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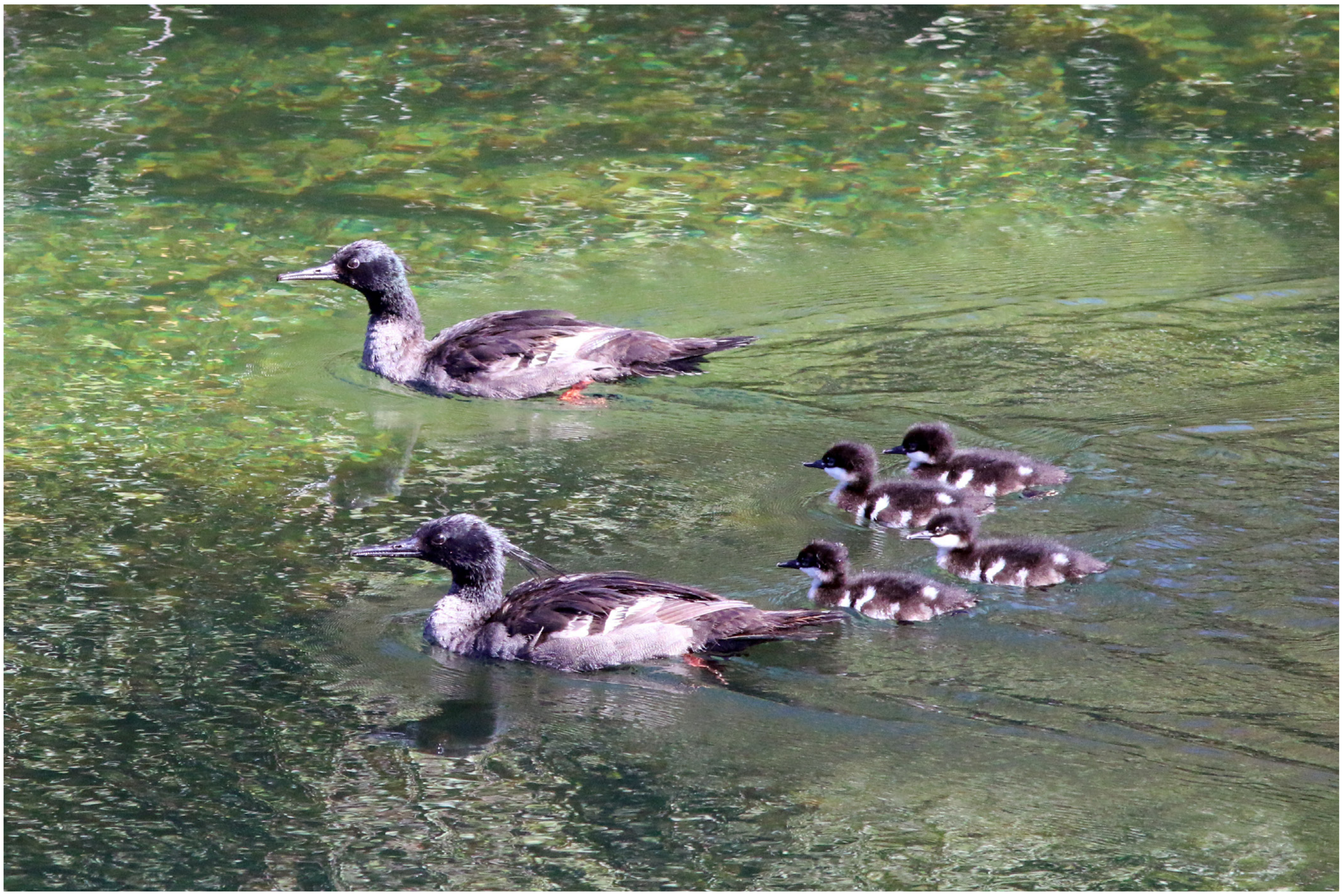

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Capa: Casal com filhotes do pato-mergulhão (*Mergus octosetaceus*) nadando juntos nas águas claras da região da Serra da Canastra-MG, Brasil. Nesse volume, Barbosa *et al.,* reportam para a região do Jalapão, Estado do Tocantins, estimativas populacionais e dados sobre seleção de habitat desta população disjunta do pato-mergulhão, uma espécie criticamente ameaçada de extinção. Foto: Sávio Freire Bruno.

Cover:.Pair and nestlings of Brazilian Merganser (*Mergus octosetaceus*) swimming together on the clear waters in the region of Serra da Canastra-MG, Brazil. In this volume, Barbosa *et al.,* present population and habitat selection data for a disjunct population of this critically endangered species from the Jalapão region, state of Tocantins. Photo: Sávio Freire Bruno.

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ARTICLE

The Purplish Jay rides wild ungulates to pick food

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ABSTRACT: Corvids are renowned for their variable foraging behaviour, and about 20 species in eight genera perch on wild and domestic ungulates to pick ticks on the body of these mammals. Herein I illustrate and briefly comment on the Purplish Jay (*Cyanocorax cyanomelas*) riding deer and tapir in the Pantanal, Western Brazil. The jay perched on the head or back of the ungulates and searched for ticks, playing the role of a cleaner bird. Deer are rarely reported as hosts or clients of tick-picking birds in the Neotropics. The Purplish Jay is the southernmost Neotropical cleaner corvid reported to date. Given their opportunistic foraging behaviour, a few other *Cyanocorax* jay species may occasionally play the cleaner role of wild and domestic ungulates.

KEY-WORDS: *Cyanocorax cyanomelas*, foraging, cleaning behaviour, Pantanal, Western Brazil.

INTRODUCTION

Corvids are renowned for their variable foraging behaviour, and about 20 species in eight genera ride wild and domestic ungulates to pick ticks, scabs, and other organic matter on the body of these mammals (Sazima 2011). In an overview of tick-removing birds in Brazil (Sazima 2007), I suggested that species of the genus *Cyanocorax* would be occasional parasite cleaners of wild large herbivores or domestic livestock.

METHODS

To test my supposition on the cleaner role of *Cyanocorax* jays, I searched for photos of these corvids perched on wild ungulates in photo archives online and found three substantiated records of the Purplish Jay (*Cyanocorax cyanomelas*) perched on such ungulates. Herein I illustrate this jay perched on deer and tapir in the Pantanal, Western Brazil, and briefly comment on its role as a cleaner bird of these two ungulates, based on the photographic records and correspondence with two colleagues (see Acknowledgements).

RESULTS

A Purplish Jay was recorded searching for ticks on a Gray Brocket Deer (*Mazama gouazoubira*) on 25 October 2014 at 16:52 h at the Pouso Alegre Lodge (16°30'37"S, 56°44'13"W, 120 m a.s.l.), in the north Pantanal of Poconé, Mato Grosso, Western Brazil. The jay perched on the deer's head and picked ticks (and possibly scabs and other organic substances) from within the ears (Figure 1). During the inspection and pecking, the deer appeared oblivious to the bird's behaviour (B. P. S. Campos Neto, pers. comm.). Another record of this jay species was made with a camera trap on 23 November 2011 at 07:25 h in central Pantanal (about 19°17'S, 55°43'W, 130 m a.s.l.), northwest of Campo Grande, Mato Grosso do Sul, Western Brazil. The jay perched on the head of a South American Tapir (*Tapirus terrestris*) resting on an excavation made by the Giant Armadillo (*Priodontes maximus*) (Desbiez & Kluyber 2013). The bird appeared alert (Figure 2) and presumably searched for ticks, scabs and organic substances near or within the ears of the tapir. The last record I found of the Purplish Jay on wild ungulates was made on 09 September 2010 at the Pouso Alegre Lodge (16°30'37"S, 56°44'13"W, 120 m a.s.l.), in the north Pantanal near Poconé, Mato Grosso, Western Brazil. The bird also rode a brocket deer, identified on the photo as the larger Marsh Deer (*Blastocerus dichotomus*) (Murphy 2010). The jay was perched on the back of the deer and, besides presumably searching for ticks, it also appeared to scan the surroundings for prey flushed by the foraging activity of the mammal.

FIGURE 1. A Purplish Jay (*Cyanocorax cyanomelas*) picks ticks, and possibly scabs, from the ears of a Gray Brocket Deer (*Mazama gouazoubira*) in the Pantanal, Western Brazil. Photo: Benedito Pio da Silva Campos Neto.

FIGURE 2. A Purplish Jay (*Cyanocorax cyanomelas*) searches for food on the head of a South American Tapir (*Tapirus terrestris*) in the Pantanal, Western Brazil. Photo: Projeto Tatu Canastra Pantanal.

DISCUSSION

The three records presented herein leave no doubt that the Purplish Jay plays the role of a cleaner bird and support my assumption that a *Cyanocorax* species picks ticks on wild herbivores, including ungulates (Sazima 2007). Besides ticks, scabs, wounded tissue and other organic matter are additional food sources available on the clients of cleaning birds (Sazima & Sazima 2010). The bird perching on the head and back of deer (and tapir as well) agrees with the behaviour of several other corvid species that clean ungulates (Sazima 2011). The jay inspecting the deer's head, picking food especially from the ears, and the apparent indifference or confidence of these ungulates to cleaning are behaviours already reported for this interaction type with corvids (Dixon 1944, Isenhart & DeSante 1985; photos in Sazima 2011). The Purplish Jay adds to the list of cleaner birds of the tapir (Peres 1996, Sazima & Sazima 2010).

Neotropical deer are rarely reported as clients of tick-picking birds (Peres 1996), and the two records of the brocket deer add this cervid type to the list of wild ungulates attended by birds. I suspect that additional deer species will be reported as clients of the Purplish Jay, including the Marsh Deer and the Pampas Deer (*Ozotocerus bezoarticus*), as both these deer species occur in the Pantanal (Tomas 1995, Tomas *et al.* 2001, IS pers. obs.). Deer seem to be important clients of tick-picking corvids in the Nearctic, Palaearctic, and even Indomalayan realms (Sazima 2011). If my supposition of the Marsh and Pampas Deer as clients of the Purplish Jay holds true, then the importance of deer to Neotropical tick-picking birds will increase. Natural history-oriented studies or photographic records (as used here) would strengthen or invalidate my suggestion.

The Western Scrub Jay (*Aphelocoma californica*) is the northernmost tick-picking bird in the Neotropics (Sazima & Sazima 2010), and the Purplish Jay stands as the southernmost cleaning New World corvid. As the latter bird's distribution reaches Argentina (Anjos 2009), it may extend its cleaning role further southwards. Given the opportunistic foraging behaviour of *Cyanocorax* jays, I would expect additional species may occasionally play the cleaner role for wild and domestic ungulates. A potential candidate is the Plush-crested Jay (*Cyanocorax chysops*), which may forage on the ground and sometimes flocks together with the Purplish Jay in the Pantanal (Sazima 2007, Anjos 2009, Gwynne *et al.* 2010).

The Brown Jay (*Psilorhinus morio*) was recently recorded picking moths from the fur of the Three-toed Sloth (*Bradypus variegatus*) in Costa Rica (Neam 2015). This record supports another suggestion I made about jays as cleaners, namely, that these birds may glean parasites from arboreal mammals such as sloths (Sazima 2007). Additionally, this latter record and the present paper strengthen the postulation that birds mostly clean medium-sized to large herbivores (Sazima & Sazima 2010, Sazima 2011).

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Distribution and natural history of the mangrove-dwelling Gray-necked Wood-Rail, *Aramides cajaneus avicenniae* Stotz, 1992, in southeastern Brazil

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ABSTRACT: We revise the distribution and habitat associations of *Aramides cajaneus avicenniae*, a localised Brazilian form of the widespread Gray-necked Wood-Rail, and provide data on its foraging and breeding behaviors. This rail is a mangrove specialist endemic to the coastal belt from São Paulo to Santa Catarina, with some insular populations off the northern coast of São Paulo. Crabs, especially *Uca* spp., are the main prey in mangroves while island birds feed on large ground-dwelling arthropods and scavenge fish dropped by seabirds. Breeding is tied to the rainy season and nests found in mangrove sites were built with twigs and leaves on trees overhanging rivers and tidal channels and had 1-6 eggs.

KEY-WORDS: Gray-necked Wood-Rail, *Aramides cajaneus avicenniae*, breeding biology, distribution, eggs, foraging, São Paulo state, Brazil.

INTRODUCTION

The Gray-necked Wood-Rail *Aramides cajaneus* occurs in many different habitats, usually near water, from sea-level to 2,000m, from southeastern Mexico through Central America and into South America, from southwestern Ecuador and eastern Peru, to the east across Brazil and south to northern Argentina and Uruguay, with nine recognized subspecies (Taylor 1998).

Although it is considered the commonest large rail in Brazil, with a wide distribution in swamps with dense vegetation, mangroves, river margins, lakes, tall swampy forests, rice fields, and sugarcane plantations throughout the country (Sick 1997), its biology remains poorly known (Taylor 1998). As Rallidae are usually secretive and rarely seen, few detailed studies have been made on most Neotropical species, and even the nest and eggs of some taxa remain undescribed (Ripley 1977, Taylor 1998).

The same is true for the Gray-necked Wood-Rail, with most of the available data coming from captive birds (Ripley 1977), from semi-tamed individuals living around a house (Skutch 1994) and from birds in an urban park in the municipality of Rio de Janeiro (Teixeira 1981). In Brazil, the only additional information was gathered by Johann Natterer, who collected two downy young at Barra do Rio Negro, Amazonas, on 20 October 1832 (NMW.38454 and 38455; Pelzeln 1871, E. Bauernfeind pers. comm.). Also in the Amazon, near Belém, Stone (1928) mentions "three nests found, two containing three eggs each and the other an addled egg" between February and May 1926 (Stone 1928). On Santa Catarina Island, Naka & Rodrigues (2000) recorded one adult followed by two young on 10 November 1997.

