (*cf.* Pinto 1938).

Herein, we provide a recent documented record of *M. mintoni* fro the Atlantic forest of southeastern Brazil, also discussing on the recorded vocalizations associated with this record.

MATERIAL AND METHODS

Our record was obtained at Reserva Natural Vale (headquarters at 19°08′15″S; 40°03′49″W; ~50 m a.s.l.), Municipality of Linhares, state of Espírito Santo, Brazil. This reserve (hereafter RNV) has approximately 22,000 ha and its vegetation, comprised of pristine lowland forest, is one of the main Atlantic forest remnants in Brazil (see Garay *et al.* 2004 for further details). Our expedition to RNV occurred during 28 - 31 July 2012. We have surveyed the avifauna in this reserve since 2010 as part of our research (authorization ICMBio/SISBIO Nº 25830-01) on the altitudinal distribution of birds in the Central Atlantic forest corridor (*sensu* MMA 2002).

The taxonomic identification of the specimen we report here was based on diagnostic characters (plumage and vocalization) provided by Whittaker (2002). The photograph was taken with a Nikon D300 camera coupled to a Nikon Af VR 80-400mm f/4.5-5.6 ED lens. We recorded the vocalizations of *M. mintoni* using an Olympus LS-10 Linear PCM recorder. The sonograms were elaborated through the software Sound Ruler, version 9.6, with FFT-length = 256 points, Overlap between FFTs = 0.9 and Window type = Hanning.

In addition, we visited the ornithological collection of the Museu de Biologia Prof. Mello Leitão (MBML), municipality of Santa Teresa, Brazil, to try to locate specimens of *M. mintoni* collected in the state of Espírito Santo.

RESULTS

On 29 July 2012, while working in the eastern part of the RNV and walking on the Gavea road, we heard a spontaneous vocalization of a bird we believed to be *Micrastur mintoni*. This vocalization was uttered from the middle forest stratum (about 6 m above the ground) at about 10:00 a.m. The bird flew before we were able to tape these vocalizations. Then, we played topotypic vocalizations of *M. mintoni* available in Minns *et al.* (2010), to attract the putative falcon back. After the play-back, one adult *Micrastur* appeared in the forest edge, enabling us to take some photos. At this time, it uttered another vocalization type (hereafter Vocalization 1: Magnago 2013a). After more play-back, the falcon uttered a vocalization similar to the spontaneous one detected prior to play-back (hereafter Vocalization 2: Magnago 2013b). The bird then flew up into the middle stratum of the forest. It sang again only after landing in places of low visibility to the observer. The photo we took assured us that the species was indeed *M. mintoni,* probably an adult female (Figure 1). A few minutes later, the falcon flew back into the forest, where it again uttered vocalization 2.

The vocalization 1 consisted of a series of isolated notes structurally similar to each other (Figure 2). The duration of this vocalization is variable and may continue for more than a minute. The notes have mean

FIGURE 1. Adult specimen of *Micrastur mintoni* observed at Reserva Natural Vale, municipality of Linhares, state of Espírito Santo, southeastern Brazil. (Photo: G. R. M.)

duration of 0.29 s (SD: ± 0.03; n = 6) and were uttered in intervals of 1.07 s (SD: ± 0.09; n = 5). The frequency is uttered in 1,495 Hz (central value). The vocalization 2 (Figure 3) presented a mean duration of 1.88 s (SD: ± 0.17; n = 5) and was uttered in intervals of 1.12 s (SD: ± 0.10; n = 5). It contained between 13 to 15 notes and the duration of the notes varied from 0.04 to 0.12 s. The first and last notes of the series had less energy and were more spaced between each other; the interval between them varied between 0.05 to 0.13 s. This vocalization was uttered at a mean frequency of 1,441 Hz (SD: ± 157; n = 5).

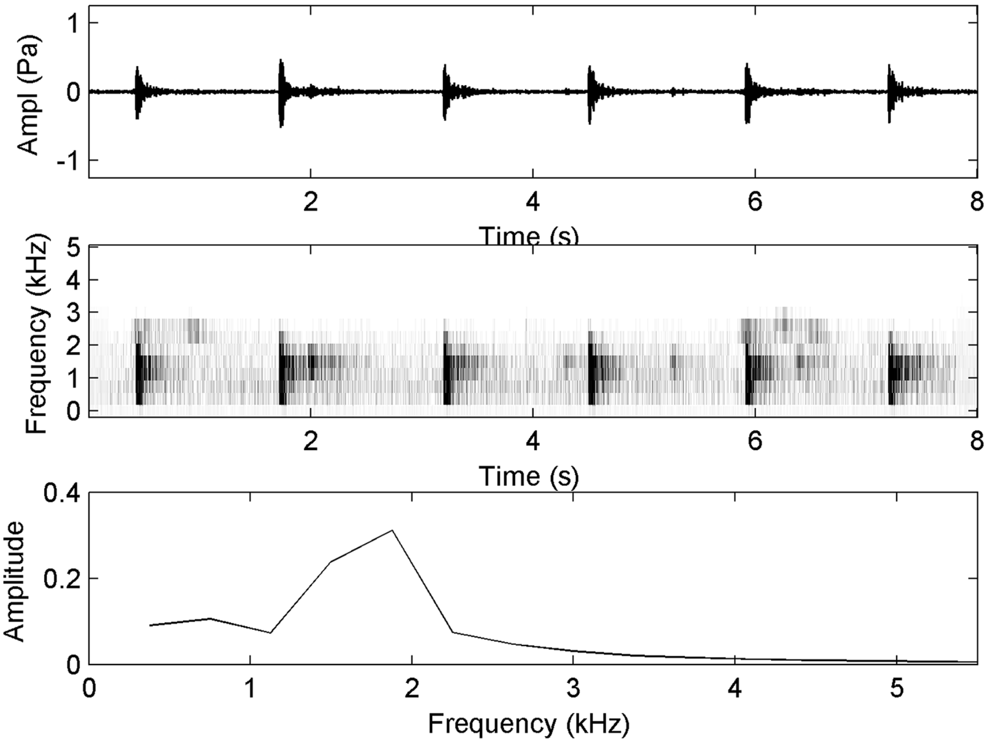

FIGURE 2. Oscillogram (a), sonogram (b) and power spectrum (c) of vocalization-type 1 of *Micrastur mintoni* recorded at Reserva Natural Vale, municipality of Linhares, southeastern Brazil, on 29 July 2012.

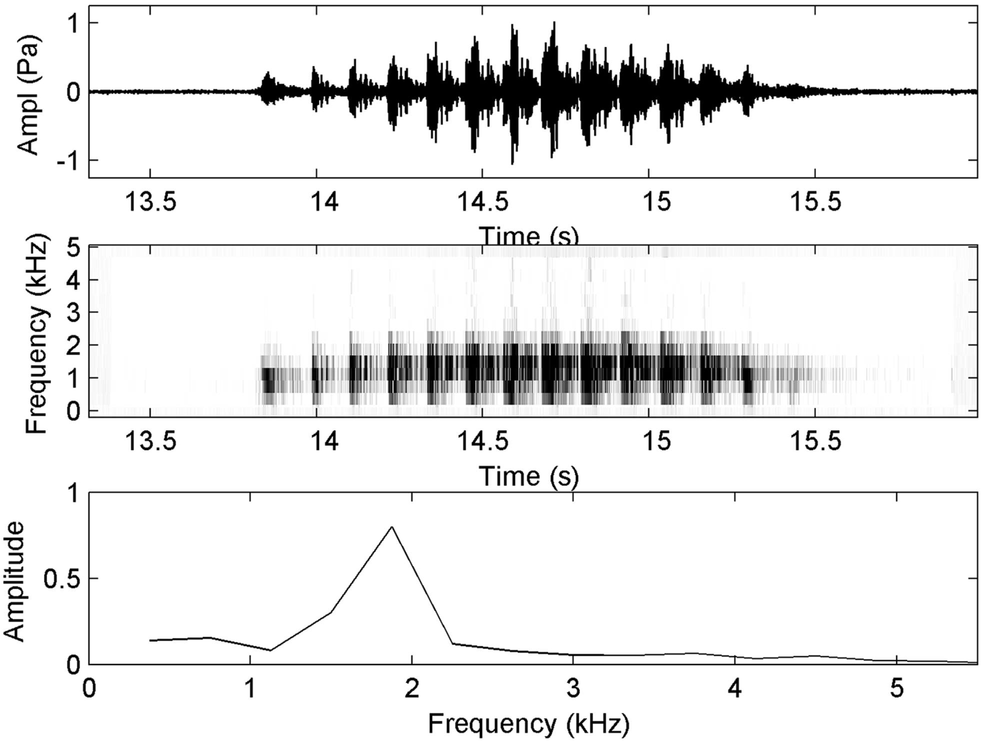

FIGURE 3. Oscillogram (a), sonogram (b) and power spectrum (c) of vocalization-type 2 of *Micrastur mintoni* recorded at Reserva Natural Vale, municipality of Linhares, southeastern Brazil, on 29 July 2012.

We found two specimens of *Micrastur mintoni* collected in the state of Espírito Santo, deposited at ornithological collection of the Museu de Biologia Prof. Mello Leitão. According to the data labels, they were both females, collected at the following localities: MBML-2114 (Figure 4a), Brejo Grande, Linhares, 30/may/1971 (collector unknown); and MBML-2115 (Figure 4b), Conceição da Barra, 01/Dec/1972 (collector unknown).

During our research we also recorded the vocalization of *Micrastur ruficollis* (Vieillot 1817), on 30 July 2012. One specimen was vocalizing in the forest understory and it was clearly observed after playback around 6:30 a.m.

FIGURE 4. Adult specimens (females) of *Micrastur mintoni* housed at the ornithological collection of Museu de Biologia Prof. Mello Leitão (Municipality of Santa Teresa, Brazil). Both were collected in northern state of Espírito Santo, southeastern Brazil: a) MBML-2114, Linhares, 30 May 1971; b) MBML-2115, Conceição da Barra, 01 Dec 1972.

DISCUSSION

The record we report here corroborate the current occurrence of *M. mintoni* in the Atlantic forest of southeastern Brazil. Furthermore, the first documented vocalizations of this population confirm beyond doubt that Whittaker (2002) was correct in assigning it to the newly described *Micastur mintoni*. The record of this species at RNV occurred four decades after the collection of the two specimens deposited at the MBML (MBML-2114, 2115), both from northern Espírito Santo and not far from the RNV. Therefore, we rectify Whittaker (2002), who stated that the specimen collected by M. O. Pinto in 1933 in the state of Bahia was the last record of *M. mintoni* in eastern Brazil.

The paucity of records of *M. mintoni* in southeastern

Brazil suggests that the species is indeed rare in the Atlantic forest, even in well preserved forests such as RNV. Other researchers have sampled birds at the Reserva Natural Vale (for example, Stotz 1993, Wege & Long 1995, Marsden *et al.* 2001, Simon 2007), but none of them recorded *M. mintoni* (formerly *M. gilvicollis*) in this area. Whittaker (2002) stated that: …"during an intensive two-day search using tape playback during peak vocal activity… in April 2000, I surveyed about 15 km of trail… at reserve and failed to encounter the species". From 2011 to 2012 we visited the RNV five times (4 days/expeditions, involving about 250 hours of fieldwork), but we were able to observe *M. mintoni* only once on 29 July 2012. Then, the rarity and secretive behavior of this falcon seems to explain why it remained unrecorded for 40 years in the Atlantic forest.

Our study reports for the first time *Micrastur mintoni* vocalizations from the Atlantic rainforest of eastern Brazil. The vocalizations 1 and 2 recorded at the RNV are congruent with both "territorial advertising song" and "excited cackling call" respectively described by Whittaker (2002). Then, the similarity between the homologous vocalizations recorded in the Amazonian (Caxiuanã, Pará) and in the Atlantic forest populations corroborates the taxonomic status advocated by Whittaker (2002) with regard to the disjunct population occurring in eastern Brazil. Furthermore, the positive reaction of the observed individual at RNV to the play-back of topotypic vocalizations of *M. mintoni* recorded by Whittaker (see Minns *et al.* 2010) provides additional evidence that Amazonian and Atlantic forest populations belong to the same species.

Other publications reported on previous records of *M. mintoni* (formerly *M. gilvicollis*) from the state of Espírito Santo, which were not mentioned by Whittaker (2002). Sick (1997) refers to the distribution of this species in Espírito Santo without indication of locality. Ruschi (1977), Simon (2000) and Vieira *et al.* (2007) records suggest that the species occurs in the mountains region of that state. However, these records were not based on material-witness (specimens, recordings, and photographs), making it impossible to exclude the possibility that these records could not be attributed to another species of *Micrastur*. Therefore, the RNV seems to be the only area with recent records of *Micrastur mintoni* in the Atlantic forest. In addition to the RNV, there are other major protected areas (> 1.000 ha) in northern of Espírito Santo (*e.g.*, Reserva Biológica de Sooretama, Reserva Biológica Córrego do Veado, and Reserva Biológica Córrego Grande) and southern Bahia (*e.g.*, Reserva Biológica de Una, Reserva Michelin/Itubera, Parque Nacional do Pau Brasil, and Parque Nacional Monte Pascoal). Therefore, such reserves are areas of potential occurrence of *M. mintoni*. Thus, we encourage additional surveys in these localities.

Since the 1950's, deforestation has intensified in the state of Espírito Santo, where there is only about 8% of native forest remaining (IPEMA 2005, SEMA 2008). Currently, the native forest of the localities (Linhares and Conceição da Barra) where *M. mintoni* was collected in Espírito Santo were turned over mostly into grassland, eucalyptus plantations and urban areas. Therefore, we reinforce Whittaker´s (2002) claim for additional modern records of the Cryptic-forest Falcon during field surveys in the Atlantic forest. Information about other localities of occurrence, population estimates and ecology will contribute to a better understanding of the current distribution and conservation strategies for this species in the Atlantic forest. According to the IUCN (2013) and MMA (2008), *M. mintoni* is not considered a threatened species (Least Concern). However, the population in eastern Brazil seems to be in a worrying situation. Then we recommend it to be a candidate species to make part on the review of the red list of the state of Espírito Santo (Simon *et al.* 2007).

Apparently, *M. mintoni* does not occur or is presumably extinct in northeastern Brazil. Roda & Pereira (2006) did not record this falcon in that region when they surveyed birds of prey from Alagoas to Rio Grande do Norte, between 1997 to 2005. Olmos *et al.* (2006) also did not record *M. mintoni* in other states of eastern Brazil. Therefore, to date, the state of Espírito Santo is the only one known to keep a relictual population of *M. mintoni* in the Atlantic forest.

According to published sources, *Micrastur semitorquatus* was the only species of the genus recorded at RNV (Quental 2009) prior to our records. Therefore, we confirm the occurrence of three syntopic species of *Micrastur* in this reserve, which consists an important area for conservation of birds in southeastern Brazil (Collar 1986, Bencke & Maurício 2006). There is an historical record of *Micrastur mirandollei* in northern Espírito Santo (Sick 1997), but this species has not been recorded at the RNV yet. Therefore, it represents another species of *Micrastur* awaiting to be rediscovered in the Atlantic forest (Andrew Whittaker, *in litt.*, September, 11th, 2013).

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ARTICLE

New records of shy-type albatrosses *Thalassarche cauta/T. steadi* off the Argentine Continental Shelf

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ABSTRACT: Shy *Thalassarche cauta* and White-capped albatrosses *T. steadi* are two taxa for which specific status has recently been posited, however, owing to their morphological resemblance they are frequently referred to as "shy-type" albatrosses. Information on the distribution of this albatross complex in the Argentine Continental Shelf is particularly scarce and limited to only a few observations, chiefly obtained in the Argentine-Uruguayan Common Fishing Zone and in the vicinity of the Malvinas (Falkland) Islands; there is virtually no information for other oceanic areas (continental shelf, shelf-break area and slope). New records of shy-type albatrosses were obtained during the development of project assessments of the interaction between commercial trawl fisheries and seabirds attending waters of the Argentine Continental Shelf. The observation effort (counts during trawling operations) covered all seasons in a four-year span. These records provide new information on the presence and abundance of this albatross complex for a wide latitudinal range off Argentina that is also an area of operation of trawling fishing fleets (e.g. Argentine hake fishery). The records presented here add to the recent body of evidence demonstrating that individuals of *T. cauta/steadi*, especially immatures, and to some extent non-breeding adults, attend waters of the southern South Atlantic, where they associate with commercial trawlers in Argentina.

KEY-WORDS: Argentina, high-seas trawl fleet, Shy Albatross, South Atlantic, White-capped Albatross.

INTRODUCTION

What was once regarded as a single Shy Albatross species *Thalassarche cauta* distributed in waters off southern Australia and New Zealand has now been split into four distinctive species of albatrosses, with the following three taxa now affording the status of independent species: Chatham *T. eremita*, Salvin's *T. salvini* and White-capped *T. steadi* Albatrosses (Robertson & Nunn 1998). Even though this taxonomy is currently followed by major authorities, such as the Agreement on the Conservation of Albatrosses and Petrels (ACAP 2012) and BirdLife International (2012), it is not universally accepted. Therefore, both the Shy and White-capped albatrosses are sometimes collectively referred in the literature as "shy-type" mollymawks (Brooke 2004, Penhallurick & Wink 2004, Onley & Scofield 2007). In this paper we consider these as separate species, although the distributions of some albatross species are greatly confounded by their resemblance with other species (Double *et al.* 2003). The White-capped, Chatham, and Salvin's Albatrosses breed only in New Zealand, but the latter two are well known in South American seas, traveling as far north as Peru in the Pacific (Couve & Vidal 2003, Shirihai 2008). The available literature shows that the White-capped Albatross has an almost circumpolar distribution outside the breeding season, but movements are not yet known in detail by either satellite tracking or banding studies (but see Thomspon & Sagar 2008). However, more recently, molecular analyses have revealed White-capped Albatrosses among birds killed by commercial fisheries in Australian, New Zealand and South African waters (Abbott *et al.* 2006, Baker *et al.* 2007). Conversely, the Shy Albatross, an Australian breeding endemic species, is less pelagic than many other albatrosses. The species is most frequently found around Tasmania and southern Australia throughout the year, usually seen over the continental shelf. However, its range also extends to southern Africa (Brothers *et al.* 1997, Hedd *et al.* 2001, Hedd & Gales 2005).