Two subspecies occur in Brazil, the nominate form *Aramides cajaneus cajaneus*, found throughout the country in habitats as different as the Pantanal, the Caatinga and the Amazon, and *A. c. avicenniae*, described only recently and apparently restricted to the mangrove swamps of the southern coast of São Paulo, Paraná and, possibly, Santa Catarina states (Stotz 1992, Bornschein & Reinert 1996, Taylor 1998). *Aramides cajaneus avicenniae* is distinguished by its gray occiput with a reduced or absent brown wash (blackish to brownish in nominate), plumbeous color from nape to back (olive in the nominate) and cinnamon underparts (richer rufous in the nominate; Figure 1).

Along the coast of São Paulo state, the Gray-necked Wood-Rail is found in some of the islands dotting the coast from 0.88 to 38 km from shore, including Búzios, Vitória, Alcatrazes (specimens in MZUSP, sight records at Búzios and Alcatrazes by FO), Palmas, Comprida, Rapada, Pesca, and Couves (Vieitas 1995). Specimens from the northern São Paulo coast, and offshore islands

(Vitória, Búzios and Alcatrazes) have been considered as intermediates between the nominate form and *avicenniae* (Stotz 1992). There are records dating from the 1960's from another island, São Sebastião (Ilhabela), where rails were not recorded in the early 1990's by Olmos (1996) but have been documented later (Silva 2007).

Here we review the distribution and habitat preferences of this taxon and present the first data on breeding biology, food habits and general ecology of this species in coastal São Paulo, as well on its distribution.

FIGURE 1. Gray-necked Wood-Rail specimens at Museu de Zoologia da Universidade de São Paulo, subspecies *avicenniae* (2 above, MZUSP 78725 and MZUSP 67212 holotype), and nominate form (2 bellow, MZUSP 74282 from Niquelândia-GO and MZUSP 32926 from Pau Grande-ES). Photo: Robson Silva e Silva.

METHODS

We recorded the presence of the Gray-necked Wood-Rail especially from its characteristic voice, during a medium-term study of the bird fauna of the mangrove swamps of Santos-Cubatão, in the central coast of São Paulo (Olmos & Silva e Silva 2001) and in several trips to the mangroves of the southern coast between Iguape and Cananéia. Data on wood-rails were gathered between March 1994 and February 2003 during 259 field trips to Santos and Cubatão and seven to the southern coast, including areas in Iguape, Ilha Comprida and Cananéia, including Ilha do Cardoso.

These two mangrove systems are the most extensive in São Paulo state (Lamparelli 1998), and 145 km apart in a straight line. The mangroves grow along river and channels of the coastal plain of São Paulo, bounded westwards by the Serra do Mar massif. While most of the lowland forests ("restinga" forests) on the plains have been lost to agriculture, urban expansion and industrial development, the Serra do Mar and associated hills remain mostly covered by forest in different sucessional stages. We also visited a few smaller areas of mangroves between both systems at Itanhaém (Rio Itanhaém and Rio Preto), Estação Ecológica Juréia-Itatins at Peruíbe (Rio Guaraú and Rio Una) and Iguape (Rio Verde), but with little success in getting more than site records of the species.

Channels and rivers crossing the mangroves were explored with small boats with an outboard motor while we searched for wood-rails and their nests, especially in smaller channels less than 10 m wide. Behavioural data were recorded *ad libitum*. When a nest was located we recorded its position with a GPS and measured its dimensions and height with rulers and a measuring tape. Eggs and hatchlings were measured with a caliper and weighed with a Pesola spring scale.

Additionally, we examined specimens housed at Museu de Zoologia da Universidade de São Paulo (MZUSP), Brazil, and American Museum of Natural History (AMNH), New York, USA and photographic records stored at Wikiaves (http://www.wikiaves.org).

RESULTS AND DISCUSSION

Distribution

Specimens collected at the islands of Búzios, Vitória and Alcatrazes (Table 1) were considered intermediate between nominate *cajaneus* and *avicenniae* by Stotz (1992), although their bluish mantles look closer to *avicenniae* and are considered as so here. Birds photographed in Bertioga (Souza 2010) and Ilhabela (Silva 2007) show the plumbeous/bluish mantle of *avicenniae*, while birds recorded at São Sebastião and Ubatuba, further up the coast, show green mantles typical of nominate birds (Cardoso 2013, Cisneros 2013).

Further down the coast, observations and photos of living birds in the mangroves of Santos-Cubatão (Figure 2) showed a color pattern agreeing with *avicenniae*, with plain gray crowns lacking a brown tinge, plumbeous (not greenish) backs and pale rufous to cinnamon underparts. This and four specimens from Santos and Cubatão (Table 1) confirm that birds there belong to *avicenniae*.

Besides Santos-Cubatão, we found *avicenniae* in the mangroves along the southern coast of São Paulo, at Iguape (including the well-known collecting locality of Icapara), Ilha Comprida and Cananéia (including Ilha do Cardoso), the same region where most specimens, including the holotype, came from (Stotz 1992). Farther south in Paraná state, Johann Natterer collected specimens (now in the Naturhistorisches Museum Wien, and Natural History Museum, Tring) in 1820 at Rio do Borraxudo and Rio da Villa, Paranaguá (Pelzeln 1871, Straube 1993; Table 1).

Also in Paraná, Bornschein & Reinert (1996) confirmed the presence of *avicenniae* in Caiobá-Passagem, municipality of Guaratuba, with a specimen now at Museu de História Natural Capão da Imbuia, Curitiba. Towards the edge of mangrove distribution in Brazil, Bangs (1907) and Stotz (1992) mention one specimen at the USNM from Santa Catarina matching *avicenniae* and Rosário (1996) and Naka & Rodrigues (2000) mention the species occurring in mangroves.

The presence of *avicenniae* in that state is confirmed by photos from São Francisco do Sul (Cremer & Grose 2010) and Florianópolis (Licco 2010, Serrão 2012).

The data show the subspecies has a fairly small range along the narrow coastal area between Bertioga and Ilhabela (aprox. 23°50'S), São Paulo, in the north, and Florianópolis (about 27°40'S), Santa Catarina, in the south. Since birds along the coast of Rio Grande do Sul have green backs, the contact zone between them and *avicenniae* must be somewhere south of Florianópolis.

TABLE 1. Specimens of *Aramides cajaneus avicenniae* and intermediates.
Collections: **BMNH** (British Museum of Natural History, Tring, UK); **LACM** (Los Angeles County Museum of Natural History, Los Angeles, USA); **MCZ** (Museum of Comparative Zoology, Harvard University, Cambridge, USA); **MHNCI** (Museu de História Natural Capão da Imbuia, Curitiba, Brazil); **MNHN** (Museum National d' Histoire Naturelle, Paris, France); **MZUSP** (Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil); **NMW** (Nathurhitorisches Museum Wien, Wien, Austria); **USNM** (United States National Museum, Washington, USA).
State: **PR** (Paraná); **SC** (Santa Catarina); **SP** (São Paulo).

Collection	Number	Date	Locality	State	Sex	Collector	Remarks
NMW	**38446**	23 Dec 1820	Rio de Borraxudo, Guaraqueçaba	PR	F	Johann Natterer	
NMW	**38447**	28 Dec 1820	Rio de Borraxudo, Guaraqueçaba	PR	M	Johann Natterer	
NMW	**38448**	13 Dec 1820	Rio da Villa, Paranaguá	PR	M	Johann Natterer	
BMNH	**89.11.20.57**	24 Dec 1820	Rio de Borraxudo, Guaraqueçaba	PR	F	Johann Natterer	
USNM	**24124**	?	?	SC	?	Lemuel Wells	
MHNCI	**187**	?	Caiobá-Passagem, Guaratuba	PR	F	?	
MZUSP	**14967**	20 Aug 1934	Cachoeirinha, Cananéia	SP	M	Carlos Otaviano da Cunha Vieira	
MZUSP	**14968**	1 Sep 1934	Tabatinguara, Cananéia	SP	F	Eurico Alves de Camargo	
MZUSP	**14969**	1 Sep 1934	Morrete, Cananéia	SP	F?	Eurico Alves de Camargo	
MZUSP	**14970**	1 Sep 1934	Morrete, Cananéia	SP	M	Eurico Alves de Camargo	
MZUSP	**14971**	28 Sep 1934	Tabatinguara, Cananéia	SP	M	Eurico Alves de Camargo	
MZUSP	**67212**	13 Jul 1969	Iguape	SP	M	Alfonso Maria Olalla	Holotype
MZUSP	**67213**	13 Jul 1969	Iguape	SP	F	Alfonso Maria Olalla	
MZUSP	**66527**	11 Jul 1970	Icapara, Iguape	SP	?	Alfonso Maria Olalla	
MZUSP	**68386**	11 Jul 1970	Icapara, Iguape	SP	M	Alfonso Maria Olalla	
MZUSP	**69411**	11 May 1969	Barra de Icapara, Iguape	SP	M	Alfonso Maria Olalla	
MZUSP	**70639**	4 Sep 1991	Rio Cachoeira Grande, Ilha do Cardoso, Cananéia	SP	F	Paulo Martuscelli	
MZUSP	**73724**	Oct 1994	Ilha do Cardoso, Cananéia	SP	?	Paulo Martuscelli	
MZUSP	**78725**	5 Jul 2007	Rio Sândi, Santos	SP	F	Robson Silva e Silva	
MZUSP	**91802**	31 Dec 2010	Cubatão	SP	M	Luís Fábio Silveira	
MZUSP	**99605**	7 Apr 2014	Canal Piaçaguera, Cubatão	SP	M	Luís Fábio Silveira	
MZUSP	**99606**	7 Apr 2014	Canal Piaçaguera, Cubatão	SP	F	Luís Fábio Silveira	
MNHN	**1971.301**	Jul/Aug 1970	Icapara, Iguape	SP	M	Alfonso Maria Olalla	
MNHN	**1971.302**	Jul/Aug 1970	Icapara, Iguape	SP	M	Alfonso Maria Olalla	
MNHN	**1971.303**	Jul/Aug 1970	Icapara, Iguape	SP	M	Alfonso Maria Olalla	
MNHN	**1971.304**	Jul/Aug 1970	Icapara, Iguape	SP	F	Alfonso Maria Olalla	

Collection	Number	Date	Locality	State	Sex	Collector	Remarks
MNHN	**1971.305**	Jul/Aug 1970	Icapara, Iguape	SP	F	Alfonso Maria Olalla	
MNHN	**1971.306**	Jul/Aug 1970	Icapara, Iguape	SP	F	Alfonso Maria Olalla	
MNHN	**1971.307**	Jul/Aug 1970	Icapara, Iguape	SP	F	Alfonso Maria Olalla	
MCZ	**177528**	1 Sep 1934	Morrete, Cananéia	SP	M	Eurico Alves de Camargo	
MCZ	**177529**	1 Sep 1934	Morrete, Cananéia	SP	M	Eurico Alves de Camargo	
MCZ	**177530**	1 Sep 1934	Morrete, Cananéia	SP	M	Eurico Alves de Camargo	
LACM	**28678**	1946	Rio da Avó, São Vicente	SP	F	José Leonardo Lima	
MZUSP	**63644**	21 Oct 1963	Ilha dos Búzios	SP	F	Mzusp expedition	Intermediate
MZUSP	**63645**	18 Oct 1963	Ilha dos Búzios	SP	F	Mzusp expedition	Intermediate
MZUSP	**63646**	20 Oct 1963	Ilha dos Búzios	SP	M	Mzusp expedition	Intermediate
MZUSP	**63647**	21 Oct 1963	Ilha dos Búzios	SP	M	Mzusp expedition	Intermediate
MZUSP	**63648**	20 Oct 1963	Ilha dos Búzios	SP	M	Mzusp expedition	Intermediate
MZUSP	**63947**	27 Oct 1963	Ilha dos Búzios	SP	F	Mzusp expedition	Intermediate
MZUSP	**6574**	12 Jul 1906	Ilha Vitória	SP	F	Francisco Günther	Intermediate
MZUSP	**5550**	Mar 1905	Ubatuba	SP	F	Ernst Garbe	Intermediate
MZUSP	**10492**	Oct 1920	Ilha Alcatrazes	SP	F	José Pinto da Fonseca	Intermediate
MZUSP	**10493**	Oct 1920	Ilha Alcatrazes	SP	M	José Pinto da Fonseca	Intermediate

FIGURE 2. Adult Gray-necked Wood-Rail at low tide in the mangroves of Canal Piaçaguera, Cubatão-SP, on 1 April 2014. Photo: Robson Silva e Silva.

Habitat

Alcatrazes Island has no permanent human occupation and lacks perennial watercourses. It is a mosaic of forests dominated by the palm *Syagrus rommanzoffiana*, exposed rocks covered by bromeliads and cacti and grassy areas resulting from man-made fires. Along four trips to Alcatrazes in 1992-93, FO found pairs or family groups of Gray-necked Wood-Rail throughout the island wherever there was denser vegetation, especially along ditch lines. Palmas, Comprida, Rapada, Pesca and Couves are small islands where rails have been recorded and show a drier vegetation, while at Ilha do Mar Virado, which has a flat area with swampy forest ("caixetal", dominated by the tree *Tabebuia cassinoides*) it is among the commonest birds (Vieitas 1995).

Both Búzios and Vitória have been long inhabited by artisanal fishermen ("caiçaras") who have destroyed large areas of the original forest and reportedly caused water resources in Vitória to dwindle to a single spring. During two trips to Búzios in 1993-94, FO found forest limited to an obviously secondary patch on the steep southern face of the island, which lacks running water, the remainder being covered by grass, young second-growth, manioc and bean fields and orchards. A pair of Gray-necked Wood-Rails was sighted in the forest remnant in 1994.

Island populations of Gray-necked Wood-Rails can be described as a forest ground bird able to live in areas where water is limited to a few springs dripping from rocks and where there are no perennial creeks or swampy areas.

This situation contrasts with the mainland. In Santos-Cubatão it is by far the commonest rail in the mangrove swamps, living in mangrove forests dominated by *Rhizophora mangle*, *Avicennia schaueriana* and *Laguncularia racemosa* reaching 12 m high. The same is true in southern São Paulo, where in the belt between Iguape and Cananéia it is easily found in mangrove forests, foraging on mudflats during the low tide.

Gray-necked Wood-Rails living in coastal São Paulo are also found in transitional areas between the mangroves and restinga forests, but are replaced on the lower slopes of the Serra do Mar massif by the Slaty-breasted Wood-Rail (*Aramides saracura*) (Olmos & Silva e Silva 2001). The possibility of competitive exclusion between the species leading to habitat segregation deserves further research.

Foraging behavior

The first data on food habits of *A. c. avicenniae* in the mangroves came from specimens taken by Natterer in Paraná and described by Pelzeln (1871): "Paranagua between mangroves on the bank of Rio da Villa in December, Rio do Borraxudo between mangroves in December,... lives on crabs (R. Borraxudo)..." (translated by E. Bauernfeind).

We witnessed the same behavior several times in the mangroves between Iguape and Cananéia, at Ilha do Cardoso and in the mudflats along Canal de Ararapira, where several birds, mostly in pairs, foraged for small crabs. Rails foraging along mudflats are a common sight in the Iguape-Cananéia mangroves along the sheltered mangroves of the Mar de Dentro and along smaller rivers such as the Sorocabinha.

The situation is different in the mangroves of Santos-Cubatão, where rails are rarely seem foraging in the open mudflats and keep close to the vegetation. Rails were seen foraging for the many small Fiddler Crabs (*Uca rapax*, *U. mordax, U. leptodactyla,* and *U. uruguensis*) (Figure 3), snails *Melampus coffeus* and *Littorina* sp. and, once, a dead Blue Crab *Callinectes danae* taken by a pair of rails into the mangrove forest. Rails are a common presence in mixed nesting colonies of Little Blue Herons (*Egretta caerulea*), Snowy Egrets (*E. thula)*, Scarlet Ibises (*Eudocimus ruber*), Yellow-crowned Night-herons (*Nyctanassa violacea*), Black-crowned Night-herons (*Nycticorax nycticorax*) and Great Egret (*Ardea alba*) scattered in the area where the rails forage for fallen regurgitates, fallen eggs and nestlings. Once we saw them feeding among young Little Blue Herons foraging on the mud exposed below their nests during low tide.

At Alcatrazes Island, where there is a large colony of Magnificent Frigatebirds (*Fregata magnificens*) nesting on trees and bushes, rails have been seen scavenging for fallen regurgitates. It is likely they will also feed on fallen eggs and nestlings. Alcatrazes and most coastal islands off São Paulo have large populations of big ground-dwelling roaches *Hormetica scrobiculata*, centipedes *Otostigmus* sp. and spiders (mainly the wolfspider *Ctenus medius* and the tarantula *Vitalius wacketi*). It is probable those provide the main prey for rails together with the local frogs and lizards, some of them endemic. For a description of the island and its biota see Mercadante & Moura (2006) and Muscat *et al.* (2014).

FIGURE 3. Feeding on a Fiddler Crab (*Uca* cf. *leptodactyla*), at Rio Cascalho mangroves, Cubatão-SP, on 15 April 2011. Photo: Robson Silva e Silva.

Breeding Behavior

The observations suggest that the rails tie their nesting to the rainy season (see Table 2), which in the region starts in late September-early October. This agrees with the nesting of several other waterbirds (Olmos & Silva e Silva 2001) and may be due to increased prey availability, including small crabs recruiting at this season.

We first recorded nesting by *A. c. avicenniae* at Cananéia, when a nest with an incubating adult was found on a mangrove tree leaning over a narrow tidal channel (Figure 4). Since then, we found another 20 nests (see Table 2 for details and localities). The nest is a high bowl of twigs and intertwined leaves, with a leaf-covered chamber. It is usually built on the leaning branches of a mangrove tree over water, commonly using a parasitic Loranthaceae bush as camouflage and support. One pair was also seen carrying nesting material to an unfinished nest at the Rio Quilombo on December 2000.

Clutches had 1-6 eggs (Figure 5) (mode = 5), with a mean of 3.4. Nests found with only 1 egg probably had incomplete clutches. 27 eggs from 10 nests measured 49.4±1.7 mm (52.22 to 45.5 mm) x 35.6±0.7 mm (36.6 to 34 mm) and weighted 32.9±2.3 g (36.5 to 26.5 g), and do not seem to differ from published measurements of other subspecies (Taylor 1998). The eggs were oblong, creamy or whitish with brown to cinnamon spots. Five just-hatched young were found on their nest in Cananéia on 8 January 1998. They weighted 23.6±0.9 g (23 to 25 g), had culmens 11.26±1.2 mm long (9.5 to 12 mm) and tarsi 20.44±2.1 mm (17.2 to 22.5 mm) (Figure 6).

Besides nests, we recorded a pair of adults together with five young with 1/3 of the adult size foraging under a heron colony in the Rio Saboó, Santos; another pair with five ¾ grown young in Cubatão in October 1997 and one adult followed by one young in washed plumage on 22 November 2000.

Predation seems an important factor accounting for nest failures, but we could not identify predators. Crab-eating Raccoons *Procyon cancrivorus* are common throughout the visited areas and are likely predators. The strategy of building nests on thin trees tilted over rivers and channels is a likely deterrent for terrestrial predators.

Gray-necked Wood-Rails in coastal southeast Brazil seem to be less generalist compared to their cospecifics elsewhere, and more restricted in their habitat choices (Taylor 1998). Nevertheless, their success in colonizing coastal islands and becoming locally common invites further research on their ecology in this specific habitat and on their interactions with prey species quite unlike the ones found in their preferred mangroves on the mainland.

FIGURE 4. Adult incubating at nest # 02. Mangroves of Cananéia-SP, on 8 January 1998. Photo: Robson Silva e Silva.

TABLE 2. Nests characteristics of *Aramides cajaneus avicenniae* found in mangroves of São Paulo. Measurements are in centimetres, except for nest height measured from the water surface, in meters.
Tree species: A – *Avicennia schaueriana*; L – *Laguncularia racemosa*; R – *Rhizophora mangle*
Content: E – egg; C – chick

Nest	Date	Locality	Coordinates	Lenght	Width	Heigth	Depth	Height from Water	Tree Species	Content
01	12 Jan 1995	Rio Quilombo, Santos	23°52'44''S, 46°21'05''W	-	-	-	-	1.2	R	1E
02	7 Jan 1998	Cananéia	24°53'00''S, 47°49'30''W	36	22	17	7	2.2	L	2E + 3C
03	2 Nov 1998	Rio Saboó, Santos	23°55'28''S, 46°20'52''W	33	26	21	6	1.7	A	3E
04	13 Jan 1999	Cananéia	24°52'36''S, 47°48'23''W	-	-	-	-	2.3	L	1E
05	17 Dec 1999	Icapara, Iguape	24°41'54''S, 47°31'25''W	27	13	10	5	1	L	5E
06	17 Dec 1999	Icapara, Iguape	24°41'50''S, 47°31'22''W	23	21	12	3	1.5	L	5E
07	9 Nov 2000	Rio Quilombo, Santos	23°52'52''S, 46°21'07''W	26	28	22	5	3.3	R	6E
08	16 Nov 2000	Rio Quilombo, Santos	23°52'36''S, 46°21'05''W	31	24	16	4	3.5	A	1E
09	16 Nov 2000	Rio Quilombo, Santos	23°53'07''S, 46°21'37''W	29	25	22	5	2.2	R	1E
10	27 Nov 2000	Rio Morrão, Santos	23°52'36''S, 46°21'35''W	40	24	11	5	2.3	R	5E
11	29 Nov 2000	Rio Quilombo, Santos	23°52'41''S, 46°21'22''W	-	-	-	-	2.4	R	0
12	9 Jan 2003	Iguape	24°42'59''S, 47°33'28''W	34	29	19	7	0.9	L	0
13	9 Jan 2003	Iguape	24°42'11''S, 47°31'36''W	27	25	15	5	1.1	L	0
14	9 Jan 2003	Iguape	24°42'11''S, 47°31'27''W	32	31	13	6	0.8	L	0
15	9 Jan 2003	Iguape	24°42'11''S, 47°31'27''W	31	24	12	6	2.3	L	0
16	9 Jan 2003	Iguape	24°42'13''S, 47°31'23''W	32	31	12	4	0.7	L	0
17	9 Jan 2003	Iguape	24°42'13''S, 47°31'23''W	32	31	14	5	1.3	L	0
18	9 Jan 2003	Iguape	24°41'52''S, 47°31'08''W	36	26	15	4	1.7	L	0
19	9 Jan 2003	Iguape	24°41'43''S, 47°28'48''W	38	26	20	8	0.9	L	0
20	9 Jan 2003	Rio Sorocabinha, Iguape	24°44'13''S, 47°35'43''W	39	25	22	-	2.1	L	0

FIGURE 5. Nest # 03 at Rio Saboó, Santos-SP, on 9 November 1998. Photo: Robson Silva e Silva.

FIGURE 6. Just-hatched young (nest # 02), Cananéia-SP, on 8 January 1998. Photo: Robson Silva e Silva.

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ARTICLE

Molina's Hog-nosed Skunk as prey of the Great Horned Owl: predation or opportunist scavenging?

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ABSTRACT: This note reports the observation of an adult Great Horned Owl (*Bubo virginianus*) holding a Molina's Hog-nosed Skunk (*Conepatus chinga*) in its claws. We assumed that it is a case of opportunistic predation because the skunk is larger than this owl's regular preys. However, we could not exclude the possibility of opportunistic scavenging, despite this being an uncommon behavior for the Great Horned Owl. This is the first report of a Molina's Hog-nosed Skunk preyed by a Great Horned Owl, an unusually large prey to an owl that preys mainly upon small mammals (*e.g.* rodents). Also, it is an uncommon report of consumption of mammal carnivores by owls in South America.

KEY-WORDS: *Bubo virginianus*, Brazil, *Conepatus chinga*, raptor, South America.

INTRODUCTION

Mammals are a common prey of raptors. Small mammals are the main prey of several raptors and some large raptors prey upon medium-sized mammals (Ferguson-Lees & Christie 2001, König & Weick 2008). Despite of that, there are not many examples of raptors preying upon carnivores (Jaksic & Marti 1984, Teta *et al.* 2008). Here we report the consumption of Molina's Hog-nosed Skunk (*Conepatus chinga*: Carnivora) by a Great Horned Owl (*Bubo virginianus*: Strigiformes). This is the first documented report of a Molina's Hog-nosed Skunk as prey of a Great Horned Owl.

METHODS

The record occurred at the Estação Experimental Agronômica (EEA/UFRGS) (30°5'41"S; 51°40'21"W) in Eldorado do Sul, Rio Grande do Sul, Brazil. The EEA/UFRGS is a 1,580 ha property of the Universidade Federal do Rio Grande do Sul (UFRGS). Vegetation is dominated by grasslands and patches of crops (used for scientific purposes), surrounded by degraded riverine forests. The landscape is a mosaic of degraded grasslands, crops, urban areas, riverine forests and exotic tree stands (*Eucalyptus* spp., *Pinus* spp.).

RESULTS

On 11 January 2014, around 09:00h, one of the authors (JA) observed an adult Great Horned Owl perched on a eucalyptus tree at around 6 m above the ground. About 30 min later, he returned to that place to photograph the owl and noticed a pungent smell, characteristic of a distressed Molina's Hog-nosed Skunk. About 20 m away he located the Great Horned Owl perched on a eucalyptus with a skunk in it claws (Figure 1). The skunk appeared to be an adult (although not a large one) based on its size compared to the owl. The skunk seemed to have died recently (the hair was still bright and the wounds looked fresh).

DISCUSSION

The Great Horned Owl is a large predator (45 to 60 cm, North American subspecies up to 2.5 kg, South American subspecies up to 1.2 kg) distributed from Alaska to Northeast Argentina, except in dense rainforest, such as the core of Amazon region (König & Weick 2008). Widespread in several kind of habitat, in South America it has been associated to open habitats with scattered trees. Although it is one of the most studied owl species of South America (Bó *et al.* 2007), most of the work about Great

FIGURE 1. An adult Great Horned Owl holding a dead, partially eaten Molina's Hog-nosed Skunk.

Horned Owl is about the Magellanic Horned Owl (*Bubo magellanicus*) (Bó *et al.* 2007), former subspecies of Great Horned Owl. However, both species (hereafter Horned Owls) appeared to be very similar in size and ecology, and we can assume that diet and foraging behavior are also similar.