The White-capped Albatross is now claimed to be a biennial breeder (Thompson & Sagar 2008) with colonies on Disappointment, Auckland and Adam Islands in the Auckland Islands group, Bollon's Island in the Antipodes Islands group, and occasionally on the Forty-Fours in the Chatham Islands group (Taylor 2000). The global population including non-breeders is estimated to be 350,000-375,000 individuals (BirdLife International 2012). However, Petersen *et al.* (2009) reported that the global estimated breeding population is approximately 95,000 pairs. On the other hand, the Shy Albatross is an annual breeding species with colonies on only three islands off Tasmania: Mewstone, Albatross Island, and Pedra Branca (ACAP 2012). Including non-breeders, the global population was estimated to be between 50,000-60,000 individuals in 1998 (Gales 1998). Still, a recent survey of all breeding sites indicates that the size of its breeding population is currently estimated to be about 12,750 pairs (ACAP 2012). Both White-capped and Shy albatrosses species are listed as "near threatened" due to their high mortality rates as a result of interactions with longline and trawl fisheries in south Indian and south-eastern Atlantic oceans (Baker *et al.* 2007, ACAP 2012).

To date there are few records of shy-type albatrosses attending waters of the Argentine Continental Shelf. In particular, this marine area off Argentina and its shelf-break constitute an important ecosystem of global importance due to the high abundance and diversity of marine vertebrates that it contains, some of which travel very long distances to forage there (*e.g.*, Antarctica, Australia, New Zealand and Tristan da Cunha) (Croxall & Wood 2002, Favero & Silva Rodríguez 2005). Likewise, the area is being heavily exploited by several industrial fishing fleet (*e.g.*, jiggers, trawlers and longliners) of which the size of the trawl fishery is considerably greater than the rest of the other fleets (400 trawlers *vs.* four longliners) (Subsecretaría de Pesca *unpubl. data*). The foraging distributions of several seabird species, especially albatrosses and petrels strongly overlap with commercial fisheries globally throughout their entire annual cycle (Grémillet *et al.* 2000, Anderson *et al.* 2011). Increased mortality rates due to interactions with fisheries, for example, were linked to the global population declines of many albatrosses and petrels, which have been extensively recognized as one of the most vulnerable group of birds (Gales 1998, BirdLife International 2012). It is important in this context that the global ranges of threatened, or potentially threatened, species of albatrosses are better understood.

Recent studies indicate that few juvenile (or immature) and non-breeding adult shy-type albatrosses have been recorded interacting with longline fisheries in the southwestern Atlantic Ocean off the Argentine-Uruguayan Common Fishing Zone (Jiménez *et al.* 2009) and off southern Brazil (Gianuca *et al.* 2011). Furthermore, Jiménez *et al.* (2009) identified – through molecular analysis – that all five individual shy-type albatrosses incidentally killed by Uruguayan pelagic longliners were White-capped Albatross. So far, shy-type albatrosses were not recorded in previous studies concerning interactions between seabirds, particularly albatrosses and, commercial longline (Favero *et al.* 2003, Seco Pon *et al.* 2007, among others) and trawl fisheries (González-Zevallos & Yorio 2006, Sullivan *et al.* 2006, Favero *et al.* 2011, González-Zevallos *et al.* 2011) operating in a wider marine area in Argentinian waters.

Herein we present new documented records of shy-type albatrosses observed off the Argentine Continental Shelf in central Patagonia, confirming their regular occurrence in the southwestern Atlantic Ocean and report that shy-type albatrosses interact with the fisheries under study during discard operations.

MATERIALS AND METHODS

Presence and abundance of seabirds were systematically recorded by the two authors onboard commercial bottom ice-trawlers (hereinafter referred to as freshies) targeting chiefly Argentine hake *Merluccius hubbsi* (other target species include Chub mackerel *Scomber japonicus* and Pink cusk-eel *Genypterus blacodes*) between the years 2008 and 2011 as part of on-going projects aimed at assessing seabird interactions with this fishery off Argentina (see Tamini *et al.* 2010, Favero *et al.* 2011). The trawl fishery under study operates within waters of the Argentine Continental Shelf between 34ºS and 48ºS, particularly concentrated between 42ºS and 46ºS. In general terms, fishers preserve the catch target species in ice within plastic cubes, trips last between four and 15 days, vessels operate a minimum of 130-150 days per year and perform some 600 hauls per year (see Favero *et al.* 2011). Species composition and abundance estimations were performed daily during trawling operations and in daylight hours only. The counts were made from either side and at the stern of the vessel, or aft, covering a 200 meters radius sampling area (200 m astern and 200 m on the starboard and port sides) and lasting 10 minutes hourly (Favero *et al.* 2011). At each survey we collected data on seabirds′ attendance by means of the strip transect method (Tasker *et al.* 1984). All seabirds that entered the designated area (200 m) were counted during 10 minutes. The 200-m radius was calibrated periodically throughout the day by using the methods proposed by Heinemann (1981). The distance of shy-type albatross relative to the vessels was assessed by means of a digital rangefinder Bushnell Yardage Pro Sport 450 with a laser rangefinder monocular of 5-731 ± 1 m accuracy. Audiovisual recordings (video and digital photos) were obtained for most of the shy-type albatrosses sightings.

RESULTS

Along the reported years (2008-2011), 22 sightings of shy-type albatrosses comprising up to 49 individuals were made from the vessels (Table 1), chiefly between 39°S to 44°S and 55°W to 60°W. Overall (pooled) sightings happened on the continental shelf and shelf-break area, mainly at depths between 80 and 300 m (Figure 1). The closest position of a shy-type albatross sighting from the South American continent measured using Google Earth was about 170 km or 92 nautical miles south-southwest of Mar del Plata, northern Argentina.

TABLE 1. Dates, locations, and number of shy-type albatrosses sighted in association with Argentinean commercial bottom ice-trawlers, 2008-2011.

Date	Latitude	Longitude	Abundance		
			Adult	*Immature*	*Total*
May 05, 2008	40° 00´S	56° 17´W	0	1	1
May 12, 2008	39° 37´S	56° 17´W	0	1	1
May 13, 2008	40° 06´S	56° 28´W	0	3	3
May 16, 2008	41° 27´S	57° 57´W	0	5	5
May 17, 2008	41° 25´S	57° 39´W	0	7	7
May 18, 2008	41° 11´S	57° 26´W	1	2	3
May 19, 2008	41° 34´S	57° 49´W	0	1	1
May 19, 2010	42° 42´S	59° 47´W	1	0	1
May 22, 2010	43° 23´S	59° 31´W	2	0	2
May 23, 2010	43° 20´S	59° 26´W	3	0	3
May 24, 2010	43° 38´S	59° 45´W	1	0	1
May 25, 2010	44° 00´S	60° 28´W	1	0	1
May 26, 2010	42° 37´S	59° 03´W	3	0	3
May 27, 2010	41° 16´S	57° 14´W	2	0	2
June 01, 2010	39° 34´S	55° 19´W	2	1	3
June 05, 2010	39° 33´S	55° 55´W	0	3	3
June 07, 2010	39° 45´S	55° 57´W	0	3	3
June 08, 2010	40° 26´S	57° 01´W	0	1	1
June 13, 2010	39° 33´S	56° 03´W	0	2	2
November 24, 2011	42° 03´S	59° 49´W	0	1	1
November 26, 2011	42° 00´S	59° 58´W	0	1	1
November 29, 2011	41° 59´S	60° 21´W	1	0	1

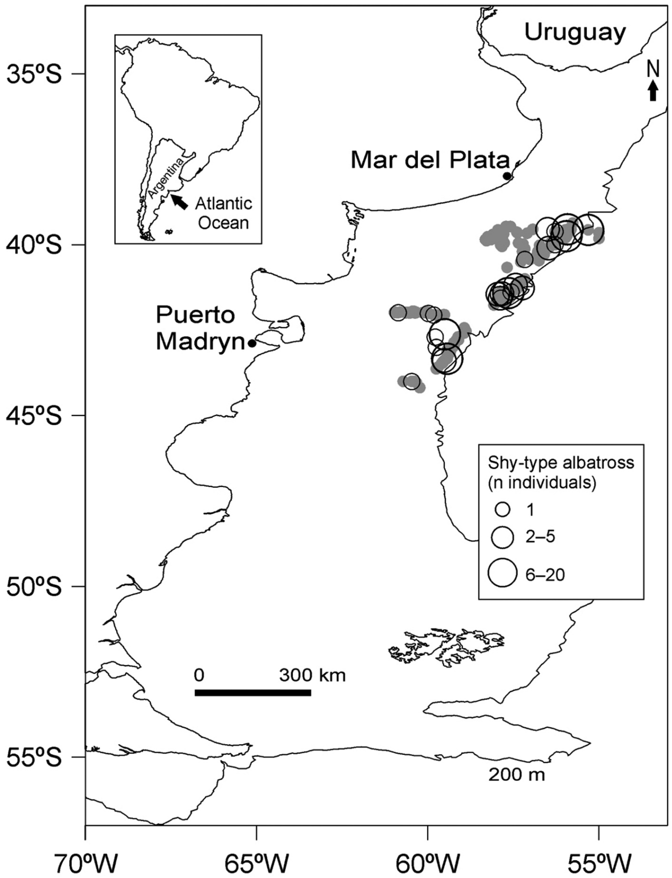

FIGURE 1. Sampling distribution of counts (solid grey circles) and sightings of shy-type albatrosses *Thalassarche cauta/steadi* (open black circles) recorded from observations aboard commercial ice-trawlers in relation to major fishing harbors in Argentina, 2008–2011.

Shy-type albatrosses occurred at bird assemblages associated with bottom ice-trawlers (mean frequency of occurrence = 13%, total number of counts = 224). The birds attended the vessels chiefly between April and May (n = 112 counts; 13 sightings), May and June (n = 83 counts; 12 sightings), and in November (n = 29 counts; 4 sightings). Most of the birds sighted (65%) were aged as immatures based on their grey bills with dark tips and grey head and nape. The bulk of the albatrosses observed in April-May had pale grey heads and necks, extending to form partial grey collars, indicative of older immature birds (Onley & Scofield 2007) (Figure 2a-c). Likewise, the majority of birds sighted in May-June were immatures, however some had pale yellowish bill with pale grey on sides, yellow on top and a small dark patch at the tip of the lower mandible, in addition to an orange skin at the base of the lower mandible, which is typical of adult birds (Fitter 2008, Shirihai 2008) (Figure 2d-f). The majority of the records obtained in April-May ranged from one up to seven shy-type albatrosses, while up to nine birds were sighted in May-June. Only two immatures and one adult bird were sighted in November.

The sightings of shy-type albatrosses occurred chiefly during trawling and hauling operations, when most of the birds are attracted to fishery discards or by fish and squids stolen from the nets. In general, the behavior of

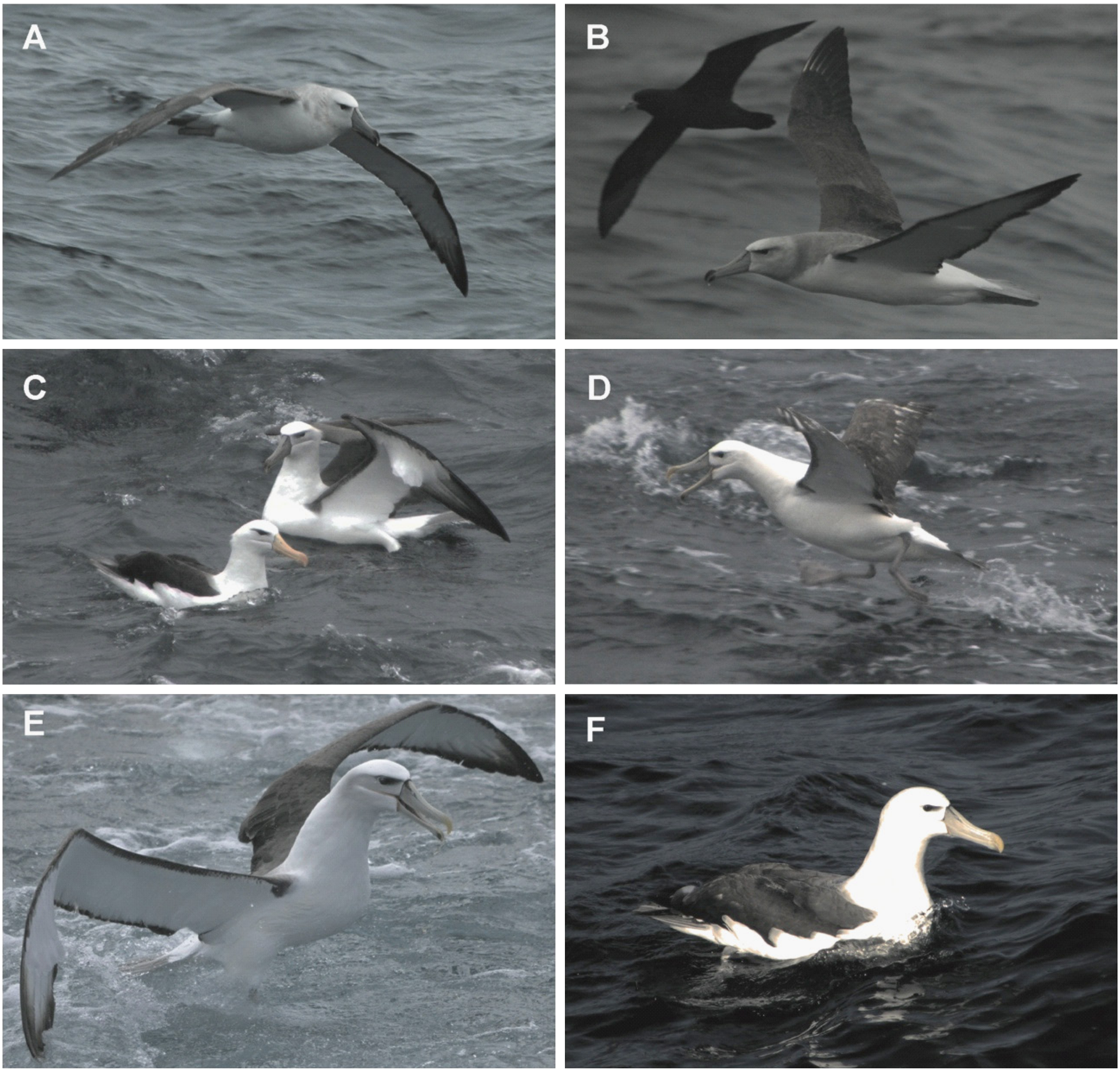

FIGURE 2. Shy-type albatrosses photographed in flight and resting on the surface of the water recorded in association with ice-trawlers off the Argentine Continental Shelf, 2008–2011, immature birds: (a-c, in the latter note an adult Black-browed Albatross *T. melanophris* in close proximity to a shy-type albatross extending its wings); adult non-breeding birds (d-f).

shy-type albatrosses fluctuated from remaining stationary astern on the sea surface in the vicinity of other seabirds (of which Black-browed Albatrosses *T. melanophris*, Southern Giant Petrels *Macronectes giganteus*, White-chinned Petrels *Procellaria aequinoctialis*, and Cape Petrels *Daption capense* were the most common) to actively feeding upon fishery discards relatively close to the vessels. The mean (± 1 SD) distance (in m) of shy-type albatrosses relative to the vessel was estimated in 32.3 ± 3.6 m (n = 7) during discard operations in May-June (Seco Pon *unpubl. data*). Although shy-type albatrosses were often observed feeding upon fishery discards relatively close to the area where the warp cables entered the water, no individual was ever observed interacting (*i.e.*, colliding) with fishing gear or incidentally captured when combining overall sightings.

DISCUSSION

Although we do not provide the first record of shy-type albatrosses for Argentina, the data reported here indicates that the Patagonian shelf is an important contemporary feeding ground for these species. White *et al.* (2002) reported that between 1998 and 2001 a total of 25 shy-type albatrosses were recorded in Malvinas (Falkland) waters. The majority of records were of immature birds, with the exception of two records of adult birds. All records were in the period between January to May and the majority was from waters to the north or northwest of the islands (White *et al.* 2002). Recent findings by Jimenéz *et al.* (2009) of up to 20 shy-type albatrosses – chiefly immature birds with the exception of two adults – attending pelagic longline vessels on the slope of the Common Argentinean-Uruguayan Fishing Zone mainly from late July to December, and by Marin (2011) of 18 immature birds in March 2008 and of one immature individual in March 2010 sighted from opportunistic vessels in a restricted marine region of the southwestern Atlantic Ocean suggest that shy-type albatrosses may be more widely distributed both spatially and seasonally in the country's shelf than previously thought. In fact, prior to this contribution none of the several seabird-fisheries research campaigns conducted by the two authors aboard commercial bottom longline and trawl vessels operating in southern waters of the Argentine Continental Shelf up to 57°S have produced sightings of shy-type albatrosses in the last 10 years (*pers. obs.*). Thus, we extend observations of shy-type albatrosses to the waters of the Argentine Continental Shelf off Puerto Madryn (42°S), confirming the presence of the species along the coast of the northern Argentine platform and corroborating with a more spatio-temporally extended database a similar temporal pattern as found by White *et al.* (2002) and Marin (2011).

Our records also highlighted the occurrence of shy-type albatrosses during the late austral spring (*e.g.*, November), though they occurred in low numbers and relatively closer to the shore. The high proportion of juvenile birds recorded in Argentine waters could be due to their greater propensity to wander during their first years of life, while adults are more restricted in their distribution, as they remain closer to their colonies, which is the case for at least *T. cauta* (Brothers *et al.* 1998). Other confirmed records of shy-type albatrosses in the region were obtained in southern Brazil (Petry *et al.* 1991, Lima *et al.* 1994, Gianuca *et al.* 2011) and on Bird Island, Georgias del Sur (South Georgia) (Phalan *et al.* 2004).

Finally, it should be highlighted that all our sightings were of birds attending commercial fishing activities, as it is also the case of the shy-type albatrosses recorded by Jimenéz *et al.* (2009) and Gianuca *et al.* (2011). Shy-type albatrosses have been previously recorded interacting with longline and trawl fisheries globally (Bartle 1991, Abbott *et al.* 2006, Baker *et al.* 2007), and the South Atlantic seems not to be an exception (Jimenéz *et al.* 2009, Gianuca *et al.* 2011). It is concerning that shy-type albatrosses could be regularly attending commercial fisheries, since these near threatened species may be affected by fishing operations during their attendance at waters of South America. Further studies that monitor and provide more information about these interactions with commercial fishing vessels should be encouraged, along with further training programs to upgrade the skills of Argentine fisheries' observers.

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ARTICLE

A new species of *Formicivora* Swainson, 1824 (Thamnophilidae) from the state of São Paulo, Brazil

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ABSTRACT: *Formicivora paludicola* sp. nov. (São Paulo Marsh Antwren) is described from 13 specimens (nine males and four females) collected in the municipalities of Mogi das Cruzes, Salesópolis, and São José dos Campos, near the city of São Paulo, in the east of the state of São Paulo, southeastern Brazil. Males of the new species are distinct from those of *F. acutirostris* (Marsh Antwren), its sister species, by their black underparts and thighs, very dark grayish brown upperparts, and smaller exposed culmen. Females can be distinguished from those of *F. acutirostris* by the color of the upperparts and flanks, which are also very dark grayish brown, and by the smaller exposed culmen. Mitochondrial DNA sequences also distinguish these two species and the analysis of their vocalizations also showed differences, mainly in the frequency in which certain phrases of the vocal repertoire are used. São Paulo Marsh Antwren inhabits marshes where the vegetation is high (*ca.* 60–250 cm). The species was found in 15 small and isolated areas, at the headwaters of the rivers Tietê and Paraíba do Sul, at altitudes between 600 and 760 m a.s.l. One of these areas was later flooded by the construction of a dam. Most of the marshes where the new species was found are heavily degraded by sand mining, housing developments, fish farming, drainage for cattle raise and agricultural activities, invasion by exotic plants and fire. We propose urgent measures for the protection of this new species.

KEY-WORDS: conservation; Marsh Antwren; marshes; *Stymphalornis*, taxonomy.

INTRODUCTION

The systematics and taxonomy of Thamnophilidae have experienced a great improvement during the last two decades as result of the description of new taxa in several different genera, the elevation of some subspecies to full species status and the reorganization of genus-level taxonomy on the basis of both morphological and molecular analyses (*e.g.*, Isler *et al.* 2007, Moyle *et al.* 2009, Belmonte-Lopes *et al.* 2012). Increased fieldwork and improvement in the design and performance of vocal and molecular analyses are enhancing our understanding of the taxonomic diversity of this family. Progress in alpha taxonomy has been followed by advances in the knowledge of phylogenetic relationships, primarily based on molecular studies (Brumfield *et al.* 2007, Moyle *et al.* 2009, Isler & Whitney 2011).

Among the 49 genera currently recognized in the family, the genus *Formicivora* Swainson, 1824 is among those that have undergone the most taxonomic changes in the last 20 years. Currently, the genus *Formicivora* included eight species: *F. grisea*, *F. serrana*, *F. littoralis*, *F. melanogaster*, *F. rufa*, *F. grantsaui*, *F. erythronotos*, and *F. acutirostris* (Gonzaga 2001, Gonzaga *et al.* 2007). A large number of taxa have been described for this genus recently, an unexpected scenario considering that most *Formicivora* species are very vocal and conspicuous birds, found in open, even disturbed areas, and are easily detected in the field. Gonzaga (2001) performed the first phylogenetic analysis of the genus and, based on vocal and morphological characters, suggested the monophily of *Formicivora* with the inclusion of *Stymphalornis acutirostris* and the exclusion of *F. iheringi*, placed in its own genus *Neorhopias* Hellmayr, 1920. More recently Hilty (2003) suggested that *F. grisea* *intermedia* could represent a valid species (see also Ridgely & Tudor 2009), and Gonzaga *et al.* (2007) described a new species from the Chapada Diamantina, northeastern Brazil. Finally, Firme & Raposo (2011) suggested that *F. littoralis* is not a valid biological species, and that this taxon and *F. serrana interposita* could be considered as subspecies of *F. serrana*, as originally described by Gonzaga & Pacheco (1990). Recent molecular studies of the genus corroborate Gonzaga (2001), and also suggest that the monophily of *Formicivora* depends on the exclusion of *F. iheringi* and inclusion of *Stymphalornis* Bornschein, Reinert & Teixeira, 1995 (Bravo 2012, Belmonte-Lopes 2013).

During field work on 6 October 2004 DRCB heard, tape recorded and observed, at an extensive marsh dominated by *Typha domingensis* and *Schoenoplectus californicus* in Mogi das Cruzes, São Paulo state, at 625 m a.s.l., a female and a subadult male of an antwren at first glance attributable to *F. acutirostris* (Marsh Antwren). This species inhabits the coastal marshes in the states of Paraná, Santa Catarina, and Rio Grande do Sul, in southern Brazil, from sea-level up to about 10 m a.s.l. (Reinert *et al.* 2007, Bencke *et al.* 2010). Believing this might be a new species, DRCB returned to the area the next day, saw an adult male with black underparts and collected a pair of this antwren (see *Formicivora* sp. nov. photos # 6 and 7 in Minns *et al.* [2009]).

LFS, learning (through Luiz Pedreira Gonzaga) of the discovery of the *Formicivora* at Mogi das Cruzes, made visits to an area at Biritiba-Mirim in February 2005 and found there another population of this *Formicivora*. Since this area was to be flooded by a dam (Barragem do Paraitinga 2), LFS invited BLR to help in an evaluation of the size of the population which would be affected by the dam. On obtaining an estimate of about 100 individuals in the area, a project was developed by a group, which included MRB, RB-L and other ornithologists to capture and transfer the antwrens to other areas. After capturing the first individuals, MRB recognized the antwren as different from *F. acutirostris*, and collected and prepared specimens for further studies. The authors initiated detailed analyses to confirm the first impressions that the São Paulo birds represent a new species, described herein.

MATERIAL AND METHODS

Morphology

The specimens of *Formicivora* sp. nov. that were collected are housed at the Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, in the state of São Paulo, the Museu de História Natural "Capão da Imbuia" (MHNCI), Curitiba, in the state of Paraná, and the Museu de Ciências e Tecnologia da Pontifícia Universidade Católica do Rio Grande do Sul (MCP), Porto Alegre, in the state of Rio Grande do Sul. For comparison with the new species, we examined specimens of *F. acutirostris* and other *Formicivora* (see list of specimens in appendix 1).

We took measurements with calipers to the nearest 0.1 mm of the length of the exposed culmen, bill length, bill depth, and bill width (the last three measurements from the proximal edge of the nares to the bill tip), wing length (chord), tail length (from the insertion of the central rectrices to their tip), and tarsus length. These measurements were taken from specimens, as well as from several live birds mist-netted for ongoing studies, of both *Formicivora* sp. nov. and *F. acutirostris*. We took measurements of the birds' total length (according to Sick 1997) and wing-span with a ruler to the nearest 0.1 cm. We did not measure tail length when the longest rectrix was damaged and when both central rectrices were absent. Tarsus lengths were measured in skins according to Sick (1997), but measurements of mist-netted birds were taken differently: the bird's toes were bent backwards and the measurement was taken from the distal part of the leg (dorsal side) to the toe pad near the base of the hallux. The measurements of mist-netted individuals were tested for normal distribution, and then compared using the t test or the Mann-Whitney test (for the measurements that did not present a normal distribution). Birds were weighed with a Pesola spring balance with a 30 g scale. We checked the pterylosis and the number of wing feathers in the collected specimens. The number of tail feathers was noted, both in the study skins and the mist-netted specimens. Carcasses of collected birds were preserved in ethanol 80% v/v, and muscular tissue in ethanol 100% v/v. Colors follow Munsell (1994) and geographic coordinates were taken in the field with a Garmin GPS.

Vocalizations

We recorded vocalizations with Sony TCM 5000EV analogue tape recorders, a Sound Devices 722 digital audio recorder and a Sony PCM50 digital recorder, with Sennheiser ME66 and ME67 microphones. DRCB's recordings are housed in the Arquivo Sonoro Dante Buzzetti (ASDCB), mantained by the first author. Copies of these recordings were or will be deposited at Arquivo Sonoro Prof. Elias P. Coelho, Universidade Federal do Rio de Janeiro (ASEC – UFRJ), and at the Arquivo Sonoro do Museu de Zoologia da Universidade de São Paulo (MZUSP). Additional vocalizations were obtained from a published DVD-ROM (Minns *et al.* 2009) and from the online collection xeno-canto (www.xeno-canto.org) (Appendix 2). All recordings of *F. acutirostris* made by the authors were of spontaneous vocalizations.

Analogue tape recordings were digitalized at 44.1 kHz, 16-bit, and digital recordings were made with the same parameters. Spectrograms were produced in Raven

1.2.1 using a Blackman window type, with a resolution of 1024 bands and overlap of 96%. The vocal variables were measured from the fundamental harmonics using screen cursors on the spectrograms. The variables measured were: total phrase duration, duration of the interval between the notes, note length, minimum frequency, maximum frequency or peak frequency (*sensu* Isler *et al.* 1998), and frequency amplitude (band-width) of the first and second notes. Descriptions of note shape were made from spectrograms at the same scale as that of the respectives figures which appear in the text. We applied the statistical tests proposed by Isler *et al.* (1998) and Patten & Unitt (2002) despite the low sample size, but as the results were not significant they are not presented.

Molecular analysis

We obtained muscular tissue of *F. acutirostris* from specimens collected and feather material of this species from individuals banded; for *Formicivora* sp. nov. we used tissue from individuals collected. We obtained sequences from four individuals of the first species and of three individuals of the second species for the mitochondrial genes cytochrome b (CYB, 1,045 base pairs – b.p.), nicotinamide dehydrogenase subunit 2 (ND2, 1,041 b.p.), nicotinamide dehydrogenase subunit 3 (ND3, 351 b.p.), and for one autossomal nuclear intron, the β-fibrinogen intron 5 (βF5, 563 b.p.). The sequences' GenBank accession numbers are given in Appendix 3.

Genomic DNA was extracted from 25 mg of pectoral muscle or 2-5 slices (0.2 mm) of the feather cannon from 2-3 contour feathers using the Qiagen DNeasy kit and following the manufacturer's protocol. The DNA extracted was subjected to polymerase chain reactions performed using the protocols of Brumfield *et al.* (2007), and each gene region was bidirectionally sequenced to verify accuracy. Additional sequences from a previous publication (Brumfield *et al.* 2007) available at GenBank were also used. Sequences for each gene were aligned using the program MAFFT v. 6 (Katoh *et al.* 2002) and manually edited in BioEdit (Hall 1999) so to include the largest number of homologous positions in all sequences. To select between the possible partition schemes, we performed Bayesian inference analyses for five different partition schemes under a GTR+G model of nucleotide substitution using MrBayes 3.1.2 (Huelsenbeck & Ronquist 2001). We compared the likelihood values of all partition schemes tested by Bayes Factors using Tracer 1.5 (Rambaut & Drummond 2009) to select the most adequated partition scheme. All analyses were performed with four chains, 2,000,000 generations (sampled at each 1,000), and two replicates. Bayes factors were calculated as marginal likelihood estimates following the method of Newton & Raftery (1994) with the modifications proposed by Suchard *et al.* (2001). We used the guidelines of Kass & Raftery (1995) for interpreting the values of $\log_{10}$ (B_{10}). The scheme selected through Bayes Factors was one with the mitochondrial genes grouped and coded by codons, in addition to a partition for βF5 (scheme IV in Table 5; total of four partitions).

After selecting the partition scheme, we used jModelTest (Posada 2008) to determine the best fit model of DNA substitution for each partition using the Bayesian Information Criterion (Schwarz 1978), given that this method has been shown to often outperform other commonly used criteria (Luo *et al.* 2010). After this we conducted Bayesian analysis using MrBayes 3.1.2 (Huelsenbeck & Ronquist 2001) using the selected partition scheme and models of DNA substitution. We performed our analysis with four runs and four MCMC chains, using 4,000,000 generations with a sample frequency of 1,000, and a burn-in of 20%, with these analyses being performed on the Cipres Science Gateway version 3.1 (Miller *et al.* 2010). The results of the Bayesian inference were analyzed for convergence using the compare splits and the slide window analyses implemented at AWTY (Wilgenbusch *et al.* 2004, Nylander *et al.* 2008), and also in Tracer and by Bayes Factors. Both approaches demonstrated that the runs converged, and we combined the trees from all runs (except for the burn-in) and used them to estimate a 50% majority rule consensus tree. We also estimated a phylogenetic hypothesis via maximum likelihood under a GTR+G model of nucleotide substitution in RAxML 7.2.7 (Stamatakis 2006), with branch support being obtained through 1,000 bootstrap replicates. Additionally, we estimated the genetic distances between the samples under the Tamura-Nei model of DNA substitution, with the variance being estimated through 1,000 bootstrap replicates using MEGA 5.05 (Tamura *et al.* 2011). The chicken mitochondrial genome (GenBank accession NC 001323.1) was used as reference sequence to define the position number of sites of CYB, ND2, and ND3. Additionally, we inferred a Bayesian chronogram for a larger set of taxa of the genus *Formicivora* with a calibration rate of 2.1% per million years for CYB (Weir & Schluter 2008) and a log-normal relaxed clock using BEAST 1.74 (Drummond & Rambault 2007) (RB-L *et al.* unpublished data) to obtain an estimate of the age of the split between the Marsh Antwrens.

RESULTS

The comparison of 13 specimens collected in São Paulo state with 13 of *F. acutirostris*, the handling of additional mist-netted birds (37 individuals from São Paulo, and 69 of *F. acutirostris*), and the additional data from vocalizations and genetics showed certain differences which lead us to describe the bird from São Paulo as a distinct species, here named:

Formicivora paludicola sp. nov.

São Paulo Marsh Antwren
Bicudinho-do-brejo-paulista
Figures 1, 2, and 3

Holotype. MZUSP 78787: adult male (Figure 1), skull ossified, testes partially enlarged (5 mm); collected by DRCB on 07 October 2004 at Córrego Taboão do Parateí (23°24'27"S, 46°13'35"W; 630 m a.s.l.), municipality of Mogi das Cruzes, São Paulo state, Brazil; prepared by LFS. Tissue sample and carcass preserved. No molt; light yellow fat; 10 rectrices.

FIGURE 1. From the top, holotype (male, MZUSP 78787) and paratype (female, MZUSP 78788) of São Paulo Marsh Antwren *Formicivora paludicola* sp. nov., and a pair of Marsh Antwren *F. acutirostris* (male, MZUSP 78797, and female, MZUSP 78798). Plate by Eduardo Brettas.

Paratypes. MZUSP 78788: adult female (Figure 1), skull ossified, ovarium partially developed (10 mm x 5 mm); other data as the holotype. MZUSP 78789: adult male, skull ossified, testes minute (1.5 x 1.0 mm); collected by MRB, BLR, RB-L, C. O. A. Gussoni, P. Lopes and G. A. Benedicto on 17 March 2005 at Rio Paraitinga (23°31'S, 45°55'W; 760 a.s.l.), Barragem do Paraitinga 2, municipality of Salesópolis, São Paulo state, Brazil; prepared by MRB. Tape recorded. Tissue sample and carcass preserved. No brood patch; molting feathers on body, wing and tail; small amount of light yellow fat in the body; 10 rectrices. MHNCI 6587 (ex MZUSP 78790): adult male, skull ossified, testes minute (1.0 x 1.0 mm); collected on 18 March 2005; other data as MZUSP 78789. MCP 3265 (ex MZUSP 78791): adult male, skull ossified, testes minute (1.0 x 0.5 mm); collected on 19 March 2005. Not tape recorded; orange fat in the body and skin; other data as MZUSP 78789. MHNCI 6725 (ex MZUSP 78792); adult female, skull ossified, ovarium inactive (5.0 x 3.0 mm); other data as MZUSP 78789. MZUSP 78793: subadult female, skull not fully ossified; ovarium inactive (3.0 x 1.0 mm); collected on 19 March 2005. Not tape recorded; orange fat in the body and skin; other data as MZUSP 78789.

Diagnosis - morphology. Males of *F. paludicola* can be distinguished from other Thamnophilidae outside the *Formicivora* genus by the presence of 10 rectrices and by the combination of dark grayish brown upperparts, black underparts and a long black tail. Females of *F. paludicola* can be distinguished from other Thamnophilidae that do not belong to the *Formicivora* genus by having 10 rectrices, unstreaked dark grayish brown upperparts, long black tail, and white underparts, heavily marked with black streaks. A recent molecular study including all species of *Formicivora* showed that the two taxa with 10 rectrices (*F. acutirostris* and *F. paludicola*) are sister species (Bravo 2012, Belmonte-Lopes 2013), so within the genus we diagnosed the new species only with respect to *F. acutirostris*.

Adult males of *F. paludicola* can be distinguished from adult males of *F. acutirostris* by their black (1: 2.5/N) instead of dark gray (1: 4/N) cheeks, auriculars, throat, belly and thighs (see Figures 1, 2, and 3). Males of *F. paludicola* also have the crown, upperparts and upper tail coverts dark grayish brown (2.5Y/4/2), as opposed to the dark brown (10YR/3/3) of males of *F. acutirostris*. Moreover, males of *F. paludicola* have a smaller exposed culmen in comparison with males of *F. acutirostris* (Table 1; see also Table 2). Females of *F. paludicola* can be distinguished from females of *F. acutirostris* by their brown (10YR4/3) crown, upperparts and upper tail coverts and dark grayish brown (10YR/4.2) flanks, and also by the smaller exposed culmen (Table 1; see also Table 2). Females of *F. acutirostris* have dark grayish brown (10YR/4/2) upperparts and dark brown (10YR/3/3) flanks (Figure 1).

FIGURE 2. Males of São Paulo Marsh Antwren *Formicivora paludicola* sp. nov. in comparison with a male of Marsh Antwren *F. acutirostris* (in the center). From left to right *F. paludicola* MZUSP 78789 and MZUSP 78787 (holotype), *F. acutirostris* MZUSP 78797, and *F. paludicola* MZUSP 78796 and MZUSP 85428.

FIGURE 3. Males of São Paulo Marsh Antwren *Formicivora paludicola* sp. nov. (A) and Marsh Antwren *F. acutirostris* (B) in the wild. Photos by Robson Silva e Silva and RB-L.

Diagnosis - genetics. Based on the specimens sequenced, *F. paludicola* can be diagnosed from *F. acutirostris* by differences in their mitochondrial DNA. For CYB, the new species differs in one transition (position 15,231 of *Gallus gallus* mitochondrial genome, from adenine in *F. acutirostris* to guanine in the the new species), and two transversions (positions 15,120 and 15,519; from thymine in *F. acutirostris* to cytosine in *F. paludicola*, and from adenine in *F. acutirostris* to cytosine in *F. paludicola*, respectively). For ND2, they differ in two transitions (positions 5,624 and 5924; respectively, from thymine in *F. acutirostris* to cytosine in *F. paludicola*, and from guanine to adenine) and one transversion (position 5828, from adenine in *F. acutirostris* to thymine in *F. paludicola*). For ND3, they differ in three transitions (positions 10,862, 10,913, and 11,114; respectively, from thymine in *F. acutirostris* to cytosine in *F. paludicola*, from cytosine to thymine, and from adenine to guanine). The uncorrected genetic distance between *F. paludicola* and *F. acutirostris* was between 0.004-0.011 according to

CYB, between 0.003-0.006 according to ND2, between 0.011-0.017 according to ND3, and between 0-0.002 according to βF5.