The Magellanic and Great Horned owls are generalist predators, which prey mainly upon small mammals (rodents, lagomorphs and marsupials) (Donázar *et al.* 1997, Teta *et al.* 2001, Cromrich *et al.* 2002, Tomazzoni *et al.*2004, Nabte *et al.* 2006, Bó *et al.* 2007, Formoso *et al.* 2012). The mean weight of the prey varies according to region, but is usually between 30.6 – 189.1g (Formoso *et al.* 2012 and references therein). The Molina's Hog-nosed Skunk, even a juvenile one, is an unusually large prey to Horned owls. It is a medium-sized carnivore, weighting about 1.62 kg (females) and 2.32 kg (males) in south Brazil (Kasper 2011). Despite the horned owls' wide range of prey sizes, most of its preys weight less than 300 g (Donázar *et al.* 1997, Cromrich *et al.* 2002, Nabte *et al.* 2006). Even their largest preys, the introduced European Hares (*Lepus europeus*; 2-7 kg), are usually juveniles weighing less than 1 kg (Donázar *et al.* 1997, Teta *et al.* 2001, Nabte *et al.* 2006).

Predation of carnivores by *Bubo* owls are common in Europe, where the larger Eurasian Eagle Owl (*Bubo bubo*) preys upon Red Foxes (*Vulpes vulpes*; 8 kg), European Wildcats (*Felis* cf. *silvestris*; 7.5 kg), and Least Weasels (*Mustela nivalis*, 100 g) (Jaksic & Marti 1984). However, it is a much larger owl, weighting around 1.9 kg (up to 4.2 kg), almost twice as heavy as South American horned owls (ca. 1.2 kg; Jaksic & Marti 1984, König & Weick 2008). There are also a few records of carnivore predation by the Great Horned Owl in the USA, including skunks: 1) Long-tailed Weasel (*Mustela frenata*; 178 g); 2) Eastern-spotted Skunk (*Spilogales putorius*; 727 g); 3) Red Fox (*Vulpes vulpes*; 8 kg), and 4) American Hog-nosed Skunk (*Conepatus leuconotus*; 1.1 – 4.5 kg) (Jaksic & Marti 1984, Dragoo & Sheffield 2009). In South America, as far as we know, the only record of carnivore predation by a horned owl is *Galictis cuja* in Argentina (Massoia *et al.* 1993 *apud* Teta *et al.* 2008), and a Molina's Hog-nosed Skunk (*Conepatus chinga*) in South Brazil (unpublished record; F. Peters *in litt.*). The horned owl also preys upon other, diurnal raptors (*e.g. Milvago chimango, Falco sparverius, Rostrhamus sociabilis*) (Donázar *et al.* 1997, Teta *et al.* 2001, Tomazzoni *et al.* 2004).

Molina's Hog-nosed Skunk is prey to other large raptors, like the Black-chested Buzzard-Eagle (*G. melanoleucus*) (Hiraldo *et al.* 1995) and the Crowned Eagle (*Buteogallus coronatus*) (Sarasola *et al.* 2010), as well as mammal carnivores such as the Puma (*Puma concolor*)

(Pacheco *et al.* 2004). Molina's Hog-nosed Skunk is relatively common at EEA/UFRGS (G. Iob *in litt.*) and, by the characteristics of our record, we assume that it was an event of predation that took place in the 30 min interval between the first and second observations. Our assumption is based on the time elapsed between our two observations (before and after the owl have caught the skunk), the abundance of skunks in the area (G. Iob *in litt.*) and the rarity of scavenging behavior in owls (Smallwood *et al.* 2010, Allen & Taylor 2013).

However, we cannot discard the possibility of a scavenging event. Carcasses consumption by horned owls is rather uncommon, being reported by Smallwood *et al.* (2010) only once during a carcass removal experiment. We cannot confirm that the Great Horned Owl preyed on the skunk, because we did not witness the event of predation. Also, the BR290, an intense traffic road, is around 1.5 km away from the place where the record occurred and could be a hunting site of this owl (Great Horned Owl home range = 163 to 460 ha; Bennett & Bloom 2005).

In view of these different scenarios, we suggest two possibilities: 1) the predation of Molina's Hog-nosed Skunk as an alternative prey for the Great Horned Owl and as an opportunistic kill; 2) a scavenging behavior by Great Horned Owl. The first scenario would be a case of opportunistic predation of an unusual prey, as an alternative prey when the main preys are scarce (Sergio & Hiraldo 2008). The second scenario would represent a risky strategy for feeding, since road kills are one of the major threats to owls (Motta-Junior *et al.* in press). In both cases, further study of horned owls' diet, with both sample (pellets or gut contents) and observational analyses, is necessary to better understand the extent to which the Great Horned Owl preys upon skunks in South America.

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ARTICLE

Dangerous traps: Anhingas mistake anthropogenic debris for prey fish at an urban site in South-eastern Brazil

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ABSTRACT: Impacts of anthropogenic inedible debris on seabirds have been well documented, but on inland waterbirds this kind of pollution remains poorly recorded. Herein we report 21 instances of inedible objects stuck in the bill of Anhinga (*Anhinga anhinga*), a fish-eating waterbird which has the cutting edges of the mandible serrated. Disturbance and harm by pieces of plastic, rope, and cotton stuck in the bill were recorded. Debris caused drag and prevented the birds from fishing. Birds with small pieces of material stuck on their bills were still able to fish, but their hunting success decreased. When the debris was large and stuck on the bill for long, the birds possibly starved and some of them died. The time spent to clean up the bill was related to the type of material, ranging from 1 to 17 days. Our records illustrate the deleterious effect that anthropogenic debris has on the life of a Neotropical aquatic inland bird.

KEY-WORDS: Anhingidae, anthropogenic pollution, deleterious effects, foraging impairment.

INTRODUCTION

Anthropogenic debris is a worldwide problem for wildlife and its deleterious effect on seabirds and shorebirds that take the debris as food has been well documented (*e.g.* Azzarello & Van Vleet 1987, Avery-Gomm *et al.* 2013, Donnelly-Greenan *et al.* 2014). However, this pollution type effect is rarely reported for inland waterbirds (*e.g.* Peris 2003, Booth 2011, Henry *et al.* 2011, Sazima & D'Angelo 2015). This difference is possibly due to the general awareness of garbage pollution in the oceans when compared with such pollution type in inland waters (*e.g.*, Booth 2011). Aside from being taken as food, anthropogenic debris cause waterbirds to entangle on plastic pieces and other materials (Waller *et al.* 2012, Corbo *et al.* 2013, Ryan 2013). Pollution by rubbish should be a concern for bird conservationists, particularly in the neglected tropical areas.

Darters and Anhingas (Anhingidae) dwell in a wide variety of inland waters, including lakes, ponds, slow-moving rivers, marshes and swamps. They forage underwater, swimming slowly with the neck held in a kink ready to dart the bill forward to spear prey with one or both mandibles, which have serrations pointing backwards on distal edges (Orta 1992, Frederick & Siegel-Causey 2000). The only record we found of Anhingidae entangled with anthropogenic material is a brief mention of an African Darter (*Anhinga rufa*) with its bill enmeshed in a clump of steel wool in South Africa (Ryan 2013). Herein we report and comment on the disturbance and harm anthropogenic materials caused to a small population of Anhingas (*Anhinga anhinga*) at an urban site in South-eastern Brazil.

METHODS

We observed the Anhingas at the "Parque Ecológico Prof. Hermógenes de Freitas Leitão Filho" (22°48'42"S, 47°04'21"W; Campinas, São Paulo, South-eastern Brazil). This mainly recreational park is surrounded by residential quarters and buildings of a local university (see a map in D'Angelo 2014). The park has a total area of 0.13 km^2, of which about 75 % is occupied by a large pond (0.1 km^2) surrounded by native and exotic vegetation composed of trees, bushes and grass patches. The pond is bordered by a sandy path about 1.5 km long used by people for walking, running, and promenading. Two playgrounds, three kiosks, several benches and tables, as well as wastebaskets along the path accentuate the recreational nature of the site. There are two rainwater and occasional sewage discharges at one side of the park, whose drifting rubbish flow is partly restrained by floating barriers of absorbent material. One of the discharges created a pool that was a favoured fishing site for several waterbirds, as it concentrated small fish that fed on detritus (D'Angelo & Sazima 2014).

Our records were made between August 2010 and February 2015, covering most of the months of the year, but November and December, both in the morning and in the afternoon. We observed the Anhingas with bare eye and through a 70-300 mm telephoto lens mounted on a camera from a distance of 3-15 m. Anhinga sexes are easily distinguished: males are black with silvery to white streaks and spots on upper back, scapulars, and wing-coverts, whereas females are duller with head, neck, and breast buffy; juveniles of both sexes are similar to adult females, but browner overall and lack most of the white marks on upperparts (Orta 1992, Frederick & Siegel-Causey 2000). Some individuals with anthropogenic debris impaled on bill were recognised by natural marks or site attachment (see Sazima & D'Angelo 2012). Throughout the observational sessions, we used the "*ad libitum*" and "sequence" samplings (Altmann 1974), which are adequate to record fortuitous or rare events. The anthropogenic materials carried by the Anhingas were identified visually or assessed from samples collected on the pond bank. The size of these materials was assessed against the bill length (culmen) by enlarging the digital photos to actual bill measurements taken from 10 museum specimens (5 males = 90-95 mm, 5 females = 85-88 mm) and measuring the debris with a flexible scale directly on the screen. Voucher digital photographs of the Anhingas with anthropogenic material impaled on bill are on file at the Museu de Zoologia da Universidade Estadual de Campinas (ZUEC).

RESULTS

The number of Anhinga individuals we recorded at a given time in the park never surpassed six, including

FIGURE 1. Anhingas (*Anhinga anhinga*) with impaled prey and anthropogenic debris stuck on bill. An adult male surfaces with a Tilapia (*Coptodon rendalli*) impaled on bill (a); a juvenile male swimming with a piece of cotton impaled on bill – note similarity of shape and general colour of the debris and a fish prey, besides the carrying posture of the bird (b); a juvenile male perches to release a piece of plastic stuck on bill (c); a juvenile female with a small piece of rope stuck on bill perches with an impaled Tilapia to free the prey and swallow it (d); an adult female with a large piece of worn-out and tangled rope perches to shake and dip the debris in an attempt to free the bill (e); the same female perches and pull a large piece of rope attempting to free the bill (f). After about 2-3 weeks, with the rope still attached on bill, this individual died.

nestlings or juveniles (Sazima & D'Angelo 2012). The birds habitually foraged close to the banks and, after a successful hunting dive, the birds surfaced with a fish impaled on bill (Figure 1a). The prey was released from the serrated bill with vigorous horizontal shaking of the head, sometimes accompanied by opening and closing of the bill. After release, the fish was flipped in the air and swallowed, a habitual behaviour for this bird (Orta 1992, Frederick & Siegel-Causey 2000, Corbo *et al.* 2013).

We recorded 21 examples of anthropogenic objects impaled on bill of 10 adult females, 3 adult males, and 8 juveniles. The objects varied from threads to ropes, including cloth pieces and cotton wastes (Figures 1b-c, e-f). The size of these objects varied from 1-3 cm (worn-out threads, cotton wastes) to 50-70 cm (worn-out and tangled cloths, ropes).

The Anhingas tried to release the debris with movements similar to those they use to free stabbed prey (Figures 1b-c). The birds shook the debris, dipped it and shook again, at times thrashing the object against the water surface. When the debris was large, the birds sought a perch where, besides shaking the debris vigorously, they scrubbed it against branches (Figures 1e-f). This scrubbing wounded the softer parts of bill, mostly at its base.

The birds managed to free most of the debris from bill in 17 out of 21 instances in 1-8 days after spending effort and time (several rounds up to 30 min), although small pieces or threads of worn-out debris remained stuck for 10-17 days. A male was able to free its bill from a large piece of woven plastic in 1 day (Figure 1 c). Another individual was recorded free of a small and worn-out debris piece after 10 days (Figures 2 e-f). From all debris

FIGURE 2. Anhingas (*Anhinga anhinga*) with anthropogenic debris stuck on bill and freed of it. An adult female with a cloth piece entangled on both mandibles tries to open the bill wide (a); the same individual just missed a stabbed fish prey that it was unable to hold and swallow (b); a juvenile male with a cotton waste stuck on bill pursued by a dominant female that dived (yellow asterisk on upper left) to surface next to the chased bird (c); the same male, with completely soaked plumage takes flight to evade the pursuer bird (d); an adult female with a natural mark (scar) behind the eye still carries a small piece of worn-out debris stuck on mandible (e) and free of the debris 10 days latter (f).

we found impaled on the bill of the Anhingas, ropes were fatal to two adult females. One of them carried a rope about 70 cm long for 2-3 weeks before dying (Figure 1f). An adult male with a tangled cotton waste about 40 cm long totally enmeshed around its bill died after about 1-2 weeks, and an adult female with both mandibles entangled by a piece of cloth (Figures 2 a-b) also died after about 1-2 weeks. We were unable to retrieve the dead birds due to the deep layer of mud on the bottom of the pond and the dense scrubs the Anhingas perch on.

Small pieces did not prevent the birds from fishing (Figure 1d), but their hunting success decreased. An individual recorded in two occasions at the same site for 30 min had a foraging success of 0.2 fish per min without debris on bill, but it dropped to 0.07 fish per min after impaling a piece of rope about 10 cm long. When debris was wrapped on both mandibles, the birds were unable to fish (Figures 2 a-b). Sometimes a bird carried more than one type of debris, perhaps caused by entanglement of other types of objects on the initially impaled debris.

Besides being troubled with debris impaled on bill, an additional trouble could occur due to the territorial behaviour of Anhingas while fishing. We recorded one juvenile male with cotton waste impaled on bill pursued by a dominant female (Figure 2c), the chase ending when the pursued bird took flight (Figure 2d).