Description of holotype. See figure 1. Crown, back, mantle and upper tail coverts dark grayish brown (2.5Y/4/2). Forehead gray (1: 5/N) and lores black. A discrete white superciliary stripe. Auriculars, throat and underparts black (1: 2.5/N). Thighs, undertail coverts and tail black, with fourth and fifth pair of rectrices tipped white. Lesser wing coverts white, and medium and large coverts black with white tips, with the exception of the proximal part of the latter two coverts, which are dark grayish brown (2.5Y/4/2). Underwing coverts white, tipped black. Primaries and secondaries are very dark brown (10YR/2/2) with white inner vane, tertials with a dark grayish brown (2.5Y/4/2) stripe on the outer vane. Irides brown, tarsi and toes dark bluish gray (2: 5/1/5GB), nails gray, and bill black.

TABLE 1. Measurements (mm) and weight (g) of live specimens of *Formicivora paludicola* sp. nov. and *F. acutirostris.* The values presented are range, mean ± standard deviation (in parentheses) and sample size. All *p* values were obtained using the Mann-Whitney test, except when indicated by *, when the t test was used.

Measurements	***F. paludicola*** **Males**	***F. acutirostris*** **Males**		***F. paludicola*** **Females**	***F. acutirostris*** **Females**	
Exposed culmen	10.9-13.5 (12.44 ± 0.55) n = 31	14.3-14.9 (14.69 ± 0.21) n = 7	$p < 0.01$	11.4-12.9 (12.32 ± 0.4) n = 35	13.8-14.7 (14.33 ± 0.29) n = 10	$p < 0.01$
Bill depth[1]	3.0-3.7 (3.33 ± 0.14) n = 30	3.1-3.6 (3.33 ± 0.15) n = 59	$p > 0.05$*	3.0-3.6 (3.27 ± 0.16) n = 34	3.0-4.1 (3.27 ± 0.20) n = 61	$p > 0.05$*
Bill width[1]	3.1-3.9 (3.51 ± 0.24) n = 30	3.1-3.7 (3.4 ± 0.18) n = 61	$p < 0.05$	3.3-3.8 (3.53 ± 0.13) n = 34	3.1-3.7 (3.4 ± 0.18) n = 61	$p < 0.01$
Wing[2]	47.0-52.6 (49.46 ± 1.3) n = 31	45.2-51.7 (48.52 ± 1.23) n = 58	$p < 0.01$	41.6-49.8 (47.11 ± 1.64) n = 34	44.4-49.9 (47.31 ± 1.2) n = 61	$p > 0.05$
Tail[3]	55.5-66.9 (62.61 ± 3.05) n = 13	53.7-67.5 (60.52 ± 3.27) n = 29	$p < 0.05$	58.1-63.6 (60.45 ± 1.59) n = 10	54.9-67.9 (59.97 ± 2.86) n = 23	$p > 0.05$
Tarsus[4]	22.8-25.3 (24.03 ± 0.54) n = 31	24.0-26.0 (24.86 ± 0.46) n = 39	$p < 0.01$	22.8-24.4 (23.68 ± 0.49) n = 34	22.9-25.8 (24.63 ± 0.54) n = 60	$p < 0.01$
Weight	8.3-10.5 (9.29 ± 0.53) n = 35	8.5-11.5 (9.96 ± 0.6) n = 69	$p < 0.01$*	8-10 (9.16 ± 0.53) n = 37	8.5-12 (9.75 ± 0.76) n = 65	$p < 0.01$*

1 From the proximal edge of nares to bill tip.

2 Chord.

3 From the central rectrices insertion to their tip.

4 From the distal part of leg (dorsal side) to the toepad near the base of the hallux (with the bird fingers flexed backwards).

TABLE 2. Measurements (mm) and weight (g) of collected specimens of *Formicivora paludicola* sp. nov. and *F. acutirostris*. The values presented are range, mean ± standard deviation (in parentheses) and sample size.

Measurements	***F. paludicola*** **Males**	***F. acutirostris*** **Adult males**	***F. acutirostris*** **Subadult males**[1]	***F. paludicola*** **Females**	***F. acutirostris*** **Females**
Bill length[2]	9.9-11.4 (10.61 ± 0.50) n = 7	11.4-12.4 (11.85 ± 0.36) n = 6	11.2; 11.4 n = 2	10.0-11.0 (10.57 ± 0.51) n = 3	11.0-12.2 (11.50 ± 0.53) n = 4
Bill depth[2]	3.0-3.4 (3.25 ± 0.14) n = 6	3.0-3.5 (3.34 ± 0.16) n = 7	2.9 n = 1	3.1-3.3 (3.20 ± 0.10) n = 3	2.9-3.2 (3.07 ± 0.15) n = 3
Bill width[2]	3.3-3.7 (3.60 ± 0.15) n = 7	3.7-3.9 (3.79 ± 0.09) n = 7	3.9 n = 1	3.5-3.6 (3.53 ± 0.06) n = 3	3.4-3.9 (3.67 ± 0.25) n = 3
Wing[3]	48.4-51.2 (49.77 ± 0.95) n = 7	49.2-51.1 (50.19 ± 0.61) n = 7	49.0; 51.7 n = 2	48.0-50.4 (48.80 ± 1.39) n = 3	48.1-52.7 (49.73 ± 2.03) n = 4
Tail[4]	57.9-64.3 (62.23 ± 2.93) n = 4	58.2-63.0 (61.07 ± 1.88) n = 7	59.7; 60.4 n = 2	55.7-61.3 (59.23 ± 3.07) n = 3	59.0-60.4 (59.70 ± 0.99) n = 2
Tarsus[5]	19.8-21.4 (20.79 ± 0.65) n = 7	20.3-21.7 (21.06 ±0.48) n = 7	21.3 n = 1	18.9-20.5 (19.80 ± 0.82) n = 3	19.3-21.7 (20.73 ± 1.01) n = 4
Total lenght[5]	145-153 (148.75 ± 3.50) n = 4	143-152 (147.43 ± 3.41) n = 7	140; 145 n = 2	139.0-143.0 (140.67 ± 2.08) n = 3	146.0; 147.0 n = 2
Wing span	160-167 (163.33 ± 3.20) n = 6	163-167 (165.0 ± 1.41) n = 7	165.0; 165.0 n = 2	155.0; 162.0 n = 2	152.0-167.0 (159.25 ± 6.60) n = 4
Weight	8.5-11.0 (9.57 ± 0.79) n = 9	9.5-10.9 (9.96 ± 0.52) n = 7	10.0; 11.0 n = 2	8.0-9.6 (8.73 ± 0.66) n = 4	9.0-10.2 (9.70 ±0.53) n = 4

[1] One with plumage like female, and the other still with considerable amount of white on underparts.

[2] From proximal edge of nares to bill tip.

[3] Chord.

[4] From the central rectrices insertion to their tip.

[5] Follows Sick (1997).

Measurements of holotype. Total length 147.0 mm; exposed culmen 13.7 mm; bill length 11.4; bill width 3.5; wing 49.7 mm; tail 64.3 mm; tarsus 21.1 mm; weight 8.9 g.

Variation in type series. Male specimens do not show significant variation in the plumage, except in the amount of white in the rectrices, which varies slightly between birds (Table 3). The males MZUSP 78794 and 78795 have some whitish feathers on the ventral surface, particularly on the sides of the body, reminiscent of the earlier plumage similar to the female plumage (see below in Discussion). Females have a distinct plumage, described below.

Description of the female. See figure 1. The female MZUSP 78788 has the crown, back, mantle and upper tail coverts dark grayish brown (10YR4/3). Forehead and lores gray (1: 5/N). A discrete white superciliary stripe. Auriculars gray, throat and underparts white with black spots. Thighs black with white tips, undertail coverts and tail black, with fourth and fifth pair of rectrices tipped white. Lesser wing coverts white, medium and large coverts black with white tips, with the exception of the proximal part of the latter two coverts, where the innermost part is dark grayish brown (10YR4/3), the middle is dark grayish brown (10YR4/3) with a white apical spot, and the remaining becoming increasingly black with white apical spots. Underwing coverts white. Primaries and secondaries are very dark brown (10YR/2/2) with white inner vane, tertials with a dark grayish brown (2.5Y/4/2) stripe on the outer vane. Irides brown, tarsi and toes dark bluish gray (2: 5/1/5GB), nails gray, and bill black. Other females (MZUSP 78792 and 78793) show the throat and belly less heavily spotted black. In other features, they do not show significant variation in the plumage, except in the amount of white in the rectrices (Table 3).

TABLE 3. Amount of white (mm) in the rectrices ventral surface tip in *Formicivora paludicola* sp. nov.[1] We presents only the largest measurement when the amount of white differed between the feathers of a pair. Abbreviation: m = male; f = female. Acronyms: MZUSP - Museu de Zoologia da Universidade de São Paulo; MHNCI - Museu de História Natural "Capão da Imbuia"; MCP - Museu de Ciências e Tecnologia da Pontifícia, Universidade Católica do Rio Grande do Sul.

Specimen	Sex	Pair of rectrices				
		1st	2s	3rd	4th	5th
MZUSP 78787	m	0.0[2]	0.0[2]	0.0[2]	1.5	1.6
MZUSP 78789	m	0.0[2]	0.3	?	?	?
MZUSP 78794	m	0.2	0.8	0.9	1.6	2.6
MZUSP 78795	m	0.0	0.0	?	0.0	1.2
MZUSP 78796	m	0.0	0.0	0.2	1.5	1.9
MHNCI 6587	m	0.2	?	1.2	1.8	2.2
MCP 3265	m	0.2	0.2	0.4	1.7	2.1
MZUSP 78788	f	0.0[2]	0.0[2]	0.0[2]	0.9	1.6
MZUSP 78793	f	0.0[2]	0.0[2]	0.0[2]	1.0[2]	1.0[2]
MHNCI 6725	f	0.0[2]	0.5	0.7	2.1	2.3

[1] Amount of white measured in the feather rachis, even if the white is expanded in the vanes.

[2] Feathers worn (white tips may have disappeared or decreased).

Additional material (non-type material). MZUSP 78794: adult male, skull not fully ossified, testes minute (1.0 x 1.0 mm left testes; 0.5 x 0.5 mm right testes); collected by MRB, BLR and RB-L on 05 April 2005 at Córrego Taboão do Parateí (23°24’27”S, 46°13’35”W; 630 m a.s.l.), municipality of Mogi das Cruzes, São Paulo state, Brazil; prepared by MRB. Not tape recorded. Tissue sample and carcass preserved. No brood patch; molting feathers on body, wing and tail; small amount of light orange fat in the body; 10 rectrices; nine secondary remiges. MZUSP 78796: adult male, skull ossified, testes minute (1.5 x 1.0 mm left testes; 1.0 x 1.0 mm right testes). Tape recorded. Other data as MZUSP 78794. MZUSP 78795: subadult male, skull not fully ossified, testes minute (1.0 x 0.5 mm left testes; 0.5 x 0.5 mm right testes); collected by MRB, BLR, RB-L, LFS, C. O. A. Gussoni, E. Machado and F. Schunck on 10 April 2005 at Rio Paraitinga (23°31’S, 45°55’W; 760 a.s.l.), Barragem do Paraitinga 2, municipality of Salesópolis, São Paulo state, Brazil; other data as MZUSP 78794. MZUSP 85428: adult male; collected by LFS and É. Machado on 21 November 2009 at Usina da Light (23°34’S, 45°49’W), municipality of Salesópolis, São Paulo state, Brazil. MZUSP 85429: adult female. Other data as MZUSP 85428. MZUSP 91700: adult male; collected by LFS, Gláucia del Rio and Marco Antônio Rego on 06 January 2011 at Fazenda Montes Claros (23°04’S, 46°02’W), municipality of São José dos Campos, São Paulo state, Brazil.

Distribution. Formicivora paludicola is known from 15 localities in the municipalities of Biritiba-Mirim, Mogi das Cruzes, Salesópolis, Santa Isabel, and São José dos Campos, São Paulo state, southeastern Brazil (Figure 4, Appendix 4), at altitudes ranging from 600 to 760 m a.s.l. These localities lie at the headwaters of the Tietê and Paraíba do Sul river basins. Since the species’ discovery in 2004, we have conducted searches in more than 50 marshes to the south of the known distribution of *F. paludicola*, from sea level (municipalities of Bertioga, Santos, Cubatão, and Itanhaém) to 900 m (in municipalities surrounding the known localities) but have found no evidence of its presence at those sites.

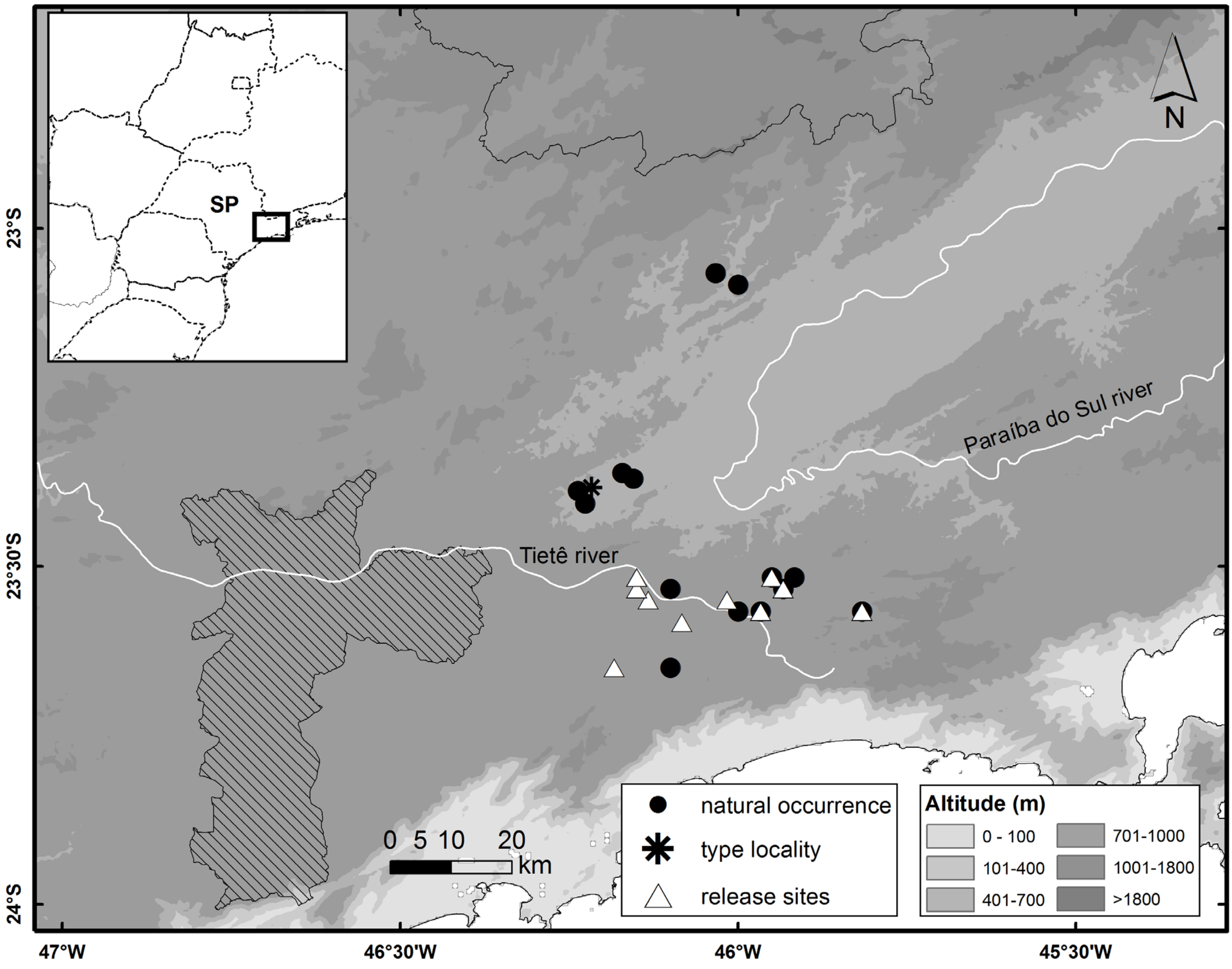

FIGURE 4. Distribution of São Paulo Marsh Antwren *Formicivora paludicola* sp. nov., São Paulo state, southeastern Brazil. Hatched area represents the city of São Paulo. The black line at the top of the figure represents the border between the states of São Paulo and Minas Gerais.

Probably the first record of a bird now known as *F. paludicola* dates of 4 November 1945, when Hélio Camargo collected a female of "*Formicivora rufa rufatra*" (Camargo 1946:158) at Boracéia Biological Station (23°38'S, 45°52'W), municipality of Salesópolis, eastern São Paulo state (see Cavarzere *et al.* 2010). Unfortunately, this specimen was severely damaged by the shot and was not prepared for the collection. Curiously, this record from outside the normal range of *F. rufa*, Rusty-backed Antwren, was not recognized as anomalous by later authors, except by Willis & Oniki (2003), who considered it to be a mistake. Boracéia Biological Station lies in montane Atlantic Forest and the nearest record of *Formicivora rufa* is about 200 km west. LFS did not found marshes in this location during recent searches and probably this habitat has disappeared from the reserve.

Etymology. *Paludicola*, from the Latin, means native to or inhabitant of marshes. This species is restricted to this habitat, and our intention in choosing the specific name *paludicola* is to focus attention on the conservation of the marshes of southern and southeastern Brazil.

Vocalizations

The name of each kind of vocalization in the vocal repertoire in any species is subjective. We have tried to name each different vocalization according to the context in which it is used by *F. paludicola* and by its sister species, *F. acutirostris*. We consider that all vocalizations described below for the two species are homologous.

Loudsong. The loudsoung (*sensu* Willis 1967) of *F. paludicola* (Figure 5) is a sequence of rapidly but evenly repeated two-note phrases, like that of *F. acutirostris*, and unlike the loudsongs of other *Formicivora* species, that consist of a repetition of a single or bipartite song note (Gonzaga 2001). The number of phrase repetitions and the interval between each sequence is highly variable in *F. paludicola* and *F. acutirostris*, and depends very much on

TABLE 4. Measurements of phrases of the loudsong (*sensu* Willis 1967) of *Formicivora paludicola* sp. nov. and *F. acutirostris*. The values presented are range and mean ± standard deviation (in parentheses).

Variable	***Formicivora paludicola*** **(6 individuals, 124 phrases)**	***Formicivora acutirostris*** **(5 individuals, 107 phrases)**
Phrase duration (s)	0.240-0.338 (0.277 ±0.028)	0.240-0.430 (0.293 ± 0.041)
Length note 1 (s)	0.047-0.070 (0.057 ± 0.004)	0.045-0.072 (0.057 ± 0.004)
Max. freq. note 1 (kHz)	2.1-3.7 (2.9 ± 0.2)	2.6-3.8 (3.2 ± 0.4)
Low. freq. note 1 (kHz)	1.2-1.9 (1.7 ± 0.2)	1.4-2.1 (1.7 ± 0.1)
Freq. amplitude note 1 (kHz)	0.8-2.4 (1.3 ± 0.3)	0.8-2.3 (1.5 ± 0.5)
Length note 2 (s)	0.017-0.052 (0.028 ± 0.006)	0.023-0.068 (0.037 ± 0.007)
Max. freq. note 2 (kHz)	2.9-4.6 (3.7 ± 0.4)	2.8-4.7 (3.7 ± 0.3)
Low. freq. note 2 (kHz)	1.4-2.3 (1.9 ± 0.1)	1.9-2.7 (2.3 ± 0.2)
Freq. amplitude note 2 (kHz)	0.9-2.7 (2.1 ± 0.7)	0.9-2.3 (1.5 ± 0.2)
Interval between notes (s)	0.144-0.257 (0.191 ± 0.020)	0.143-0.347 (0.200 ± 0.042)

the level of excitement of the bird (BLR *et al.*, unpub. data). For this reason, the number of phrase repetitions and the interval between them were not considered. Measurements of loudsongs of *F. paludicola* and *F. acutirostris* are given in Table 4. For *F. paludicola* the interval between the notes represents about 69% of the phrase duration, with the first note of the phrase presenting a sharp descending frequency modulation, as does the second, although the latter often ends in a short duration frequency modulation slight upward or horizontal. For *F. acutirostris* the interval between the notes represents about 68% of the phrase duration, with the first note also presenting a sharp descending frequency modulation, as does the second, although the latter ends in a small upward and downward modulation (Figure 5, F and H).

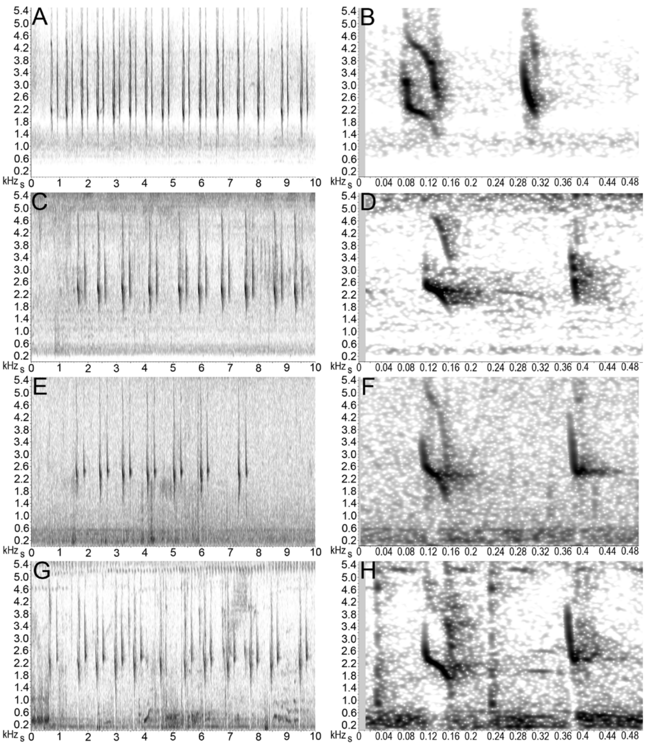

FIGURE 5. Loudsongs of *Formicivora paludicola* sp. nov. and *F. acutirostris*. A. Female of *F. paludicola* recorded at Bairro Rio Acima, municipality of Biritiba-Mirim, São Paulo state (recorded by A. Whittaker). B. Detail of a phrase of A. C. Male of *F. paludicola* recorded at Bairro Rio Acima (recorded by J. C. Minns). D. Detail of a phrase of C. E. Male of *F. acutirostris* recorded at Jundiaquara Island, municipality of Guaratuba, Paraná state (recorded by BLR). F. Detail of a phrase of E. G. A different male of *F. acutirostris* recorded at Jundiaquara Island (recorded by MRB). H. Detail of a phrase of G.

Alarm call. This call type (Figure 6) is known from *F. paludicola*, *F. acutirostris*, *F. rufa*, and *F. grantsaui*, supposedly being homologous to the call with a similar structure given by *F. grisea* (Gonzaga 2001, Gonzaga *et al.* 2007). In *F. paludicola* and *F. acutirostris* this call consists of a two note phrase emitted by birds alone and in duet, with a phrase repetition rate depending on the bird's level of excitement. In *F. paludicola* the alarm call phrases (n = 3 individuals and 44 phrases) had a total duration ranging from 0.194-0.355 s (0.275 ± 0.071 s), with the interval between the notes ranging from 0.113-0.342 s (0.178 ± 0.058 s), which represents 65% of the phrase duration. The first alarm call note has a duration ranging between 0.022-0.063 s (0.032 ± 0.011 s), with a minimum frequency of 2.3-3.7 kHz (3.0 ± 0.5 kHz), a maximum frequency between 2.8-4.5 kHz (3.8 ± 0.4 kHz), and a frequency amplitude ranging from 0.5-1.5 kHz (0.8 ± 0.2 kHz). The second alarm call note lasts between 0.049-0.106 s (0.067 ±0.014 s), with a minimum frequency of 0.7-1.8 kHz (1.3 ± 0.2 kHz), a maximum frequency between 3.1-4.5 kHz (3.8 ± 0.3 kHz), and a frequency amplitude ranging from 1.8-3.7 kHz (2.5 ± 0.4 kHz).

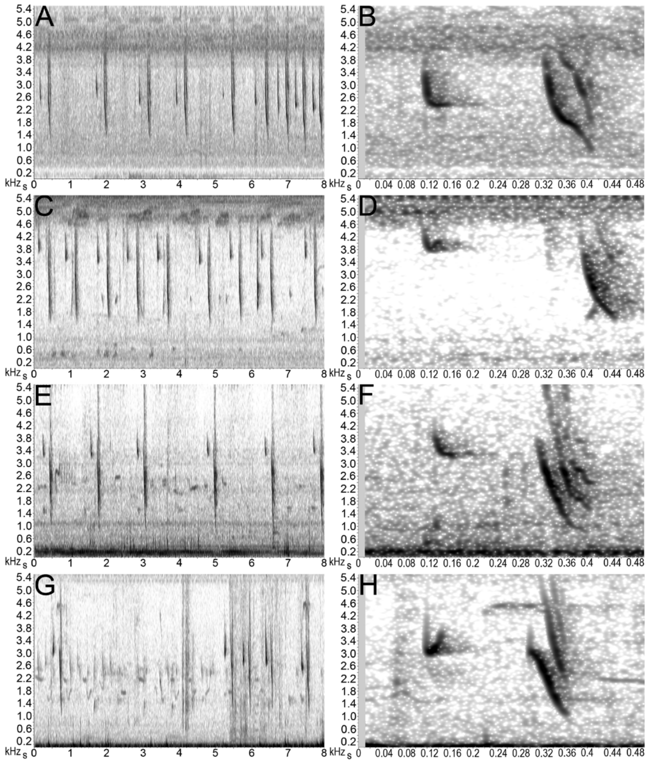

FIGURE 6. Alarm calls of *Formicivora paludicola* sp. nov. and *F. acutirostris*. A. Male of *F. paludicola* recorded at Estrada do Rio Acima, municipality of Biritiba-Mirim, São Paulo state (recorded by LFS). B. Detail of A. C. Female of *F. paludicola* recorded at Rio Paraitinga, Barragem do Paraitinga 2, municipality of Salesópolis, São Paulo state (recorded by BLR). D. Detail of C. E. Male of *F. acutirostris* recorded at Jundiaquara Island, municipality of Guaratuba, Paraná state (recorded by RB-L). F. Detail of E. G. Female of *F. acutirostris* recorded at Jundiaquara Island (recorded by BLR). H. Detail of G.

Contact call. The contact calls of *F. paludicola* and *F. acutirostris* (Figure 7) have a similar note shapes to those that Gonzaga *et al.* (2007) described as a "territorial duet calls" of *F. rufa*. However, in the former two taxa, they can also be produced by birds vocalizing alone, following other vocalizations or as an isolated series of calls. In *F. paludicola* and *F. acutirostris* this vocalization consists of a single note repeated in short sequences or alone, with the note presenting a sharp descending frequency followed by a small ascending modulation that ends with a small plateau. The contact call note of *F. paludicola* (n = 2 individuals and 34 notes) had a duration of about 0.031-0.049 s (0.041 ± 0.001 s), with a minimum frequency of 1.6-2.1 kHz (1.8 ± 0.1 kHz), a maximum frequency between 3.4-4.8 kHz (4.1 ± 0.01 kHz), and a frequency amplitude ranging from 1.7-3.1 kHz (2.3 ± 0.1 kHz). In *F. acutirostris* the final part of the note after the plateau presents a small downward frequency modulation that can reach half of the amplitude of the ascending modulation of the note.

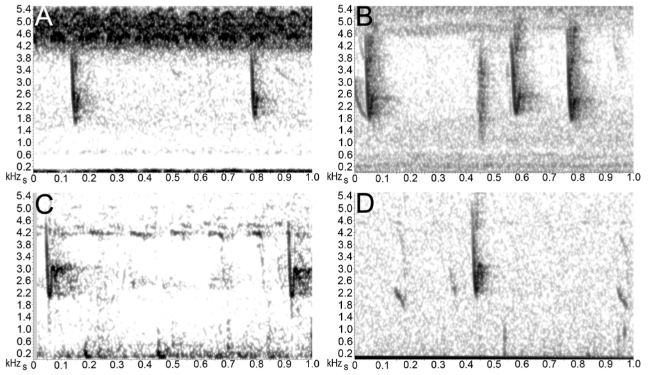

FIGURE 7. Contact call of *Formicivora paludicola* sp. nov. and *F. acutirostris*. A. Male of *F. paludicola* recorded at Estrada da Casa Grande, municipality of Biritiba-Mirim, São Paulo state (recorded by LFS). B. Pair of *F. paludicola* recorded at Rio Paraitinga, Barragem do Paraitinga 2, municipality of Salesópolis, São Paulo state (recorded by MRB). The first two calls were from one individual and the third from the other. C. Male of *F. acutirostris* recorded at Jundiaquara Island, municipality of Guaratuba, Paraná state (recorded by RB-L). D. Another male of *F. acutirostris* recorded at Jundiaquara Island (recorded by BLR).

Distress call. The distress call of *F. paludicola* (Figure 8) is similar to those described for *F. acutirostris*, *F. grisea*, *F. serrana*, *F. littoralis*, *F. rufa*, *F. grantsaui*, *F. melanogaster*, *Neorhopias iheringi*, *Myrmotherula axillaris*, and *M. longipennis* (Gonzaga 2001, Gonzaga *et al.* 2007). The distress calls of both Marsh Antwrens consist of a constant repetition of the same harmonic rich fundamental note, which can show a highly variable shape, but never turns into a trill as described for *F. rufa* (Gonzaga *et al.* 2007). In *F. paludicola* the general note shape can be described as an upward modulation followed by a descending modulation (inverted "u" or "v" shape"), but the midpoint between the ascending and descending part of the note is not always centered (it may be displaced to the left or right), and the downward part can show small plateaus while descending in frequency. Alternatively, it may start with a small upward frequency modulation followed by a almost vertical ascending modulation, then forming a plateau or descending slowly until a almost vertical downward modulation followed by a slow downward modulation at the end of the note (Figure 8, E); or the notes may even show an initial sharp downward frequency modulation followed by a modulation similar to the one found in the inverted "u" notes (Figure 8, G).

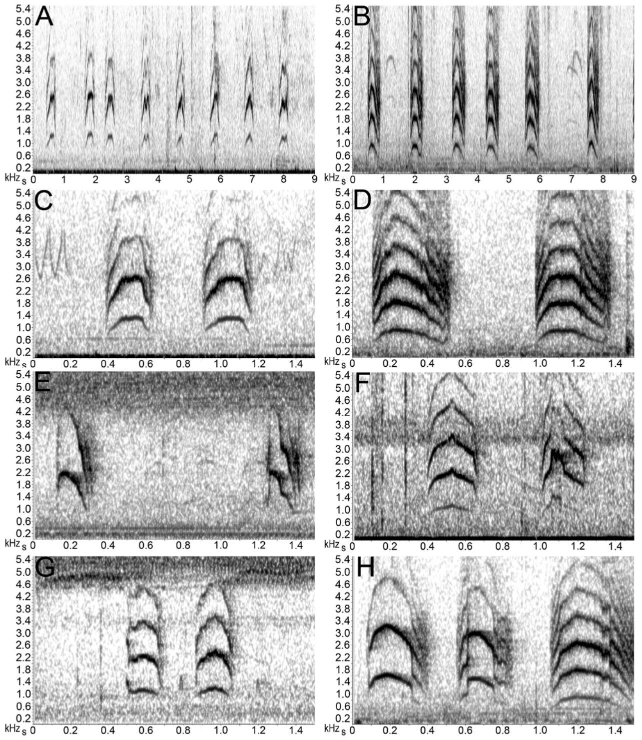

FIGURE 8. Distress calls of *Formicivora paludicola* sp. nov. and *F. acutirostris*. A. Female of *F. paludicola* recorded at Estrada da Casa Grande, municipality of Biritiba-Mirim, São Paulo state (recorded by LFS). B. Female of *F. acutirostris* recorded at Rio São João near the Folharada Island, municipality of Guaratuba, Paraná state (recorded by RB-L). C. Detail of A. D. Detail of B. E. Female of *F. paludicola* recorded at Rio Paraitinga, Barragem do Paraitinga 2, municipality of Salesópolis, São Paulo state (recorded by BLR). F. Male of *F. paludicola* recorded at Sitio do Caleb, municipality of São José dos Campos, São Paulo state (recorded by LFS). G. Female of *F. paludicola* (same individual of E). H. Male (first two notes) and female (third note, same individual of B) of *F. acutirostris* recorded at the Rio São João (recorded by RB-L).

In *F. paludicola* the duration of the fundamental note of the distress call (n = 5 individuals and 51 calls) ranged from 0.110-0.295 s (0.186 ± 0.049 s), with its minimum frequency ranging from 0.6-1.3 kHz (0.9 ± 0.2 kHz), the maximum frequency between 1.0-1.9 kHz (1.4 ± 0.3 kHz), and the frequency amplitude ranging from 0.2-0.7 kHz (0.5 ± 0.1 kHz). The duration of the first harmonic note ranged from 0.142-0.315 s (0.232 ± 0.059 s), with its minimum frequency going from 0.9-2.0 kHz (1.4 ± 0.3 kHz), the maximum frequency between 1.9-3.5 kHz (2.7 ± 0.5 kHz), and the frequency amplitude ranging from 0.6-1.8 kHz (1.2 ± 0.1 kHz).

Display call. The display calls of *F. paludicola* and *F. acutirostris* are different from those described by previous authors for all other *Formicivora* species (Gonzaga 2001, Gonzaga *et al.* 2007). The typical notes are composed of two linked ascending and descending modulations, but birds sometimes emit only half of the note (one upward and downward frequency modulation; Figure 9). There are also some other variations found in the display call of *F. paludicola* and *F. acutirostris* (Figure 10), but these variants were found in only one individual of each species. The display call notes of *F. paludicola* (n = 5 individuals and 51 calls) had a duration between 0.110-0.295 s (0.186 ± 0.049 s), with its minimum frequency going from 0.6-1.3 kHz (0.9 ± 0.2 kHz), a maximum frequency between 1.0-1.9 kHz (1.4 ± 0.3 kHz), and a frequency amplitude ranging between 0.2-0.7 kHz (0.5 ± 0.1 kHz).

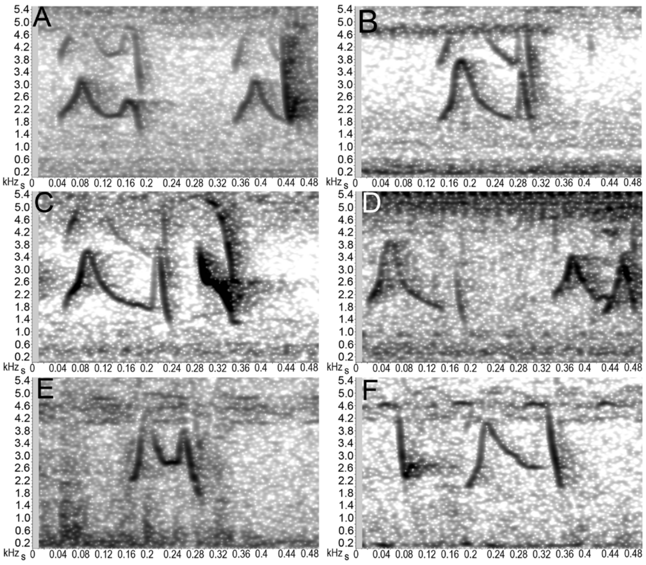

FIGURE 9. Display calls of *Formicivora paludicola* sp. nov. and *F. acutirostris*. A. Pair of *F. paludicola* recorded at Rio Paraitinga, Barragem do Paraitinga 2, municipality of São Paulo state (recorded by MRB). The two display calls are by the female, one note complete and the other being half of a note, with the male responding with a contact call. B. Another example of recording A by the same female. C. A third example from same recording A. In this example the display call is by the male, and the second note is the first note of a phrase of the song of the female. D. A fourth example from the same recording A. The first note and the first modulation up and down seemed to be emitted by the male, whereas the second up and down modulation seemed to be emitted by the female. E and F. Pair of *F. acutirostris* recorded at Jundiaquara Island, municipality of Guaratuba, Paraná state (recorded by RB-L). In F, the first note is a contact call by one individual and the second is the display call by the other.

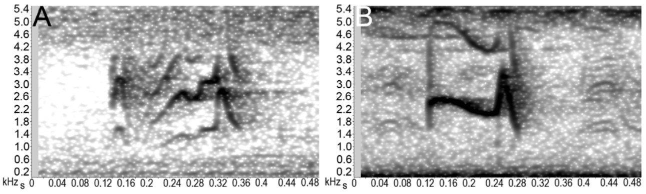

FIGURE 10. Variations of the display calls found in *Formicivora paludicola* sp. nov. and *F. acutirostris*. A. Female of *F. paludicola* recorded at Rio Paraitinga, Barragem do Paraitinga 2, municipality of Salesópolis, São Paulo state (recorded by BLR). B. Female of *F. acutirostris* recorded at Rio Claro, municipality of Guaratuba, Paraná state (recorded by BLR).

Foraging call. This vocalization is uttered by birds while foraging, being found in *F. paludicola* and *F. acutirostris*. Most of the time this one note call of low intensity is almost inaudible, and can only be heard at very close quarters, although sometimes the voice is loud enough to be heard at up to 2 m. The notes of *F. paludicola* ranged from 0.025-0.047 s (0.037 ± 0.008 s), with a minimum frequency of 2.1-2.3 kHz (2.2 ± 0.1 kHz), a maximum frequency between 2.4-2.8 kHz (2.6 ± 0.2 kHz), and a frequency amplitude ranging from 0.3-0.6 kHz (0.4 ± 0.1 kHz).