DISCUSSION

Anthropogenic objects stuck to bill of Anhingas are related to the foraging behaviour of these birds, which probably mistake waterborne debris for their prey. For instance, cotton wastes or worn-out and tangled cloths may seem a fish to Anhingas foraging in translucent or turbid waters. Due to this probable mistake, the fishing birds stab the objects, which remain stuck on bill because of the fine serrations pointed backwards (Orta 1992, Frederick & Siegel-Causey 2000). The serrations, which preclude prey fish to free themselves from the bill, become a major trouble when debris is impaled instead of fish. There are records of waterbirds such as White Storks (*Ciconia ciconia*) in France that ingest rubber bands while foraging in rubbish dumps, possibly mistaking the bands for earthworms (Henry *et al.* 2011). Additionally, at the same site we studied the Anhingas, we recorded Wood Storks (*Mycteria americana*) handling and ingesting pliable plastic cable pieces that they likely mistook for elongate fish or snake prey (Sazima & D'Angelo 2015). However, the most similar mistake to that we recorded for Anhingas occurs with sea turtles that ingest floating plastic debris instead of jellyfish (Mrosovsky *et al.* 2008, Schuyler *et al.* 2013). In a few cases, however, accidental debris entangling cannot be completely ruled out, as Anhingas occasionally begin a dive with semi open bill (our pers. obs.).

The effort Anhingas invest to free the impaled debris is a waste of time and energy, and may hurt the birds while they scrub the bill against branches. Additionally, large objects cause drag to swimming and diving Anhingas. Drag also disturbs feeding effort and decreases its success, even when the debris is small, due to the spearing technique employed by Anhingas (Orta 1992, Frederick & Siegel-Causey 2000).The ropes are a case apart among the anthropogenic objects in the pond, because the two instances we recorded with this type of debris resulted in death of the individuals that impaled a knot at the end of the rope. A knot is the bulkiest part of the rope and would be targeted by Anhingas as a fish prey.

Anthropogenic objects and their risk to underwater hunting birds include an instance of an African Darter with a clump of steel wool enmeshed on the bill in South Africa, briefly mentioned by Ryan (2013). This instance is the most similar situation to that we present here for the Anhinga. At sites frequented by fishers in the USA, entanglement with monofilament line and ingestion of hooks and fishing gear by Anhingas would be a threat, but there are no quantitative data (Frederick & Siegel-Causey 2000). Enmeshing the bill with an anthropogenic object invariably results in death by starvation, according to Ryan (2013). We were unable to find obvious indications of Anhingas starving in our study, as these birds have a slender built that makes such kind of checking a difficult task. However, starving to death was possible in the cases of the two females that impaled a rope, one male with bill enmeshed in a large cotton waste, and the female that had the two mandibles tied by a cloth piece. Besides starvation, they could become exhausted and drowned. Thus, anthropogenic debris caused the death of four individuals, a heavy toll for the small number of Anhingas that dwell (or dwelt) in the park.

At this study site, adult Anhinga females hold hunting territories, with one of them dominant (Sazima & D'Angelo 2012) and reproductively active, outnumbering males by 2:1 (our pers. obs.). The death of an adult male negatively affects the reproductive cycle of Anhingas at the studied area until the arrival of a new male and its mating with the dominant female, which may delay reproduction in the pond for 2-3 years (our pers. obs.).Thus, besides affecting foraging activities, the anthropogenic debris stabbed by Anhingas may affect their reproductive cycle as well.

Clearly, anthropogenic waterborne debris is a hazard for Anhingas and other waterbirds such as Wood Storks in the park (present paper, Sazima & D'Angelo 2015). We suspect that most of this debris reaches the pond via the sewage and rainwater discharges. A gravel sieve-like device mounted on the outlets would catch the waterborne rubbish and lessen this problem in the pond. This sieve should be periodically cleaned to prevent clogging. However, the "Anhinga problem" at the pond seems to have no end due to the generalised bad custom to discard waste everywhere.

The Anhinga may be regarded as an environmental indicator (*sensu* Sekercioglu 2006) of some types of anthropogenic debris at our study site. Waterborne inedible rubbish negatively affect foraging and may hamper the breeding of small or range-restricted populations. We suggest that additional observational studies will reveal that the type of accident we described herein occurs in others habitats in which Anhingas forage in, and that are polluted by anthropogenic inedible debris. As almost nothing is known about the survivorship of the Anhinga, which is a long-lived bird that may reach about 10-15 years and has few predators (Orta 1992, Frederick & Siegel-Causey 2000), the hazard caused by anthropogenic objects deserves particular attention by conservationists and wildlife officials.

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ARTICLE

The return of the Scarlet Ibis: first breeding event in southern Brazil after local extinction

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ABSTRACT: Here we describe the first breeding event of the Scarlet Ibis (*Eudocimus ruber*) in southern Brazil after a long period of local extinction. The species reproduced in a mixed colony on Jarivatuba Island, a mangrove area in Babitonga Bay, northern Santa Catarina. During the breeding season, between August 2011 and March 2012, regular surveys were carried out in the area with a powerboat to collect basic information on the species breeding. The first adult was recorded in November 2011, along with a group of White-faced ibises (*Plegadis chihi*) that was nesting at the same site. In January 2012, the local Scarlet ibises displayed reproductive behavior, with adults in incubation position in the nests. The first chicks were recorded on January 20, 2012. In March 2012, there were few adults in the colony, and juveniles were recorded in flight groups, including some outside the colony. Although there is no on-site housing, the region is very disturbed, with industries and marinas nearby, and it suffers from the discharge of domestic and industrial effluents. The creation of a local protected area would be an adquate long-term strategy for the conservation of the Scarlet Ibis and this ecosystem.

KEY-WORDS: Colony, *Eudocimus ruber*, mangrove, Santa Catarina State.

INTRODUCTION

The Scarlet Ibis, *Eudocimus ruber* (Linnaeus, 1758) is considered one of the prettiest birds on the planet (Sick 1997, Silva and Silva 2007). It inhabits mostly the coastal mangroves and wetlands in northern South America, in countries such as Colombia, Venezuela, Trinidad and Tobago, Suriname and Guyana (Olmos & Silva and Silva 2003). In Brazil, there are populations in the northern region (Amapá, Pará and Maranhão states), in the northeast (Piauí, Ceará and Bahia states) and the other is in the south-southeast region (Rio de Janeiro, São Paulo, Paraná and Santa Catarina states) (Teixeira *et al.* 1990; Olmos & Silva and Silva 2003, Lima *et al.* 2007, WikiAves 2015). The south-southeast population of the Scarlet Ibis has suffered a great decline in numbers and disappeared from many places in the last decades (Sick 1997). There are no documented and satisfactory explanations about the causes of local extinctions (Teixeira *et al.* 1990), but the most likely reasons are believed to be the collecting of eggs and feathers, capture of chicks and adults, and the destruction of mangrove areas (Sick 1997,Gonçalves *et al.* 2010).

The last records of the Scarlet Ibis in Santa Catarina State were in 1712 and 1763 in Florianópolis, and in 1820 and 1858 in Urussanga and Palhoça (Rosario 1996). Afterwards, there were no further records, and the species was considered virtually extinct in Santa Catarina (Rosario 1996,Naka & Rodrigues 2000). Recent and occasional records of the species in the north of the state (Wasilewski *et al.* 2008) led it to be included in the list of threatened fauna of Santa Catarina in the category "critically endangered" (Consema 2011).

In Babitonga Bay, on the north coast of Santa Catarina, field work directed to the study of waterbirds was conducted between 2005 and 2009, but the species was never recorded (Cremer & Grose 2010). An interesting historical record made by Henderson (1821) indicates that the species was abundant in the region: "The whole of these rivers generally run tamely between low banks, of marshy nature, abounding with considerable number of the beautiful scarlet guara bird, which delight the eye of navigators."

Research involving breeding aspects of the Scarlet Ibis in mangrove areas in Brazil was carried out at a breeding colony on Cajual Island, Maranhão State (Rodrigues 1995; Hass *et al.* 1999; Martinez & Rodrigues 1999), and in great detail in the mangroves of Santos-Cubatão, in São

Paulo State (Olmos & Silva and Silva 2001, 2003, Olmos 2003, Silva and Silva 2007). Both colonies suffered from the pressures of poaching, collecting of eggs and chicks and habitat degradation. This human interference can put in danger the reproduction of the species, leading adults to change or abandon the colony (Rodrigues 1995, Hass *et al.* 1999, Martinez & Rodrigues 1999, Olmos & Silva and Silva 2003, Gonçalves *et al.* 2010).

Here we describe the first breeding event of the Scarlet Ibis in southern Brazil after a long period of local extinction. More precisely, breeding records were made on Jarivatuba Island, in the Babitonga Bay estuary, northern Santa Catarina State.

METHODS

Study Area

Jarivatuba Island (26°29'66.45"S and 48°79'58.14"W) is near the mouth of the Cachoeira River, and near Joinville city (Figure 1), in Babitonga Bay. The island has an area of approximately 136,645 m² and was recently formed by the growth of mangrove trees. There is no human settlement on the island, probably due to the muddy and unconsolidated soil. The mangrove forest in this region is mainly composed of black mangrove (*Avicennia shaueriana*) and white mangrove (*Laguncularia racemosa*) (Ibama 1998, Dornelles *et al.* 2006). The salinity of the surface water in the vicinity of the breeding colony varies from 17 to 22 ‰ (Oliveira *et al.* 2006). Nearby there is a large foundry as well as the Joinville Yacht Club and small marinas. The island is situated next to a navigation channel that leads to the marinas in Joinville city.

The Babitonga Bay estuary has an area of 160 km². It is surrounded by the cities of São Francisco do Sul, Araquari, Barra do Sul, Itapoá, Garuva and Joinville. The climate is characterized as super-humid, according to the Thornthwaite classification (Gaplan 1986), and the average annual rainfall is around 2.265 mm (Gonçalves *et al.* 2006). High tide is about 2 m during spring season (Cremer 2006).

The largest bird colony in Babitonga Bay is located in Jarivatuba Island (Fink 2013). Besides the Scarlet Ibis, five species of Ardeidae breed in the area (Black-crowned Night-heron, *Nycticorax nycticorax;* Yellow-crowned Night-heron, *Nyctanassa violacea*; Cattle Egret, *Bubulcus ibis;* Snowy Egret, *Egretha thula*; and Little Blue Heron, *E. caerulea*), and one species of the family Threskiornithidae, the White-faced Ibis, *Plegladis chihi*.

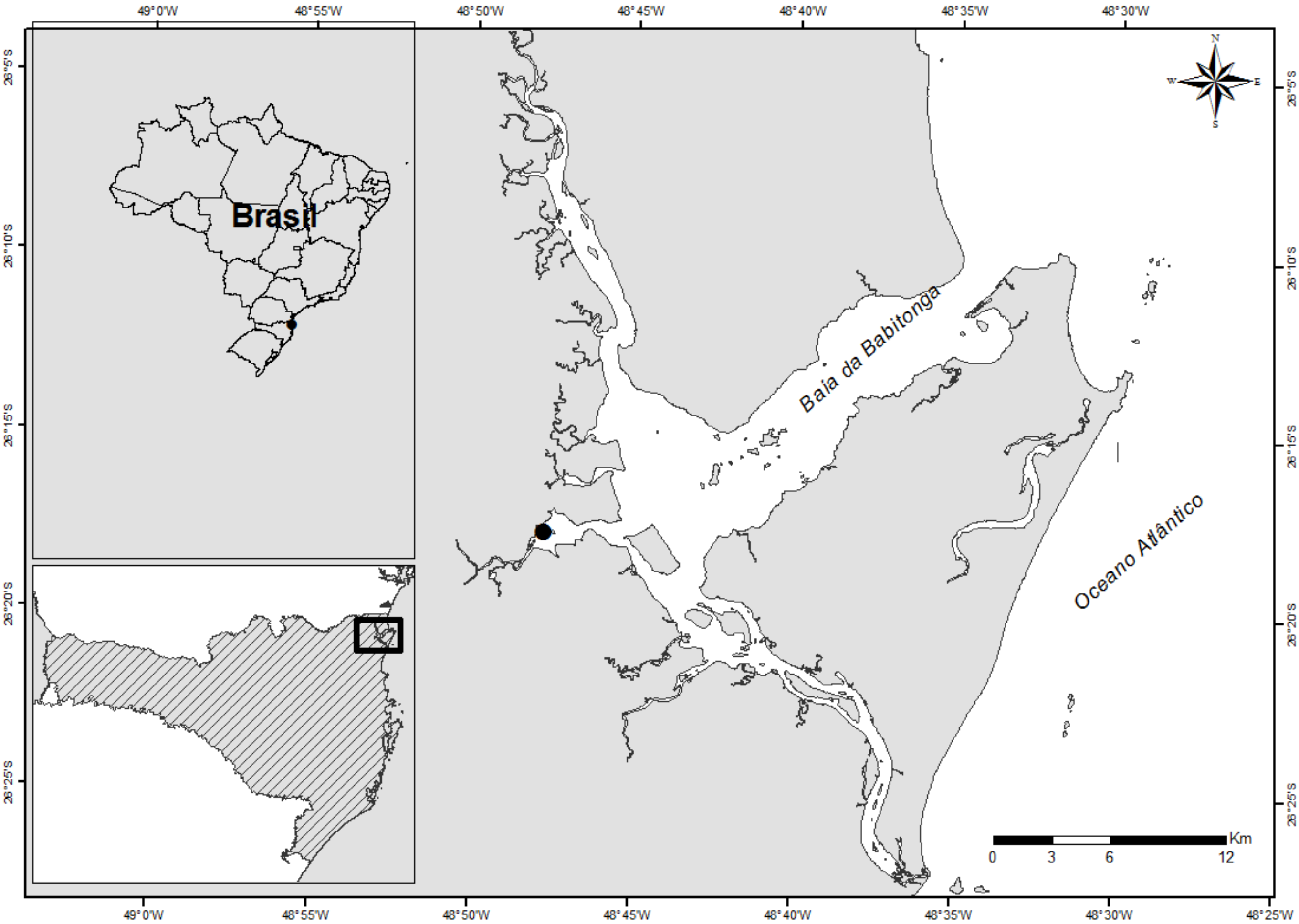

FIGURE 1. Localization of Jarivatuba Island, in Babitonga Bay, Joinville, Santa Catarina State.