Aggressive call. This vocalization was heard and tape recorded at the type locality, and at three other areas in its vicinity. It was emitted by four different females of *F. paludicola* after playback of the loudsong, almost always when the male was issuing the loudsong. *Formicivora acutirostris* also emits this vocalization, which is used in the same context. In *F. paludicola* this vocalization is generally repeated once or in short sequences of up to nine emissions between other vocalizations (n = 4 individuals and 48 calls). For *F. acutirostris* we heard up to four repeats of this vocalization, but were only able to record single emissions (n = 2 individuals and 2 calls) of this call by this species.

This call lasts from 0.042-0.144 s (0.114 ± 0.006 s), and is composed of two notes, the first one more variable in form, but normally resembling an inverted "u", and the second consisting of an abrupt descending note with a inflection upward and then downward. The first note varies in shape from an inverted "u" to flatter or almost pulse-like emissions. The fundamental of this note lasted from 0.013-0.036 s (0.020 ± 0.004 s), with a minimum frequency of 0.9-2.2 kHz (1.3 ± 0.2 kHz), a maximum frequency between 1.6-4.0 kHz (2.0 ± 0.4 kHz), and a frequency amplitude ranging from 0.3-2.4 kHz (0.7 ± 0.2 kHz). The fundamental of the second note lasted from 0.025-0.050 s (0.039 ± 0.003 s), with a minimum frequency of 1.3-1.7 kHz (1.6 ± 0.1 kHz), a maximum frequency between 3.4-4.6 kHz (3.9 ± 0.3 kHz), and a frequency amplitude ranging from 1.8-3.0 kHz (2.5 ± 0.2 kHz). The aggressive call of the two species overlaps in frequency and time, and there are small variations in the shape of the two notes of this call.

Molecular analysis

The comparison by Bayes Factors (Table 5) showed that the two replicates of the runs used for the partitioning test converged. The comparison between different partitioning schemes by Bayes Factors (Table 5) shows that the models that treated each codon position separately received very strong support over the others. Between the codon partition schemes there are no significant differences between the full partitioned scheme (10 partitions, each mitochondrial gene separately partitioned into different codon positions, and βF5 treated separately) and the scheme considering three codon positions (independently of the mitochondrial gene) and βF5 separately (four partitions). Due to this aspect, the second partition scheme was used for further analysis.

The trees obtained by the two different methods presented the same topology, and both analyses indicated with high support that *F. paludicola* and *F. acutirostris* represent distinct clades, with samples of each of these taxa representing reciprocally monophyletic groups (Figure 11). The combined mitochondrial genetic distance between *F. acutirostris* and *F. paludicola* ranged between 0.005-0.009 (0.006 ± 0.001) (Table 6). The variability within *F. paludicola* was of 0-0.001 (0.001 ± 0.000), and within *F. acutirostris* was of 0-0.003 (0.002 ± 0.001). Except for one individual of *F. paludicola*, all other sequences of both species of Marsh Antwrens for the βF5 presented the same base composition.

Habitat

Formicivora paludicola is found only in marshes where cattails *Typha domingensis* (Typhaceae) and bulrush *Schoenoplectus californicus* (Cyperaceae) are abundant (Figure 12), and their height ranges from 60 to 250 cm. The vegetation is also composed of other Cyperaceae (*e.g.*, *Rhynchospora globosa*, *Rhynchospora* sp.), and Poaceae (*e.g.*, *Brisa* sp.). Some bushes can be found among the main vegetation, such *Eupatorium* spp., *Baccharis semiserrata*, *B. illinita*, *Baccharis* sp. (Asteraceae), *Tibouchina gracilis*, *T. ursina* (Melastomataceae), *Siphocampilus verticillatus* (Campanulaceae), *Leucothoe* sp. (Ericaceae), *Rapanea parvifolia* (Myrsinaceae) and *Eupatorium bupleurifolium* (Asteraceae), the latter being most abundant. Grasses such *Eriochrysis* sp., *Panicum* sp., and ferns are also observed. At the type locality, the area of the marsh comprises almost 13 ha, and when *F. paludicola* was discovered in 2004, almost 70% of the area was dominated by *T. domingensis* and 30% by *S. californicus*. Further observations were conducted by DRCB in the same area in 2010, and at that time, *T. domingensis* had expanded its area to occupy almost 80% of the marsh, while *S. californicus* occupied less than 15%, the balance consisting mainly of the exotic grass *Melinis minutiflora* (Poaceae). The marshes inhabited by the São Paulo Marsh Antwren occur as patches of different sizes located along small rivers or on river flood plains. Along the course of

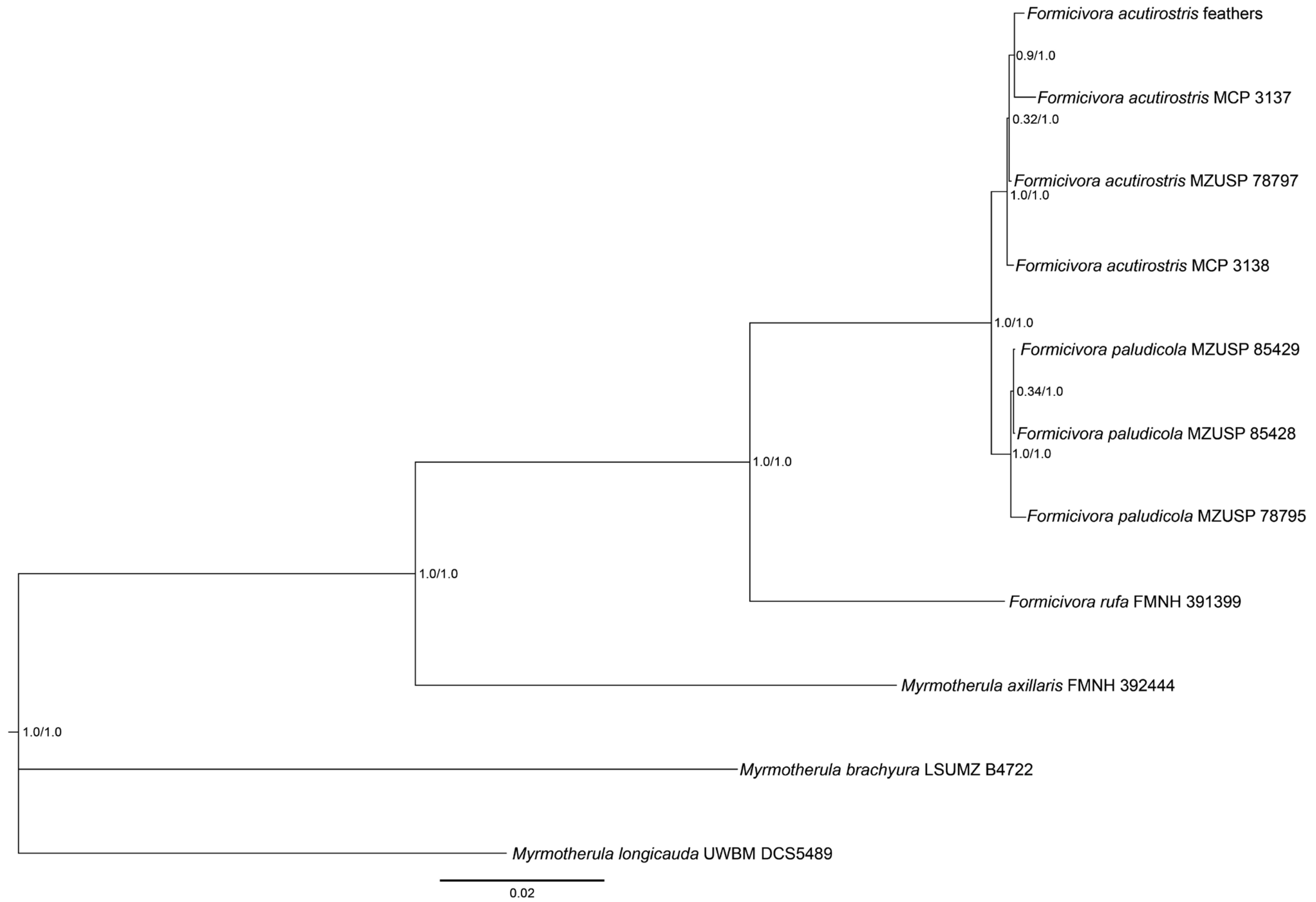

FIGURE 11. Phylogenetic tree obtained by Bayesian inference and maximum likelihood. Small values at the nodes are posterior probabilities and the bootstrap support. Specimen acronyms are detailed in appendix 3.

TABLE 5. Comparison by Bayes Factors of the likelihood of different partition schemes estimated using MrBayes. The roman numbers indicates the different partition schemes and the letters a and b the two replicates. The guidelines of Kass & Raftery (1995) for interpreting the values of $\log_{10}(B_{10})$ suggests that values ≤ 3 over not worth more than a bare mention, values from 3 to 20 suggest positive evidence against H_0, values from 20 to 150 suggests strong evidences against H_0, and values > 150 suggests very strong evidence against H_0. MIT (contatenated mitochondrial genes) refers to all mitochondrial genes together, and $_{\text{codon}}$ refers to the use of a codon partitioning (all codon positions analyzed separately. βF5 = intron 5 of the β fibrinogen; CYB = cytochrome b; ND2 = nicotinamide dehydrogenase subunit 2; ND3 = nicotinamide dehydrogenase subunit 3.

Partition scheme		**lnP** **(model|data)**	**S.E.**	B_{10}									
				Ia	**Ib**	**IIa**	**IIb**	**IIIa**	**IIIb**	**IVa**	**IVb**	**Va**	**Vb**
no partitions (I)	Ia	-7688.921	0.503	-	-0.70	-13.05	-13.34	-13.62	-13.51	-159.98	-160.02	-160.99	-161.13
	Ib	-7687.304	0.347	0.70	-	-12.35	-12.63	-12.92	-12.81	-159.28	-159.31	-160.29	-160.43
MIT+βF5 (II)	IIa	-7658.872	0.434	13.05	12.35	-	-0.29	-0.57	-0.46	-146.93	-146.97	-147.94	-148.08
	IIb	-7658.213	0.357	13.34	12.63	0.29	-	-0.29	-0.17	-146.64	-146.68	-147.66	-147.80
CYB+ND2+ND3+βF5 (III)	IIIa	-7657.551	0.449	13.62	12.92	0.57	0.29	-	0.12	-146.35	-146.39	-147.37	-147.51
	IIIb	-7657.820	0.481	13.51	12.81	0.46	0.17	-0.12	-	-146.47	-146.51	-147.48	-147.63
$\text{MIT}_{\text{codon}}$+βF5 (IV)	IVa	-7320.560	0.429	159.98	159.28	146.93	146.64	146.35	146.47	-	-0.04	-1.01	-1.16
	IVb	-7320.472	0.472	160.02	159.31	146.97	146.68	146.39	146.51	0.04	-	-0.98	-1.12
$\text{CYB}_{\text{codon}}$+$\text{ND2}_{\text{codon}}$ +$\text{ND3}_{\text{codon}}$+βF5 (V)	Va	-7318.224	0.481	160.99	160.29	147.94	147.66	147.37	147.48	1.01	0.98	-	-0.14
	Vb	-7317.901	0.377	161.13	160.43	148.08	147.80	147.51	147.63	1.16	1.12	0.14	-

TABLE 6. Combined mitochondrial genetic distances for several taxa of the tribe Formicivorini calculated under the Tamura-Nei model of DNA substitution, with the variance (upper diagonal) estimated with 1,000 bootstrap replicates. The bold type values indicates comparisons between *Formicivora paludicola* sp. nov. and *F. acutirostris*.

	Specimen	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	*Myrmotherula longicauda* UWBM DCS5489		0.014	0.020	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.021
2	*Myrmotherula brachyura* LSUMZ B4722	0.173		0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
3	*Myrmotherula axillaris* FMNH 392444	0.224	0.215		0.015	0.015	0.015	0.015	0.015	0.014	0.014	0.015
4	*Formicivora rufa* FMNH 391399	0.225	0.239	0.160		0.008	0.008	0.009	0.009	0.008	0.008	0.008
5	*Formicivora acutirostris* MZUSP 78797	0.218	0.231	0.172	0.079		0.000	0.001	0.001	0.001	0.001	0.002
6	*Formicivora acutirostris* MCP 3138	0.220	0.232	0.173	0.080	0.000		0.001	0.001	0.001	0.001	0.002
7	*Formicivora acutirostris* MCP 3137	0.224	0.237	0.178	0.083	0.003	0.003		0.001	0.002	0.002	0.002
8	*Formicivora acutirostris* feathers	0.219	0.233	0.176	0.082	0.002	0.002	0.004		0.002	0.002	0.002
9	*Formicivora paludicola* MZUSP 85428	0.223	0.234	0.175	0.079	**0.005**	**0.005**	**0.008**	**0.006**		0.000	0.001
10	*Formicivora paludicola* MZUSP 85429	0.223	0.234	0.175	0.079	**0.005**	**0.005**	**0.008**	**0.006**	0.000		0.001
11	*Formicivora paludicola* MZUSP 78795	0.226	0.236	0.178	0.081	**0.006**	**0.006**	**0.009**	**0.008**	0.001	0.001	

the upper Tietê river we found several narrow strips of marsh dominated by *Panicum* sp. (possibly *P. mertensii*) between the forest and the water, but we not found *F. paludicola* in this habitat.

Formicivora paludicola shares its habitat with typical marsh species such as *Laterallus melanophaius*, *L. leucopyrrhus*, *Pardirallus nigricans*, *P. sanguinolentus*, *Phacellodomus ferrugineigula*, *Certhiaxis cinnamomeus*, *Pseudocolopteryx sclateri*, *Donacobius atricapilla*, *Agelasticus cyanopus*, and *Sporophila bouvreuil*.

Behavior

Formicivora paludicola is found in pairs or family groups of four birds, moving by small leaps and short flights through the vegetation in the lower strata of the marshes. The birds do not leave the marshes and their flight is short and heavy, not exceeding *ca.* 25 m in a straight line. The species spends most of the time looking for insects such as mosquitoes, mantises, and caterpillars. Pairs stay very close together, giving short, weak foraging calls. They do not vocalize very much, and are heard mostly in the early morning or afternoon. Their territories are defended aggressively by both sexes, and the birds are readily responsive to playback.

The first pair of the species found in October 2004 consisted of a subadult male and a female, indicating that subadult males can start to breed before they acquire full adult plumage (see below). A male and female collected in early October (MZUSP 78787 and 78788) had incubation patches, indicating reproductive activity and participation by the male in incubation, as is observed for almost all the Thamnophilidae (Zimmer & Isler 2003). Copulations were recorded in October 2006, and young birds, whose plumage is like that of the adult female (see below), were recorded in January, February, and March.

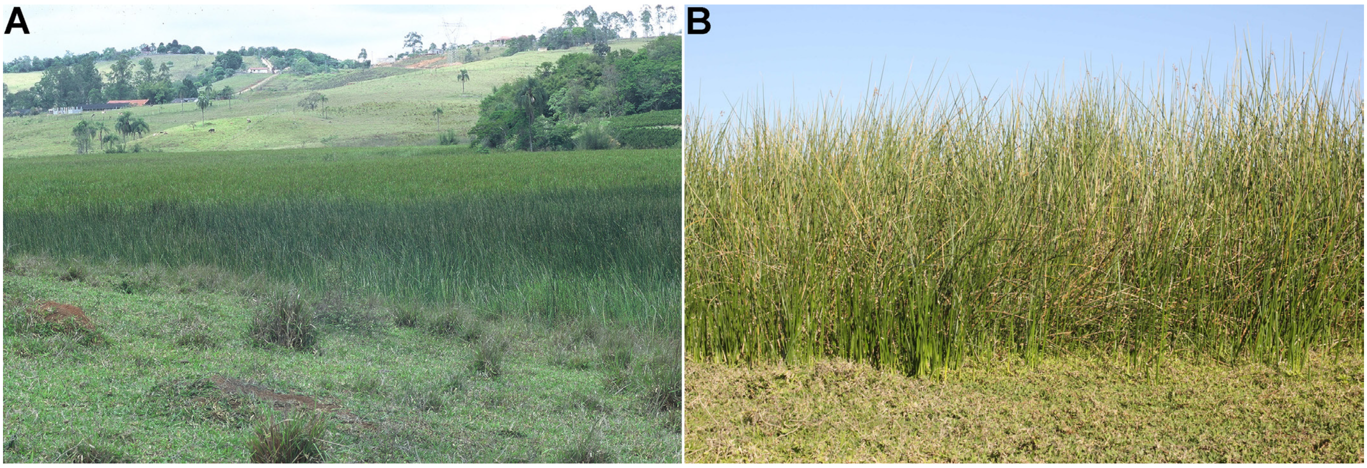

FIGURE 12. Habitat of the São Paulo Marsh Antwren *Formicivora paludicola* sp. nov. at its type locality, Córrego Taboão do Parateí, municipality of Mogi das Cruzes, São Paulo state, Brazil. A. General view of the marsh, with the domain of cattails *Typha domingensis* in the light green area, and the domain of bulrush *Schoenoplectus californicus* in the darker green area. B. Close-up of bulrush. Photos by DRCB.

DISCUSSION

Plumage

We observed and banded individuals of *F. paludicola* with plumage similar to that of the females, as described above, but with some gray rather than black on the breast, and in some cases also with a lesser amount of white on the breast. This plumage is similar to that of the male of *F. acutirostris* described in Bornschein *et al.* (1995), which was later recognized to be a young bird (Reinert & Bornschein 1996; see also Reinert 2008). Because *F. paludicola* and *F. acutirostris* are sister species, we believe that plumage succession of young males of *F. paludicola* follows that of young males of *F. acutirostris*, with a temporary plumage pattern (immature plumage) similar to that of the female before acquisition of adult plumage, as in several other thamnophilids (Zimmer & Isler 2003).

In several banded males of *F. paludicola* we observed one or a few white feathers on the breast or flanks, a remainder of the immature plumage. Remainders of immature plumage are also found in *F. acutirostris*, but in a different pattern. The immature males of the latter species change at an age of about seven months to a subadult plumage characterized by gray or dark gray underparts, with the presence of several ventral feathers with white margins (Reinert 2008). Thus, *F. paludicola* and *F. acutirostris* exhibit distinct patterns in their subadult plumage. We do not discard the possibility that the white feathers amid the black ventral plumage of *F. paludicola* are maintained as a neotenic characteristic, due to the abundance of individuals with this characteristic.

Vocalizations

The vocalizations of *F. paludicola* and *F. acutirostris* that were analysed do not meet the diagnosticability criteria proposed by Isler *et al.* (1998) because of the extensive overlap in the range of the continuous variables of these two taxa. Despite this overlap, the second note of the loudsong of *F. paludicola* tends to present a shorter duration and greater frequency amplitude than that of *F. acutirostris* (Figure 5), and the contact call note of *F. paludicola* seems to lack the final downward modulation found in *F. acutirostris* (Figure 7). The differences in the number of repetitions of the aggressive calls between *F. paludicola* and *F. acutirostris* can also be indicative of a ongoing divergence process.

In this context it is worth mentioning the example of *Terenura maculata* and *T. sicki*, species with evident plumage differences, with the latter replacing the former in the northern Atlantic Forest, but which do not fit the diagnostic criteria proposed for vocalizations by Isler *et al.* (1998) (see Minns *et al.* 2009), as in the case of *F. paludicola* and *F. acutirostris*. Although we have analysed seven different vocalizations of the Marsh Antwrens, the vocal repertoire of a Thamnophilidae can include up to 16 vocalizations (*Gymnopythis leucaspis*) (Willis 1967). This suggests the need for additional knowledge and recordings of the complete accoustic repertoire of *F. paludicola* and *F. acutirostris* to analyse the possibility of divergence in other types of vocalization not contemplated here.

Molecular analysis

Although the mitochondrial genetic distances between *F. paludicola* and *F. acutirostris* were low, the phylogenetic analyses showed that all individuals of *F. paludicola* formed a monophyletic clade that was sister to another clade formed by all samples of *F. acutirostris* (i.e., reciprocal monophyly in mtDNA was achieved). The low genetic distances suggests a recent divergence between *F. paludicola* and *F. acutirostris*. The estimated Bayesian chronogram (not show) suggests that the divergence between these two species can be estimated to have occurred between 250,000 to 640,000 years before the present (median of 420,000 years before the present).

Biogeography

Considering the small dispersal capability of *F. acutirostris* and other thamnophilids (Reinert *et al.* 2007, Lees & Peres 2009, Woltmann *et al.* 2012), which also seems to be the case for the *F. paludicola* (see Results, and below), the Serra do Mar escarpment appears to be a insurmountable physical and ecological barrier between the two species at the present time. The Serra do Mar reaches about 1,000 m a.s.l. on the latitude of Mogi das Cruzes and Biritiba-Mirim, where *F. paludicola* is found, and almost all the area of Serra do Mar is covered by forests. However, there are records of neotectonic activity (≤ 1,2 million years) in the Paraíba do Sul river valley and specially at the headwaters of the Tietê river basin (Saadi *et al.* 2002, Ribeiro *et al.* 2006), the area to which *F. paludicola* is restricted.

Biogeographic models described for eastern Brazil freshwater fishes (Ribeiro 2006) propose mechanisms that could at first sight be involved in the present relationships and distribution of the two Marsh Antwren species (see below). Ribeiro (2006) identified three biogeographic patterns for freshwater fishes, related to different taxonomic units with different ages. Pattern "A" dates back to the Cretaceous period, and involves large clades at familial and subfamilial levels; pattern "B" dates back to the Tertiary period, and involves sister group relationships between genera; and pattern "C" involves recent species-level fauna interchange between uplands and coastal rivers due to stream capture and neotectonics (Ribeiro 2006). Although these models were proposed to explain fish distributions, they should be considered for the Marsh Antwrens because of the fact that the present day species occur in habitats associated with water, distributed along water bodies and flood plains.

Considering the time estimated for the divergence of the two Marsh Antwrens (250,000 - 640,000 years before present), the divergence between these species could be related to the pattern "C" of Ribeiro (2006). Ribeiro (2006) suggests that part of the fish fauna of the upper Tietê river could be the result of the capture of the lowland biota of coastal drainages by an uplift, but does not give the precise timing of this event. If it occurred in the last one million years, it could be related to the split between the Marsh Antwrens, in which case it would be expected that the ancestor of the Marsh Antwrens ocurred at the coast and was captured together with the fish fauna. The separation of the Marsh Antwrens could also be related to a stream capture event, as in the case of some fishes of the Guaratuba River basin at Boracéia Ecologial Station and its coastal affluents (Ribeiro *et al.* 2006).

However, as one species occurs in the Paraíba do Sul river drainage and the other on the coast, is possible that the Marsh Antwrens' ancestor occupied the whole drainage and also marshes in the lowlands. The Paraíba do Sul River valley is an old geological feature, which has seen the formation of several paleolakes (*e.g.* Petri & Fúlvaro 1983, Zanão *et al.* 2006), and therefore the existence of marshes in this valley over a long time is to be expected. Recent studies suggest that on the coast of southeastern and southern Brazil the colonization by the mangrove *Rhizophora mangle* started after the Quaternary Glaciation (Pil *et al.* 2011), and the area occupied today by mangroves could have been occupied by marshes before the mangrove expansion. Mangroves are a habitat that occupies tidal flats in tropical areas, being replaced by salt marshes in temperate zones (Doody 2001), and salt marshes are the core area for *F. acutirostris* (MRB *et al.*, unpubl. data). In this scenario of an ancestor with a continous population in the Paraíba do Sul drainage and on the coast, the marked changes in sea levels in the Pleistocene (Haq *et al.* 1987) and the respective environmental changes could have isolated the populations in the valley from the ones on the coast and at the same time extinguished the populations intermediary to the present day distribution of the species.

Sea level fluctuations are also implied in the present distribution of *F. acutirostris* as isolated populations in Paraná and Santa Catarina coast (Reinert *et al.* 2007). The hypothesis of a continuous population would be supported by the occurrence of populations of *F. paludicola* in the medium and lower course of the Paraíba do Sul River. Independently of the biogeographical events involved in the speciation between *F. paludicola* and *F. acutirostris*, we consider that, in spite of present day climatic change and the predicted rise in sea level (Church & White 2006, IPCC 2007), there is no possibility of expansion in the ranges of *F. paludicola* and *F. acutirostris* and contact between them in the near future. Under an evolutionary and conservationist view, *F. paludicola* represents a distinct evolutionary lineage from *F. acutirostris*, and as so it should be a target for conservation action.

Habitat

At the type locality of *F. paludicola*, *T. domingensis* was a localy invasive plant to the detriment of *S. californicus* (even though both are native plants to Brazil). In the headwaters of the Taboão do Parateí stream, many signs of degradation were observed, with the expansion of *T. domingensis* and the disappearance of *S. californicus* in the sedimented areas. *Typha domingensis* is also an invasive plant in highland marshes around the city of Curitiba in the state of Paraná in southern Brazil (*ca.* 900 m a.s.l.), the habitat of the Marsh Tapaculo (*Scytalopus iraiensis*) (Bornschein *et al.* 1998). We believe that the original habitats of *F. paludicola* were marshes dominated by *S. californicus*. Reinert (2008) highlights that areas dominated solely by *S. californicus* were never used for nesting by *F. acutirostris*, but where associated with other plants *S. californicus* supplies fibers for nest building and support for nest attachment (Reinert *et al.* 2012). Nevertheless, *F. paludicola* seem to have adapted to *T. domingensis*, as suggested by the number of pairs using this vegetation at the type locality (DRCB, unpubl. data). We are not aware of the presence of marshes dominated by *S. californicus* at other sites in the Paraíba do Sul or Tietê river basins, except for small areas at Cunha, Mairiporã and Atibaia (DRCB, unpubl. data), which could support populations of *F. paludicola*.

On a visit in 2004 to a marsh of about 4 ha near the type locality, the species was not found in the area despite hours of search with playback. The locals informed that the marsh appeared only three years previously, due to changes in the topography and natural drainage that led to the establishment of *T. domingensis*. The area was located less than 1 km from the type locality, which indicates the low dispersal capabilities of *F. paludicola*, and the need for marsh corridors for its dispersal.

Conservation

The conservation of open areas in Brazil is highly problematic (Bornschein *et al.* 1998). Environmental legislation protects mainly forests and open areas such as natural savannas, and marshes are treated as less important habitats (Bornschein *et al.* 1998). Most of the marshes where the new species was found are heavily degraded by sand mining, housing developments, fish farming, drainage for cattle raising and agricultural activities, fire, and invasion by exotic plants. Exotic plants include the grasses *Urochloa arrecta* (or *Brachiaria subquadripara*) and *Melinis minutiflora*, and *Hedychium coronarium* (Zingiberaceae). Invasion by *U. arrecta* is one of the main factors that threaten populations of *F. acutirostris* (Reinert *et al.* 2007).

Geological evaluation of the subsoil at the type locality of *F. paludicola* revealed a layer of pure sand almost 15 m deep below the area (Luis A. Kaimoto, pers. comm.). This suggests that many areas where *F. paludicola* occurred in the past have been affected by sand mining, which has been carried out for more than 100 years ago by the companies of one family (Luis A. Kaimoto, pers. comm.). Sand mining causes continual changes in the landscape where marshes occur, creating an environment where even *T. domingensis* is not able to establish itself. Many other marshes may be associated with the presence of sand deposits, and therefore could be affected by future sand mining projects. Sand mining is also a threat to the habitats of its sister species, *F. acutirostris* (Reinert *et al.* 2009).

Other areas where *F. paludicola* might occur have been affected by the construction of dams in several rivers. The species was found by LFS in the area of the Paraitinga dam while it was filling, which prompted a project to rescue and relocate the birds. During a period of about 15 days, BLR, MRB, RB-L, LFS, and other ornithologists captured 72 individuals at the dam, and relocated them in other nearby marshes. In a search three years after the release, most of these individuals were found, and some of them were accompanied by young birds, indicating successful breeding (Érika Machado and Gláucia del Rio *et al.*, unpubl. data).

Over the last three years we have unsuccessfully searched for this species in marsh habitats in more than 50 localities surrounding the known areas, but *F. paludicola* seem to be restricted to the higher regions of the Tietê and Paraíba do Sul rivers. Auditory and visual censuses of marshes within the species known range indicate an estimated population of 250-300 individuals. *Formicivora paludicola* has been considered as "Critically Endangered" in the state of São Paulo even before its formal description (Silveira 2010), but the species is not yet classified as threatened neither by the Brazilian government, nor by the World Conservation Union.

The new species has not been found in any conservation unit until the present, and there is a clear need to create protected areas including large populations of the São Paulo Marsh Antwren. There is also a need to restrict economic activities (*e.g.* agriculture and sand mining) and increase surveillance over marsh areas, as some of the areas where the species occurs should be preserved according to Brazilian law, but in practice there is no protection and many sites are being exploited commercially. Urgent action is needed on these issues to prolong this species' survival in the face of imminent extinction. This is the third species of bird to be described in the last 20 years that lives exclusively in the marshes of southern and southeastern Brasil. The discovery of this shy and severely threatened bird less than 50 km from the center of the largest and still growing city in South America (with more than 13 million inhabitants) makes the remark in Zimmer & Isler (2003:450) sound prophetic: "...how much remains to be discovered about birds in South America, even in relatively well-studied and heavily populated regions".

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APPENDIX 1.

Material analyzed of *Formicivora* spp. (all skins from Brazil).

Formicivora acutirostris. **Paraná**. Antonina: MHNCI 4884-5. Morretes: MHNCI 5748. Guaratuba: MN 42978-80, MZUSP 78797-8, MCP 3137-8, 3799. Matinhos: MN 39458 (holotype), 39457 (paratype). The specimens at MZUSP were previously housed in Louisiana State University Museum of Natural Sciences respectively under numbers LSUMZ 161021 and 161020 (ex MHNCI 4883 and 4882, respectively).

Formicivora erythronotos. **Rio de Janeiro**. Mambucaba: MZUSP 76678-9.

Formicivora grantsaui. **Bahia**. Mucugê: MZUSP 76676-7 (paratypes), MCP 3151, 3163.

Formicivora grisea. **Pará**. Conceição do Araguaia: MZUSP 42371; Fordlândia: MZUSP 70509; Santana do Araguaia: MZUSP 82139, 90074-5. **Mato Grosso**. Pontes e Lacerda: MZUSP 78071. **Bahia**. São Francisco do Conde: MCP 3145, 3154.

Formicivora littoralis. **Rio de Janeiro**. Cabo Frio: MZUSP 73506-7 (paratypes).

Formicivora melanogaster. **Piauí**. MZUSP 77741-2. **Pernambuco**. Agrestina: MZUSP 63492, 63525. **Alagoas**. Palmeira dos Índios: MZUSP 37419. **Bahia**. Bonito: MCP 3158; Ibicoara: MCP 1899; Mucugê: MZUSP 76450, Muquém do São Francisco: MZUSP 81536. **Tocantins**. Conceição do Tocantins: MZUSP 84399-401. **Goiás**. Colinas do Sul: MZUSP 74116. **São Paulo**. Avanhandava: MZUSP 4446.

Formicivora rufa. **Pará**. Santana do Araguaia: MZUSP 90073. **Rondônia**. Cerejeiras: MCP 2622. **Rio de Janeiro**. Campos dos Goytacazes: MZUSP 78861; Cardoso Moreira: MZUSP 26906-7. **São Paulo**. Bebedouro: MZUSP 4675; Franca: MZUSP 8021, 8081-2; Itapura: MZUSP 5035; Jaboticabal: MZUSP 1157; Lins: MZUSP 26662-4; Presidente Venceslau: MZUSP 32670; Rincão: MZUSP 1675.

Formicivora serrana. **Minas Gerais**. Almenara: MZUSP 85997; Brumal: MZUSP 85432; Coronel Fabriciano: MZUSP 25243; Marliéria: MZUSP 10385; Poté: MZUSP 87032-3.

APPENDIX 2.

Vocalizations of *Formicivora paludicola* sp. nov. and *F. acutirostris* examined (all recordings from Brazil). Unless stated otherwise, the recordings listed here were obtained by the authors. When recordings were associated with collected specimens, the latter's label number is given in brackets. For each set of recording, general localities are followed by the name of municipalities. Abreviation: XC = recording available at Xeno-Canto collection.

Formicivora paludicola. **São Paulo**. Bairro Rio Acima (23°32'S, 45°05'W), including "Estrada do Rio Acima", municipality of Biritiba-Mirim: loudsong (n = 49 phrases from two or three individuals, recorded by J. C. Minns and A. Whittaker; in Minns *et al.* [2009]; n = 30 phrases from one individual); alarm call (n = 28 calls from one individual); distress call (n = 27 calls from one individual). Córrego Taboão do Parateí (23°24'27"S, 46°13'35"W), municipality of Mogi das Cruzes: loudsong (n = 4 phrases from one individual, recorded by N. Athanas, XC 6432); alarm call (n = 1 calls from one individual, recorded by N. Athanas, XC 6433); distress call (n = 12 calls from one individual, recorded by N. Athanas, XC 6434); aggressive call (n = 39 calls from 3 individuals). Estrada da Casa Grande (23°34'S, 46°00'W), municipality of Biritiba-Mirim: contact call (n = 11 calls from one individual); distress calls (n = 1 call from one individual). Jardim Guanabara (23°22'14"S, 46°09'18"W), municipality of Mogi das Cruzes: aggressive call (n = 9 calls from one individual). Rio Paraitinga (23°31'S, 45°55'W), Barragem do Paraitinga 2, municipality of Salesópolis: loudsong (n = 41 phrases from 2 individuals); alarm call (n = 15 phrases from one individual); contact call (n = 34 calls from 2 individuals); distress call (n = 8 calls from 2 individuals); display call (n = 12 calls from at least 2 individuals); foraging call (n = 6 calls from at least 2 individuals). Sitio Caleb (23°05'S, 46°00'W), municipality of São José dos Campos: distress call (n = 4 calls from one individual).

Formicivora acutirostris. **Paraná**. Jundiaquara Island (25°52'24"S, 48°45'32"W), municipality of Guaratuba: loudsong (n = 87 phrases from 7 individuals, one of them recorded by D. D. Sobotka); alarm call (n = 54 calls from 5 individuals); contact call (n = 13 calls from 3 individuals); display call (n = 10 calls from 2 individuals); foraging call (n = 3 calls from one individual); aggressive call (n = 3 calls from 2 individuals). Rio Claro (25°52'22"S, 48°45'38"W), municipality of Guaratuba: foraging call (n = 18 calls from one individual). Rio São João near the Folharada Island (25°51'26"S, 48°44'19"W), municipality of Guaratuba: distress call (n = 105 calls from 2 individuals). Road from Garuva to the north (25°57'06"S, 48°48'52"W), municipality of Guaratuba: loudsong (n = 30 phrases from one individual, recorded by A. Whittaker, in Minns *et al.* [2009]). **Santa Catarina**. RPPN Volta Velha (26°04'57"S, 48°38'27"W), municipality of Itapoá: loudsong (n = 22 phrases from one individual) (see Minns *et al.* 2009).

APPENDIX 3.

Taxa used in the phylogenetic study, including *Formicivora paludicola* sp. nov., with voucher number and GenBank accession numbers for sequences of the mitochondrial genes cytochrome b (CYB), nicotinamide dehydrogenase subunit 2 (ND2), nicotinamide dehydrogenase subunit 3 (ND3), and the autossomal nuclear intron 5 of β-fibrinogen (βF5). Acronyms: FMNH - Field Museum of Natural History; LSUMZ - Louisiana State University Museum of Natural Sciences; MCP - Museu de Ciências e Tecnologia da Pontifícia, Universidade Católica do Rio Grande do Sul; MZUSP - Museu de Zoologia da Universidade de São Paulo; UWBM - University of Washington Burke Museum.

Specimen	Voucher	Origin	CYB	ND2	ND3	βF5
Myrmotherula brachyura	LSUMZ B4722	Peru: Loreto	EF639973.1	EF640040.1	EF640107.1	---
Myrmotherula longicauda	UWBM DCS5489	Bolivia: Cochabamba	EF639974.1	EF640041.1	EF640108.1	EF639907.1
Myrmotherula axillaris	FMNH 392444	Brazil: Pernambuco	EF639972.1	EF640039.1	EF640106.1	EF639906.1
Formicivora rufa	FMNH 391399	Brazil: Amapá	EF639946.1	EF640013.1	EF640080.1	EF639881.1
*Formicivora acutirostris**	MZUSP 78797	Brazil: Paraná	KJ151919*	KJ151926*	KJ151933*	KJ151940*
*Formicivora acutirostris**	MCP 3138	Brazil: Paraná	KJ151920*	KJ151927*	KJ151934*	KJ151941*
*Formicivora acutirostris**	MCP 3137	Brazil: Paraná	KJ151921*	KJ151928*	KJ151939*	KJ151942*
*Formicivora acutirostris**	feathers	Brazil: Paraná	KJ151922*	KJ151929*	KJ151935*	KJ151943*
*Formicivora paludicola**	MZUSP 85428	Brazil: São Paulo	KJ151923*	KJ151930*	KJ151936*	KJ151944*
*Formicivora paludicola**	MZUSP 85429	Brazil: São Paulo	KJ151924*	KJ151931*	KJ151937*	KJ151945*
*Formicivora paludicola**	MZUSP 78795	Brazil: São Paulo	KJ151925*	KJ151932*	KJ151938*	KJ151946*

* This study.