Data Collection

Between August 2011 and March 2012, excursions were made fortnightly to Jarivatuba Island to record the waterbirds that nest, rest and feed in the area. Observations were made in a 5,5 m long boat with a 15 or 60 hp outboard motor, always during high tide, when it was possible to cross the channels inside the island. During each survey when reproductive groups of the Scarlet Ibis were sighted, their geographic positions were recorded, along with the number of adults, nests and chicks, besides behavioral information and physical characteristics related to the reproductive period (Olmos & Silva and Silva 2003). Binoculars 8x42 were used during observations.

Since this is a wary bird (Rodrigues 1995, Sick 1997), which responds quickly to any type of disturbance (Olmos & Silva and Silva 2003), and considering that this was the first reproductive event of the species at this site, we decided not to perform any type of interference other than observing (*e.g.*, tagging or collecting biological samples). The observations were conducted no closer than 5 m from the nests.

RESULTS

Eighteen surveys were done in the breeding colony of Jarivatuba Island. The Scarlet Ibis was present in 11 surveys, totaling 25 hours of direct observations of the species.

The first Scarlet Ibis was recorded at the site on November 4, 2011. It was an adult flying with a group of White-faced Ibises, a species that was present in the colony since October in reproductive activity (Table 1).

TABLE 1. Date, number of adults and chicks and characteristics of Scarlet ibises recorded on Jarivatuba Island, Joinville, SC.

Date	Number of adults	Number of chicks	Observations
Nov/04/2011	1	0	First adult, flying over the breeding colony with *Plegadis chihi*.
Nov/17/2011	1	0	Adult, flying over the breeding colony with *P. chihi*.
Dec/06/2011	6	0	Adults, flying over the colony.
Dec/13/2011	50	0	Collective flocks of adults, some individuals displaying: opening of wings and cleaning.
Dec/20/2011	30	0	Presence of reproductive characteristics in adults: gular pouch, black bill and intense red feathers.
Jan/05/2012	71	0	Five reproductive nuclei (set of nests). Some adults in incubation position in the nests.
Jan/20/2012	52	0	Chicks with few days of life, showing thin and black fuzz. 28 nests recorded.
Feb/01/2012	52	25	Chicks with fuzz and black claws at the tip of the wings. 26 nests recorded.
Feb/17/2012	26	35	Chicks with gray fuzz and white bellies making small flights.
Mar/06/2012	8	47	Chicks gray with fuzzy white bellies, performing flights with some adults. Chicks aggregated in nurseries.
Mar/20/2012	27	39	Chicks gray with fuzzy white bellies fliying with some adults. Chicks aggregated in nurseries.

Scarlet ibises selected the site for reproduction in early December, when many adults formed collective flocks in the colony. The birds established the colony in late December, after the end of the reproductive cycle of the White-faced Ibis. The Scarlet Ibis had only one breeding pulse. When recorded for the first time, this species already had bright red plumage and a black beak, a typical reproductive characteristic (Olmos & Silva and Silva 2003).

Five Scarlet Ibis reproductive nuclei (set of nests) were recorded on Jarivatuba Island; four were located in the central region of the island and one on the edge (Figure 2). Two other nests were built individually. The nests were built very close to each other, ranging from 5 to 12 nests per nucleus. They were build with wood sticks, irregularly arranged and shaped like a coarse bowl (Figure 3). Most nests were about 4 m above the ground. In this period the chicks hardly moved, had black feathers, and a very thin and orange beak, with black spots. It was not possible to count each chick individually, because we kept a safe distance to avoid stressing the adults, making it difficult to see the chicks. Eleven days later (Figure 4), the chicks could move out the nest and reach nearby branches.

FIGURE 2. Jarivatuba Island, in Babitonga Bay, Joinville, Santa Catarina State. The white circles represent the Scarlet Ibis reproductive nuclei. Source: Google Earth.

FIGURE 3. Nest of Scarlet Ibis about one week old, on Jarivatuba Island, Babitonga Bay. Photo: D. Fink.

FIGURE 4. Scarlet Ibis chick about three weeks old, on Jarivatuba Island, Babitonga Bay. Photo: D. Fink.

The last survey was made on April 18, when 14 juveniles were observed foraging along the Cachoeira River, in pairs or alone. A group of 36 adults remained on Jarivatuba Island, but reproductive activity was no longer recorded in the area. Only one chick was foraging in the tidal flat, together with a group of adults.

During the surveys, seven species of potential predators of bird eggs or chicks were recorded flying over the colony: Turkey Vulture (*Catarthes aura*), Black Vulture (*Coragyps atratus*), Great Black Hawk (*Urubitinga urubitinga*), Roadside Hawk (*Rupornis magnirostris*), Southern Caracara (*Caracara plancus*), Yellow-headed Caracara (*Milvago chimachima*), and Kelp Gull (*Larus dominicanus*). However, only one predation event was recorded. On January 20, a Great Black Hawk attacked a Scarlet Ibis chick in the nest. This nest was located in the only reproductive nucleus at the edge of the colony. After this event, no more adult Scarlet ibises were recorded at this nucleus.

DISCUSSION

There was a gap of about 150 years in the occurrence of the Scarlet Ibis in Santa Catarina, and the species was considered extinct in the state (Rosario 1996; Naka & Rodrigues 2000).The records of Scarlet Ibis in Santa Catarina were only historical, dating back to the eighteenth and nineteenth centuries (Rosario 1996). Thus, no scientific or technical information about the species in the region existed until now. James Henderson, who wrote about his trip to Brazil (Henderson 1821), described a large number of scarlet ibises in Babitonga Bay. However, it is unknown why the species became extinct in the region. Recently, Wasilewski *et al.* (2008) reported two Scarlet ibises in Santa Catarina in a personal communication and without geographic coordinates: one in Babitonga Bay, without specifying the year, and one in São Francisco do Sul Bay in 2007. We believe that this second record is related to the Palmital River region, referred to in some maps of Babitonga Bay as São Francisco do Sul Bay.

There are reports of young individuals in the neighboring state of Parana, but so far, a Scarlet Ibis breeding colony has not been recorded in this region; the last Scarlet Ibis record in this area was in 1820 (Olmos & Silva and Silva 2003).

The displacement of the Scarlet Ibis from Santos-Cubatão to the Cananéia - Iguape - Ilha Comprida region, where they formed new breeding colonies, was confirmed through the capture and tagging of some individuals (Paludo *et al.* 2005, Silva and Silva 2007). The distance between the two aforementioned sites is 140 km in a straight line (Silva and Silva 2007). The most likely hypothesis for the origin of the Scarlet ibises that reproduce in Babitonga Bay is that the individuals came from Ilha Comprida, São Paulo State, the nearest known colony. In this case, Scarlet Ibis individuals traveled about 200 km in a straight line.

The breeding colony of Jarivatuba Island is the largest in Babitonga Bay, considering the number of species and individuals (Fink 2013). Besides the Scarlet Ibis, six other waterbird species nested in this colony. This could explain why the species chose this area first for reproduction in the region. A large breeding colony represents security, and a mixed colony apparently is a safe place where other species reproduce (Burger 1981). The island apparently does not suffer any direct anthropogenic disturbance, such as the capture of eggs and chicks or hunting by humans.

This first breeding event of the Scarlet Ibis reported on Jarivatuba Island herein occurred after a period of heavy rains in December, where 314 mm of rain were recorded for 20 days. Some authors suggest that the species starts breeding after being stimulated by heavy rainfall in the rainy season (Rodrigues 1995, Silva and Silva 2007). The rainfall could be related to the availability of some forms of prey, more abundant under these conditions, such as crustaceans, fish and insects (Rodrigues 1995, Sick 1997, Frederick 2002).

Olmos & Silva and Silva (2001, 2003) and Olmos (2003) report that in the Santos-Cubatão mangrove, the Scarlet Ibis can have three reproductive pulses, in November, December and January, being the first species to start breeding activities in the whole waterbird colony. In this area the mean number of breeding pairs was 130 and the last reproductive pulse produced few chicks, due to predation by the Harris Hawk (*Parabuteo unicintus*). Herons and ibises, in general, have two reproductive peaks, referred to as a bimodal pattern. In this case, the second peak generally accommodates pairs that were unsuccessful in the first breeding pulse and also migrants who arrived later (Rodgers 1980). In Babitonga Bay, the Scarlet Ibis was the last species to reproduce. These individuals could be latecomers, arriving from other breeding colonies, and this could cause a delay in their beginning of reproductive activities and the occurrence of only one reproductive pulse. Colonial birds that nest later tend to have less reproductive success, a phenomenon known as late breeder, which often occurs with young or inexperienced individuals (Rodgers 1980, Olmos & Silva and Silva 2003). Another possibility is that these individuals were mature and experienced, and arrived later because they had their nests destroyed in another breeding colony.

Seven species of potential bird predators were recorded on Jarivatuba Island, but the only event of predation recorded involved a Black Hawk. In Santos-Cubatão, predation of chicks has been observed by the Harris Hawk, the main predator at this site, and peregrine falcons (*Falco peregrinus*). Predation by mammals such as the Crab-eating Raccoon (*Procyon cancrivorus*), the Lesser Grison (*Galictis cuja*), the Crab-eating Fox (*Cerdocyon thous*) and the Black Rat (*Rattus norvegicus*) or reptiles such as the Broad-snouted Caiman (*Caiman longirostris*) were recorded in breeding colonies (Olmos & Silva and Silva 2003), but were not detected in our study. It is probable that Jarivatuba Island is more protected from terrestrial predators because it is an isolated mangrove area.

People access Jarivatuba Island with boats only during high tide, which can cause some disturbance in the area. Although artisanal fishermen fish around the island, there has been no report of any situation of vandalism in this breeding colony. However, the region that surrounds the colony is very urbanized and industrialized, including a large foundry nearby. These factors could cause the Scarlet Ibis to move away and change location for breeding in the future (Hass 1999, Olmos & Silva and Silva 2003).

The city of Joinville has only 14% of domestic sewage treated. Much of the untreated domestic and industrial effluents are dumped into Babitonga Bay through the Cachoeira River (Oliveira *et al.* 2006). Moreover, Joinville is the largest industrial city in Santa Catarina State and industrial effluents without proper treatment can cause contamination by trace elements and organochlorine compounds, especially for species at the top of the food chain, such as waterbirds (Fink 2013).

At one edge of the island is the navigation channel to the Cachoeira River, where many marines are installed. The mangrove trees on this edge suffer serious impact due to motorboat traffic at high speed, which leads to soil erosion and consequently the toppling of trees. One solution to reduce this impact could be the establishment of navigation rules in the area, such as speed limits for vessels.

Babitonga Bay is home to many species of birds, resident and migratory, which use the site for feeding, resting and reproduction (Cremer & Grose 2010, Cremer *et al.* 2011). Furthermore, the region is considered an "Important Area for Conservation of Birds" due to the presence of endangered species (Bencke *et al.* 2006). Thus, the presence of an endangered species, such as the Scarlet Ibis, which is "critically endangered" in Santa Catarina State, deserves special attention by the government, and the creation of a protected area would be a long-term strategy for the conservation of this species and its ecosystem. Continued research on the colony would be very important to determine if the species will stay in this area.

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ARTICLE

Save your tears: eye secretions of a Ringed Kingfisher fed upon by an erebid moth

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ABSTRACT: Bodily fluids and secretions of birds are fed upon by flying insects, the best-known example being the worldwide blood-feeding mosquitoes. Much less known are the Neotropical mucus-feeding stingless bees, and the Malagasy tear-feeding moths. Herein I illustrate and briefly comment on a night-roosting Ringed Kingfisher female whose tears were fed upon by an erebid moth in the Colombian Amazon. The moth perched on the bird's neck and fed on the secretions in the anterior upper corner of the eye. Careful checking of night-roosting birds probably will disclose additional cases of Neotropical bird species sought by tear-feeding moths.

KEY-WORDS: *Megaceryle torquata*, lachryphagy, Erebidae, Colombia, Neotropics.

INTRODUCTION

Bodily fluids and secretions of birds are fed upon by several types of flying insects, the best-known example being the worldwide blood-feeding mosquitoes (Griffing *et al.* 2007, Burkett-Cadena *et al.* 2014), no doubt due to these insects' role as pathogen vectors. Much less known are the Neotropical mucus-feeding stingless bees (Lobato *et al.* 2007, Sazima 2015), or the Malagasy tear-feeding erebid moth (Hilgartner *et al.* 2007). Since lachryphagous moths are mostly recorded exploiting mammals (Bänziger 1972, 1990, Büttiker *et al.* 1996, Plotkin & Goddard 2013), the Malagasy case study piqued my interest about moths feeding on eye secretion of birds.

METHODS

I searched public online photo archives for any additional evidence of moths feeding upon bird tears. I found only one record (http://www.projectnoah.org/spottings/32518118), a blog featuring four photos of a night-roosting kingfisher whose eye secretions were fed upon by a moth. I contacted the author, Dan Doucette, who kindly gave permission to make available his record to the scientific community. Herein I illustrate and briefly comment on this remarkable example, seemingly the first record of such relationship for South America.

RESULTS

A night-roosting Ringed Kingfisher (*Megaceryle torquata*) female was recorded on 04 December 2012 at 21:47h in the area of Leticia (04°12'19"S, 69°55'58"W), department of Amazonas in Colombia, Northwestern South America (D. Doucette pers. comm.). The kingfisher roosted on a branch above a tributary of the Marañon River, a moth perched on the left side of the bird's neck (Figure 1). A closer approach disclosed an erebid moth (*Azeta melanea*) with its proboscis tip inserted under the nictitating

FIGURE 1. A night-roosting female Ringed Kingfisher (*Megaceryle torquata*) in the Amazonian Colombia, with an erebid moth (*Azeta melanea*) perched on left side of the bird's neck (yellow asterisk). Photo: ©Dan Doucette.

FIGURE 2. A night-roosting female Ringed Kingfisher (*Megaceryle torquata*) with and erebid moth (*Azeta melanea*) feeding on its eye secretions. The moth has its proboscis tip inserted under the nictitating membrane. Photo: ©Dan Doucette.

membrane at the upper corner of the bird's eye (Figure 2), presumably feeding upon secretions that lubricate the ocular area (tears). It was not possible to establish the degree of disturbance the moth might cause to the bird, as this latter was on the alert due to the approaching observer.

DISCUSSION

The present record of a Ringed Kingfisher with an erebid moth feeding on its eye secretions seems to be the first substantiated instance of a bird exploited by a lachryphagous moth in the Neotropics. To the best of my knowledge, the previous and only published record of birds exploited by a tear-feeding moth are two Malagasy passerines, the sylviid warbler *Newtonia brunneicauda* and the thrush *Copsychus albospecularis* (Hilgartner *et al.* 2007). The main difference between the Malagasy and Neotropical records is that the Malagasy moth (*Hemiceratoides hieroglyphica*) was large relative to the passerine birds, and perched on the bird's upper side of the neck and the back (Hilgartner *et al.* 2007). These authors related the position of the moth to its proboscis size, which is about half the size of the insect (Hilgartner *et al.* 2007). On the other hand, the proboscis of the Neotropical moth *Azeta melanea* is about the same size of the insect (present paper), which presumably allow it to exploit larger birds such as kingfishers and to perch on various parts of the head and neck of the bird host to feed on tears.

Seeking salts and moisture, besides proteins, are among the possible explanations for erebids and other tear-feeding moths to exploit vertebrate eyes, including those of birds (Bänziger 1990, Hilgartner *et al.* 2007, Plotkin & Goddard 2013, present paper). Lachryphagy probably evolved several times among Lepidoptera, since this habit is found in unrelated moth and butterfly groups (Plotkin & Goddard 2013).

Birds exploited by tear-feeding moths may actually be a rare phenomenon, as these insects feed mostly on the secretions and fluids of mammals (Bänziger 1972, 1990, Büttiker *et al.* 1996, Plotkin & Goddard 2013). If this holds true, it would partly explain the scarcity of records of moths feeding on birds (Hilgartner *et al.* 2007, present paper). On the other hand, this scarcity may be due to lack of attention of professional biologist to this phenomenon or, conversely, spotting a moth perched on a night-roosting bird may be a difficult task in the field. Nevertheless, I suppose that a careful checking of birds at night roosts will reveal additional cases of Neotropical bird species sought by tear-feeding moths.

Understanding this peculiar relationship between birds and moths would certainly benefit from substantiated records made by amateur naturalists, photographers, filmmakers, and citizen scientists. The role citizen scientists may play in the expansion of knowledge about organisms and their interactions in nature, *i.e.* natural history, should be stimulated and supported by professional biologists (see convincing argumentation in Tewksbury *et al.* 2014).

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Predation on *Amphisbaena heterozonata* by the Whistling Heron *Syrigma sibilatrix* at Tucumán, Argentina

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ABSTRACT: Twelve species of birds have been reported to prey upon amphisbaenians (Squamata: Amphisbaenidae). We document the first report of predation on an amphisbaenian by a heron (Pelecaniformes: Ardeidae). On 1 November 2012 we photographed a Whistling Heron *Syrigma sibilatrix* preying on an *Amphisbaena heterozonata* at Tucumán, Argentina.

KEY-WORDS: Amphisbaenidae, Ardeidae, diet, foraging, prey.

Due to their fossorial habits, the natural history of South American amphisbaenians (Squamata: Amphisbaenidae) is poorly known. Amphisbaenians are occasionally preyed upon by birds, with published records including the Chicken (*Gallus gallus* × *sonnerati*) (Gallardo 1967), Maguari Stork (*Ciconia maguari*) (Tozetti *et al.* 2011), Turkey Vulture (*Cathartes aura*) (Zamprogno & Sazima 1993), Harpy Eagle (*Harpia harpyja*) (Silva 2007), White-necked Hawk (*Buteogallus lacernulatus*) (Rajão *et al.* 2013), Roadside Hawk (*Buteo magnirostris*) (Zotta 1934), Gray-lined Hawk (*Buteo nitidus*) (West 1975), Southern Lapwing (*Vanellus chilensis*) (Gans 1971), Barn Owl (*Tyto alba*) (Wiley 2010), Ashy-faced Owl (*Tyto glaucops*) (Wiley 2010), Red-legged Seriema (*Cariama cristata*) (Folly *et al.* 2015), Southern Caracara (*Caracara plancus*) (Zamprogno & Sazima 1993), and Yellow-headed Caracara (*Milvago chimachima*) (Zamprogno & Sazima 1993). Herein we report the first record of a heron (Pelecaniformes: Ardeidae) preying upon an amphisbaenian.

The Whistling Heron (*Syrigma sibilatrix*) is a medium-sized heron in the family Ardeidae occurring throughout South America (Kushlan & Hancock 2005). It usually forages alone or in pairs in wet savannas, and preys mostly upon invertebrates and less frequently on fishes (including eels), amphibians, lizards, and snakes (Schubart *et al.* 1965; Gallardo 1970; Hancock & Elliott 1978; Kushlan *et al.* 1982; Kushlan & Hancock 2005; Franz *et al.* 2006; Beltzer *et al.* 2010; Dean 2012; Aoki & Filho 2013; Buitrón-Jurado & Quiroga-Carmona 2015). Gallardo (1970) reported 15 legless lizards (*Ophiodes vertebralis*) in the stomach of a *S. sibilatrix* collected in Argentina, suggesting that it could easily prey upon similarly elongated and legless amphisbaenians; however, no amphisbaenians were found in the stomachs of 19 *S. sibilatrix* in Argentina (Beltzer *et al.* 2010).

At about 17:30 h on 1 November 2012 two of us (Hayes and Capllonch) observed an adult *S. sibilatrix* struggling to consume an adult amphisbaenian at the edge of a shallow pool of water in a flooded field near the Hotel Sol San Javier, on Cerro San Javier, Yerba Buena, Tucumán, Argentina (26.8005° S, 65.3594° W; 1 274 m.a.s.l.). Although the initial attack by the heron was not observed, a series of photos taken by Hayes revealed that the amphisbaenian was grasped by its head (Figure 1) and swallowed head-first (Figure 2) within 2 min. The amphisbaenian wriggled, indicating it was still alive. Caudal autotomy, a defensive behavior previously observed in a congeneric species (*Amphisbaena mertensi*) when attacked by a snake (Brito *et al.* 2001), did not occur. The photos indicate that the amphisbaenian was about 3.5 times longer than the length of the heron's bill. Based on a mean bill length of 6.41 cm for the nominate race of *S. sibilatrix* (6.65 cm in males, 6.17 cm in females; Dean 2012), the amphisbaenian's length can be estimated as 22.4 cm long, but given the inexactness of our measurement it is best to estimate its length as 20-25 cm. It was raining slightly when the predation event occurred.

FIGURE 1. A *Syrigma sibilatrix* grasping an *Amphisbaena heterozonata* by its head at Cerro San Javier, Yerba Buena, Tucumán, Argentina, on 1 November 2012. Photo by Floyd Hayes.

FIGURE 2. A *Syrigma sibilatrix* swallowing an *Amphisbaena heterozonata* with its posterior end still protruding at Cerro San Javier, Yerba Buena, Tucumán, Argentina, on 1 November 2012. Photo by Floyd Hayes.

The normally dry field was flooded due to recent rainfall (0.79 cm on 1 November, 0.89 cm on 28 October, 2.79 cm on 27 October 2012 at the Tucumán Aerodrome, 25.7 km away, 26.84° S, 65.10° W, 450 m.a.s.l.; data from wunderground.com), which probably flooded the amphisbaenian's burrow and forced it to the surface where it was opportunistically preyed upon by the heron.

The amphisbaenian was identified as *Amphisbaena heterozonata*, based on its body proportions (the snout-vent length of the species reaches up to 27.5 cm plus 2.5 cm of tail length, so the estimated size of the observed specimen fits well), coloration, and because it is the only amphisbaenian known from this locality (Montero 1996; Nuñez Montellano *et al.* 2010). It is a relatively common amphisbaenian and classified as non-threatened (Abdala *et al.* 2012).

This record appears to represent the first of an amphisbaenian preyed upon by a heron. Because many species of herons forage on snakes and lizards (Kushlan & Hancock 2005), amphisbaenians may be preyed upon opportunistically by herons and similarly large wading birds more frequently than the lack of reports suggests, especially when amphisbaenians are forced to the surface when their burrows are flooded. As an example, an analysis of the stomach contents of a single Maguari Stork , which is a larger wading bird often foraging in the same habitats as *S. sibilatrix* and other species of herons, revealed that *Amphisbaena trachura* accounted for more than half of its prey (Tozetti *et al.* 2011).

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ARTICLE

Diet and breeding of the poorly known White-chinned Swift *Cypseloides cryptus* Zimmer, 1945, in Brazil

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ABSTRACT: The White-chinned Swift *Cypseloides cryptus* is perhaps one of the rarest swift species in the New World, and many aspects of its life history are poorly known. Here we report some new information on diet and reproductive behavior of a breeding population of *C. cryptus* at Asframa Falls, Rio Preto da Eva, Amazonas, Brazil. During four surveys at the breeding site (March and August 2012, July and August 2013), six active small cup-shaped nests were found and are described. Measurements and plumage information of five collected adults and two chicks are also provided. Stomach contents (n=5) revealed the presence of insects of the order Hymenoptera and Hemiptera. The presence of a member of Psyllidae (Hemiptera) in the stomach contents suggests that this swift might also use a slightly different foraging strategy than commonly stated about swifts. Additionally, with this new information it is possible to determine the presence of the species over at least nine months in Brazil, indicating year-round residence.

KEY-WORDS: Apodidae, Hemiptera, Hymenoptera, nest, stomach contents.

INTRODUCTION

The White-chinned Swift *Cypseloides cryptus* Zimmer, 1945, might be one of the rarest swift species in the New World with fewer than 20 specimens collected from all parts of its known range (Kiff 1975). Additionally, with only a few scarce observations in southern Central and northern South America (Chantler 1999), the natural history and distribution of the species are, unsurprisingly, still poorly known.

This bird occurs between sea level and 3000 m a.s.l. Its main habitats are classified as montane and tropical lowland evergreen forests, with a clear preference for gorges and waterfalls, which are used to nest and roost (Chantler 1999). This swift was recently discovered in Brazil, in the municipality of Presidente Figueiredo, Amazonas State, where some individuals were observed breeding in local waterfalls (Whittaker & Whittaker 2008). Central American records are from Belize, Honduras, Nicaragua, Costa Rica, and Panama. In South America outside of Brazil, there are records from Peru, Ecuador, Colombia, Suriname, Venezuela (on the cordillera and tepuis) and Guyana (Chantler 1999).

METHODS

The Asframa Falls (02°08'10.37"S, 59°59'46.46"W) (Figure 1A) is located in the Urubu river, municipality of Rio Preto da Eva, state of Amazonas, Brazil, *c.* 10 km distant from the Natal Waterfall breeding site discovered by Whittaker & Whittaker (2008). It is a recreational area with a playground and two waterfalls, a large and a smaller one, surrounded by several acres of pristine forest. The largest waterfall is approximately 5 m high and is formed by two levels, a short one *c.* 1 m high and a larger one with a fall of 4 m.

The data presented here were gathered during four surveys at the breeding site (5 to 9 March and 9 to 15 August 2012, 13 July and 17 August 2013). Collected specimens (all fully-grown adults, being one male and four females) are housed in the ornithological collection of Museu Nacional/UFRJ, Rio de Janeiro, Brazil (MN). Four specimens were prepared as study skins and one was prepared as a "*shmoo*", saving the full skeleton (Winker 2000) (Figure 1B). All carcasses were fixed in 4% formalin and subsequently preserved in 70% ethanol; muscular tissue samples were preserved in anhydrous ethanol. Two nests were dried and stored in the nest collection (MNON-5482; MNON 5483); their classification follows Simon & Pacheco (2005). Unfortunately, the small and delicate eggs were damaged during transport and could not be measured.