APPENDIX 4.

Gazetteer of localities of *Formicivora paludicola* (all in the São Paulo state, southeastern Brazil; see Figure 4).

Natural occurrence. **Municipality of Biritiba-Mirim**. Avenida Presidente Castelo Branco com Estrada do Rio Acima (23°32’, 46°06’W); Bairro Rio Acima (23°32’S, 45°05’W); Barragem de Ponte Nova (23°23’S, 46°13’W); Estrada da Casa Grande (23°34’S, 46°00’W). **Municipality of Mogi das Cruzes**. Barragem do Rio Biritiba 1 (23°39’S, 46°06’W); Córrego Taboão do Parateí (23°24’27”S, 46°13’35”W); Jardim Guanabara (23°22’14”S, 46°09’18”W); Jardim Itapeti (23°21’42”S, 46°10’17”W). **On the border of the municipalities of Mogi das Cruzes and Santa Isabel**. Fazenda Taboão (23°23’19”S, 46°14’15”W). **Municipality of Salesópolis**. Barragem do Paraitinga 1 (23°32’S, 45°56’W); Distrito Nossa Senhora dos Remédios (23°31’S, 45°57’W); Rio Paraitinga (23°31’S, 45°55’W), Barragem do Paraitinga 2; Usina da Light Estrada dos Mirandas (23°34’S, 45°49’W). **Municipality of São José dos Campos**. Fazenda Montes Claros (23°04’S, 46°02’W); Sítio Caleb (23°05’S, 46°00’W).

Release sites (from individuals captured in an area to be flooded by a dam [Barragem do Paraitinga 2] and relocated). **Municipality of Biritiba-Mirim**. Barragem de Biritiba Mirim (23°34’S, 46°04’W); Barragem de Ponte Nova (23°34’S, 45°58’W); Barragem do Rio Biritiba 2 (23°35’S, 46°05’W); Pomar do Carmo (23°33’S, 46°01’W). **Municipality of Mogi das Cruzes**. Barragem do Rio Jundiaí / Taiaçupeba (23°39’S, 46°11’W); Cocuera (23°33’S, 46°08’W); Condomínio Toyama (23°31’S, 46°09’W); Kimberly-Clark (23°32’S, 46°09’W); Linhão Vila Oliveira (23°31’S, 46°09’W); Ponte dos Vilares (23°31’S, 46°09’W). **Municipality of Paraibuna**. “Nascente do Tietê” (23°34’S, 45°44’W). **Municipality of Salesópolis**. Barragem do Paraitinga 2 (23°32’S, 45°56’W); Rio Paraitinga a jusante do eixo da Barragem do Paraitinga 2 (23°31’S, 45°57’W); Usina da Light Estrada dos Mirandas (23°34’S, 45°49’W).

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SHORT-COMMUNICATION

Upland Goose *Chloephaga picta* (Anseriformes, Anatidae): first Brazilian record

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ABSTRACT: From April 2012 until at least January 2013, a vagrant male Upland Goose *Chloephaga picta* was observed and photographed at Lagoa do Peixe National Park, on the coastal plain of Rio Grande do Sul, southern Brazil. This is the first record of this species for the country and also the northernmost on its wintering grounds.

KEY-WORDS: sheldgeese, vagrant, migration, Lagoa do Peixe, Rio Grande do Sul.

The five species of sheldgeese of the genus *Chloephaga* are endemic to southern South America and the central Andes. Continental populations of the Upland Goose *Chloephaga picta*, Ashy-headed Goose *C. poliocephala* and Ruddy-headed Goose *C. rubidiceps* are partially or entirely migratory. They breed in southern Patagonia and Tierra del Fuego and winter in northern Patagonia and the southern Pampas of Buenos Aires province, Argentina (Blanco & de la Balze 2006).

The Upland Goose is the most numerous and widespread species of the genus. The mainland subspecies, *C. picta picta*, breeds in Tierra del Fuego and the islands of Cape Horn north through the grasslands of southern Patagonia and along the Andes to the Neuquén province in Argentina and to at least 42°S in Chile (Jaramillo 2003, Blanco *et al.* 2008). The southernmost populations are migratory (Madge & Burn 1989, Jaramillo 2003), with migrants arriving to the main wintering areas in open grasslands of central Chile and Argentina in May (Blanco *et al.* 2008). Wandering birds have rarely been recorded further north, up to near Santiago, Chile, and in the departments of Rocha and Treinta y Tres, Uruguay (Arballo & Cravino 1999, Jaramillo 2003).

Adult males of the nominate race are distinctly dimorphic (Delacour 1974). Some are completely barred black and white on the underparts, while others are predominantly white underneath, with black bars restricted to the flanks. The two color morphs may be found together in almost any locality within the species range, but barred birds predominate in the south and white-breasted ones in the north (Delacour 1950, Madge & Burn 1989).

There are no known records of the Upland Goose for Brazil, although vagrants have been recorded very close to the Brazilian border, *e.g.*, at Laguna Guacha, dpto. Treinta y Tres, Uruguay (Arballo & Cravino 1999). Here we report the first record of this species for Brazil, and also the northernmost on its wintering grounds, based on the observation of a single immature male at Lagoa do Peixe, on the coastal plain of Rio Grande do Sul, southern Brazil.

The bird was discovered by fisherman E. B. dos Santos, who reported its presence at one site in the southern section of the Lagoa do Peixe National Park (LPNP) from April 2012 onwards. On 21 January 2013, members of the LPNP staff R. V. Martins, R. S. dos Santos, F. J. S., L. E. Burgueño and F. S. Weber visited the area and photographed the bird at approximately 31°24'26"S and 51°05'50.5"W, around a small freshwater lagoon in littoral grassy fields just inland of the coastal dunes and not far from the edge of Lagoa do Peixe. The individual was not particularly shy and allowed walking approaches to within 60 m after some habituation. On this occasion and also in previous sightings (E. B. dos Santos *pers. comm.*), the bird was frequently associated with a pair of Southern Screamers *Chauna torquata*. No vocalizations were heard.

The whitish head, the dark legs and the black-and-white barring on the underparts identify the bird as a male of the barred morph (Figure 1). The mottled dark brown instead of pure white rump, the greater wing-coverts mostly dull brown with a very reduced amount of metallic green on the outer feathers, and the neck slightly tinged brownish grey (Figure 1), in turn, indicate it was an immature individual, perhaps in its second year (Delacour 1974, Madge & Burn 1989). In northeastern Argentina, barred-morph birds winter in coastal grasslands, while white-morph ones predominate in inland areas (Madge & Burn 1989). The observation of a bird of the barred morph on the coastal grasslands of Lagoa do Peixe agrees with this pattern.

The date when the bird was first detected at Lagoa do Peixe roughly coincides with the timing of arrival of migrating sheldgeese in their wintering grounds (early May; Lean 2012). It is somewhat strange, however, that this individual failed to migrate and remained in the area through the following breeding season. The bird's immaturity at the time it should start migrating back to the breeding grounds may have been the reason for its failure to migrate.

In view of the lack of evidence of a regular occurrence of the Upland Goose in southern Brazil and adjacent Uruguay, and considering that the record above is supported by photographic evidence, we recommend the species be included in the primary list of Brazilian birds as a southern vagrant (*sensu* CBRO 2011). We propose the Portuguese name *ganso-de-magalhães* for the species, which means "Magellanic Goose", in reference to the main source area of its migratory population.

FIGURE 1: Male Upland Goose *Chloephaga picta* photographed at Lagoa do Peixe, Rio Grande do Sul, southern Brazil, on 21 January 2013 (Photo by F. J. de Souza).

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SHORT-COMMUNICATION

Historical and recent records of the Harpy Eagle (*Harpia harpyja*) in the Cerrado biome of the state of Goiás, Brazil

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ABSTRACT: We report on a historical record of *Harpia harpyja* for the Cerrado biome, in the municipality of Jataí, southwestern Goiás and on a recent record from Cocalzinho (central Goiás) obtained in 2012. There is no current evidence supporting the occurrence of this species in the southern and southwestern portions of the State of Goiás, suggesting that it may be considered regionally extinct there, probably as a result of the extensive deforestation that took place in the region over the last 50 years. The recent Cocalzinho record revealed that at least small isolated populations of *Harpia harpyja* might persist in more densely forested regions of the state.

KEY-WORDS: Cocalzinho; Geographic distribution; forest; Jataí; Range extension.

The Harpy Eagle (*Harpia harpyja*) is the largest species among raptors in the Neotropical region, occurring from southern Mexico to Central and South America (Ferguson-Lees & Christie 2001, Vargas *et al.* 2006). In Brazil, it has been recorded in almost all states, with the exception of a few regions in the northeast, and most of the remaining populations are currently concentrated in the Amazon (Vargas *et al.* 2006). The occurrence of this species became extremely rare in other biomes such as the Atlantic Forest and the Cerrado, where few recent records have been obtained (Hilty & Brown 1986, Galetti *et al.* 1997, Sick 1997, Pacheco *et al.* 2003, Scherer-Neto & Ribas 2004, Silveira *et al.* 2005, Oliveira & Silva 2006, Srbek-Araujo & Chiarello 2006, Aguiar-Silva *et al.* 2012).

One of the rare exceptions with potential for population stability outside of the Amazon is the Atlantic Forest region in southern to Bahia, where multiple individuals have been recorded in recent years (Silveira *et al.* 2005, Srbek-Araújo & Chiarello 2006, ICMBio 2008), and the first release of this species in the wild occurred in Brazil (C. E. A. Carvalho *pers. comm.*). Regions close to southern Bahia such as the municipality of Bandeira, in the state of Minas Gerais, which still present remnants of Ombrophylus Dense Forests, also shelter resident individuals of *Harpia harpyja* (Melo 2004).

This species has been threatened by habitat destruction, hunting, practice of captivity by humans, and natural vulnerability resulting from low population densities and low reproductive rates (Hilty & Brown 1986, Trinca *et al.* 2008). In addition, *Harpia harpyja* is considered as near threatened with extinction (BirdLife International 2013), and it is not protected by specific legislation in Brazil (Pivatto *et al.* 2006). In Brazil, formal protection is only present in states where the species figures in published red lists such as in Minas Gerais and Espírito Santo (Passamani & Mendes 2007, Drummond *et al.* 2008).

Silva (1995) and Sick (1997) report *Harpia harpyja* in the Brazilian Cerrado, and Hidasi (1983) collected specimens in the state of Goiás (municipality of Aragarças), in the decades of 1950 and 1960. Silva (1995) points out that several bird species with occurrence in the Cerrado are dependent on forests, which is the case of the Harpy Eagles, reinforcing the importance of these types of environments for large raptor species. Nevertheless, records of the Harpy Eagle in savannah-like environments exist, despite being scarce, with the latest ones obtained in 2006 (Oliveira & Silva 2006, Zorzin *et al.* 2006).

Herein, we report on a new record of the Harpy Eagle for the Cerrado biome in southwestern Goiás.

One sub-adult specimen of *Harpia harpyja* was hunted down in 1965 in the region known today as "Mata do Suluca" (17º57'S; 51º46'W), a forested area near the municipality of Jataí (Goiás) (Figure 1). This locality is only about 250 km south of Aragarças, where Hidasi (1983) collected specimens around the same time when the Jataí bird was shot. The Jataí bird was shot with a firearm and not consumed as food. It is not possible to establish the exact reasons for this kill because the people involved have passed away. It is known that some potential Harpy Eagle preys still live in this area such as coatis (*Nasua nasua*), Capuchin monkeys (*Cebus libidinosus*), baby deers (*Mazama* spp.), armadillos (*Dasypus* spp., *Cabassous unicinctus*, and *Euphractus sexcinctus*), Red-legged seriemas (*Cariama cristata*), Bare-faced curassows (*Crax fasciolata*), and Rusty-margined guans (*Penelope superciliaris*). There is no evidence of occurrence of sloths (*Bradypus* spp. and *Choloepus* spp.) in this region regardless of these animals being considered one of the favorite Harpy Eagle preys in tropical forests (Galetti & Carvalho Jr. 2000, Touchton *et al.* 2002).

Our hypothesis is that Harpy Eagles were present in the past in southwestern Goiás based on the past predominant presence in this region of phytophysiognomies that are typical of Seasonal Deciduous and Semi-deciduous forests (Veloso *et al.* 1991, Oliveira-Filho & Ratter 2002, Scariot & Seville 2005, Sano *et al.* 2008). However, these forests practically no longer exist, except for the presence of forest remnants such as in the municipality of Jataí. Oliveira-Filho & Ratter (2002) point out that 40,000 km^2 of these two forest typologies were decimated before the consolidation of modern agriculture in the Cerrado region. In early 2000s, it was possible to go through more than 1,400 km between Goiás and Tocantins passing through about 50% of forest stretches originally known as "Mato Grosso de Goiás" (Oliveira-Filho & Ratter 2002). Nowadays, these forests are almost completely decimated as the result of the level of deforestation practiced and reached in Goiás (Carvalho *et al.* 2009); few significant areas remained untouched, in portions of isolated hills, in south-central Goiás. Because of the degree of fragmentation in the area, it is unlikely that this forest typology could hold a minimal Harpy Eagle population.

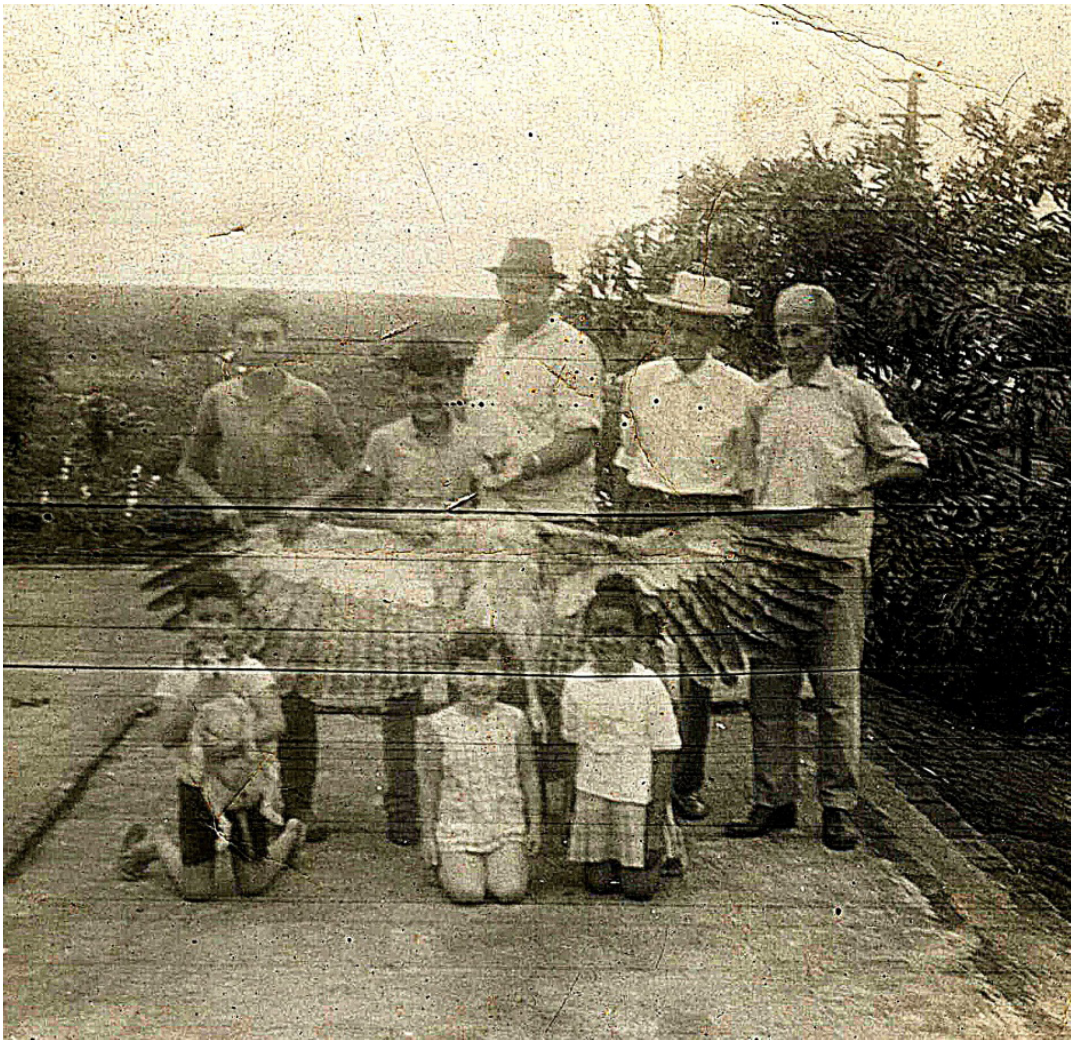

FIGURE 1. Sub-adult individual of a Harpy Eagle (*Harpia harpyja*) photographed in 1965 after being hunted near the municipality of Jataí, Goiás. Photo taken by: Izaltino Gonçalves Guimarães *in memorian*.

The historical record reported herein contributes to a better understanding of the Harpy Eagle's distribution and knowledge on the past avifauna of the state of Goiás. The Harpy Eagle is considered a good indicator of little disturbed ecosystems (Albuquerque 1995), however, with the Cerrado destruction and advancement of agriculture and farming, Harpy Eagle populations that inhabited this region in the past were likely extinct. Nevertheless, one recent report in Goiás revealed that even small isolated populations might persist in more densely forested regions. In 2012, one adult female was shot with a firearm ("cartucheira"), captured by the Forest Police Battalion in the city of Cocalzinho, in the central region of Goiás state (15°46'10"W; 48°46'10"S), and taken to the Screening Center for Wild Animals (CETAS) at the Brazilian Institute for the Environment and Natural Resources (IBAMA), located in Goiânia. This Harpy Eagle was examined by a veterinary team, treated to recover, and will probably be released when ready to re-enter its natural habitat. The reason for this shooting is unknown (L. C. F. da Silva *pers. comm.*). This recent record is extremely important because it is the most recent confirmation of the presence of this species in the state of Goiás. Furthermore, it indicates that this region and probably also the northern part of the state, might be hosting small Harpy Eagle populations, and hence can be regarded as priority areas for scientific research on this species.

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SUMÁRIO / CONTENTS

ARTIGOS / PAPERS

NOTAS / SHORT-COMMUNICATIONS

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9 770103 565003