The entire digestive tract was examined for food items, but remains were present in stomachs only. Stomachs were extracted from the abdominal cavity, dissected and stored in 70% ethanol. Each individual's stomach content was placed in a Petri dish and analyzed with a stereomicroscope. Arthropods were identified to the lowest possible taxonomic level with help of specialized literature (Rafael *et al.* 2012). Fragments were grouped and counted by morphological similarities, estimating the minimum number of prey of each taxa present in each sample. Digital photographs were taken using Canon Rebel XSi and Sony Cyber-Shot DSC-HX1 cameras, lens Sigma 150-500-mm, and cellular phone IPhone 4S. Nest measurements were taken using a digital caliper Mitutoyo Absolute and a measure tape.

RESULTS AND DISCUSSION

During the first field trip to Rio Preto da Eva, in March 2012, a group of about 10 to 12 individuals of the White-

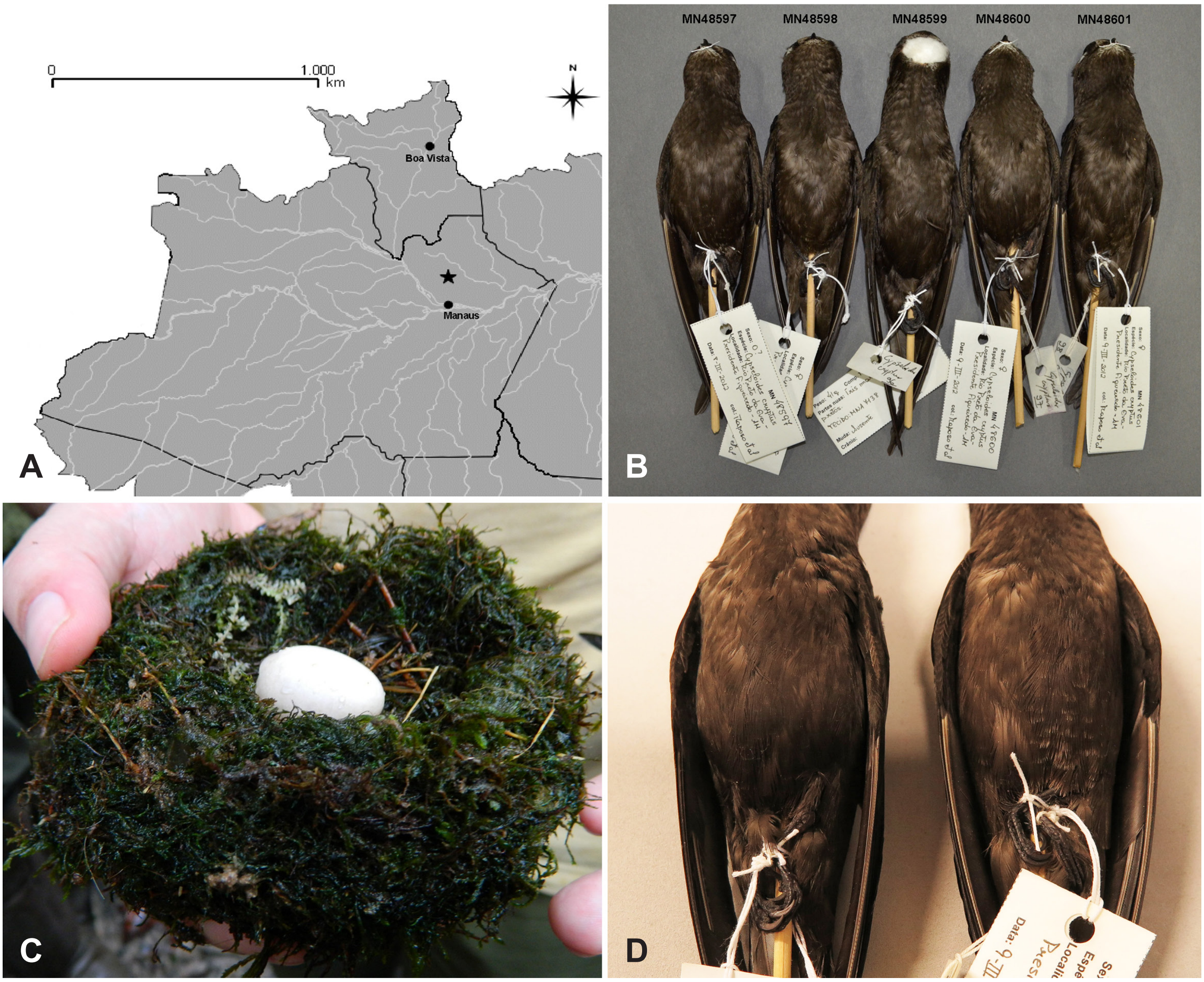

FIGURE 1. A – Star = Asframa Falls, Rio Preto da Eva, Amazonas; B – White-chinned Swifts collected and housed in Museu Nacional/UFRJ, all fully-grown adults. MN 48599 – male with full skeleton preserved; MN 48597, 48598, 48600 and 48601 – females (Photo: Guilherme Brito); C – White-chinned Swift nest and egg collected and housed in Museu Nacional/UFRJ (Photo: Gabriella Frickes); D – Detail of possible undescribed plumage sexual dimorphism. Male on the left (MN 48599); female on the right (MN 48601); note white-tipped feathers on female's abdomen (Photo: Guilherme Brito).

chinned Swift was found using the rocky wall behind the waterfall. On that occasion, five adult specimens, and two active nests, each containing one small and overall white egg (Figure 1C), were collected by hand (see measurements of birds and nests below). Other four nests described in the present work (hereafter numbered N1 – N4) were observed in the subsequent surveys in 2013, but not collected, with features discussed below (Tables 1 and 2, Figure 2).

All specimens had good amount of accumulated fat on their interclavicle, abdominal, intercostal and uropygium regions, with no visual difference between the individuals despite their differences in mass.

The measurements of the birds (Table 2) show that the overall size of the male specimen is larger than those of the females and an interesting plumage pattern was observed on the abdominal area of the skins of adult specimens. All females have several feathers on that region tipped white, while the only male has them uniformly dark-brown and very few feathers tipped buff. This might be an important and previously undescribed character of sexual dimorphism in plumage (Figure 1D). Analyzing specimens of adult Sooty Swifts *Cypseloides fumigatus* (Streubel, 1848) housed at the Museu Nacional, the same pattern was found, and further work on collections with specimens of the small and dark *Cypseloides* should be done to confirm our suggestion. The suggestion that white tips to the lower belly might be an indicative of immaturity (Schulenberg *et al.* 2007, Roesler *et al.* 2009) should also be investigated, because all specimens collected had fully ossified skulls, indicating adulthood.

Diet

In the stomach contents, we counted 36 prey items among the five samples. The material was in an advanced stage of digestion and two of the five analyzed stomachs were completely empty (MN 48597; MN 48598 – both females). The remaining three stomachs contained 72.2% Hymenoptera (n = 26) and 27.8% Hemiptera (n = 10). We have also found some green moss (Bryophyta) fragments in two female samples (MN 48600; MN 48601), but these were considered to have possibly been ingested accidentally because the same material is used in nest construction. Most of the whole Hymenoptera that allowed further identification were mainly winged ants (Formicidae). All Hemiptera identified belonged to Psyllidae (jumping plant lice).

TABLE 1. Measurements of five White-chinned Swift *Cypseloides cryptus* nests at Rio Preto da Eva, state of Amazonas, Brazil. N1 nest was only observed but not measured in time before being destroyed.

Nest Metrics	NH[1] (cm)	H[2] (cm)	ND[3] (cm)	BW[4] (cm)
MNON 5482*	4.9	-	4.3	8
MNON 5483*	4.1	-	2.4	9.3
N2	4.6	255	2.7	14.5
N3	3.0	255	-	11.9
N4	3.4	255	-	8.5

[1]NH = Nest height measured on the exterior from bottom to top; H[2] = height from the ground to the nest; ND[3] = internal nest depth; BW[4] = nest width measured at the base.
*Nests already dry, stored in the proper collection.
MNON 5482 and MNON 5483 collected in March 2012.
N2 – N4 nests observed in August 2013.

TABLE 2. Measurements of the collected individuals of White-chinned Swift *Cypseloides cryptus* in Rio Preto da Eva, Amazonas State, Brasil.

Catalog Number	TL (mm)	WS (mm)	WL (mm)	CH (mm)	BL (mm)	BH (mm)	BW (mm)	T (mm)	Ta (mm)	W (g)	Sex
MN48597	145	345	133.30	135	4.98	2.25	7	15.02	45	37	F
MN48598	137	348	130.00	133	5.02	2.24	6.8	13.35	43	34	F
MN48599	145	364	142.35	137	5.03	3	8	16.15	50	41	M
MN48600	138	348	135.05	139	4.97	2.3	7.1	15	46	39	F
MN48601	146	342	133.00	137	5.00	2.35	6.3	13.3	47	40	F

TL = total length, WS = wing span, WL = wing length, CH = chord, BL = bill length (nostril to tip), BH = bill height (at the base), BW = bill width (at the base), T = tarsus, Ta = tail length, W = weight. Sex, mass, total length and wingspan taken in recently euthanized specimens. Remaining data after preparation (bill measures from the "schmoo" skin made on the carcass).

FIGURE 2. Locations of White-chinned Swift's studied nests (N1 – N4) on Asframa Falls, Rio Preto da Eva - Amazonas in 17 August 2013 (Photo: R. Biancalana).

Such preference for preying upon winged individuals of Formicidae corroborates the report by Beebe (1949), who found "great quantities of *Crematogaster* and *Azteca* flying ants" in the stomach of one specimen and "winged female *Azteca* ants" in another specimen of *C. cryptus.* Howell (1957) observed *c.* 35 individuals of this species feeding in flight above the forest border at a clearing in Nicaragua, where the stomach content of one collected female was not identified, but believed to be Hymenoptera. Marín & Stiles (1992) reported contents of four stomachs and two boluses with 91.7% Hymenoptera (mainly Formicidae and Blastophagidae), but the Psyllidae records reported here are new.

The presence of Psyllidae or "jumping plant louse" as one of the most important food items found in the stomachs gives us some interesting insights about foraging strategies of this species. As members of the Sternorrhyncha suborder, insects known to be relatively inactive for most of their lives (Borror *et al.* 1992), our findings suggest that birds might use a different foraging strategy to reach and consume them, rather than capturing swarming insects during flight. Some swifts are known to catch aquatic insects in lakes and rivers by reducing their flight speed sufficiently to permit them to grab individual prey items directly from the water surface (Chantler 1999). Similar observations, not from water bodies, but on Amazonian tree canopies were made when individuals of Short-tailed Swifts *Chaetura brachyura* (Jardine, 1846) were observed slowing down their flight speed and taking unidentified insects directly from the tree leaves near Manaus (R. P., *pers. obs.*). This could be a recurrent and rarely recorded foraging strategy of swifts. Bull & Beckwith (1993) also report Vaux's Swifts *Chaetura vauxi* (Townsend, 1839) capturing insects from the tree canopy in the USA.

Although the hypothesis above is speculative to a certain degree, our data indicate its plausibility. The 30% of the diet by number composed by neither non-volant nor swarming Psyllidae is noteworthy. In addition, these insects are sessile and animals with these characteristics are predated by closely related birds (Chaeturinae – Bull & Beckwith 1993). Further observations of this rare swift and other Cypseloidinae might clarify this issue.

Breeding

Two nests were collected on 8 March 2012 attached to a rocky bed with one side leaning against the rocky wall near the ceiling behind the waterfall, only accessible via a bypass where the water volume was reduced (Figure 2). They consisted of a cup-shaped simple/platform (Simon & Pacheco 2005) mainly constructed of moss, rootlets and mud, which were humid due to constant water sprinkle. Both nests contained a single sub-elliptical pure opaque white egg. On the occasion of the second survey, the water volume was greater compared to the first one due the advanced stage of the raining season, and despite careful searches behind the waterfall, no individuals or nests were found.

On 13 July 2013, RNB made a visit to the Asframa Falls and observed a flock of 5 to 6 individuals of White-chinned Swifts foraging with Fork-tailed Palm-Swifts *Tachornis squamata* (Cassin, 1853). One active nest (N1) occupied by an adult individual (denoted by the dark brown plumage with characteristic whitish facial marks) was found behind the upper part of the main fall. This nest had a small cup shape and was of plant material, rootlets and leaves visibly damp on the exterior.

A subsequent visit to Asframa Falls made by RNB on 17 Aug 2013 revealed the presence of two individuals foraging above the area of the falls as well as three additional nests (N2 - N4) behind the fall, one of them empty, made of bryophytes, mud and fine rootlets. The interior was lined with interwoven fine roots, sitting on a dry area of the lower part of the fall (N2). The nest seen in July (N1) was found partially destroyed, and this was the reason for the absence of measurement data for it (Figures 2 and 3; Table 1).

A single nestling in its early stage of development was found in N3. It was not larger than 2 cm, had closed eyes, overall dark sooty gray down and forehead feathers in their sheaths. N4 was also active. The brooding adult occupying this nest reacted to human approach by conspicuously shaking its wings and ruffling its nape feathers. After a few minutes the adult left the nest enabling the observer to confirm the presence of a chick, which was in a more advanced stage of development than the chick in N3. Its body was covered with dark gray downy plumage. The eyes were open and it had sluggish movements, occasionally moving the head towards the flanks (Figure 3). No vocalization was heard from the adults or nestlings during visits.

Nests were in place and conditions similar to those described by Marín & Stiles (1992) and Whittaker & Whittaker (2008). The main difference being the position and type of the nest described as a "low cup/lateral" for the latter, and in some aspects similar to those observed by Ayarzaguena (1984) and Marín & Stiles (1992) for the same species. The reuse of reproductive sites is well known for species of Cypseloidinae (see Pichorim 2002). Regarding clutch size, Marín (1997) reports one-egg

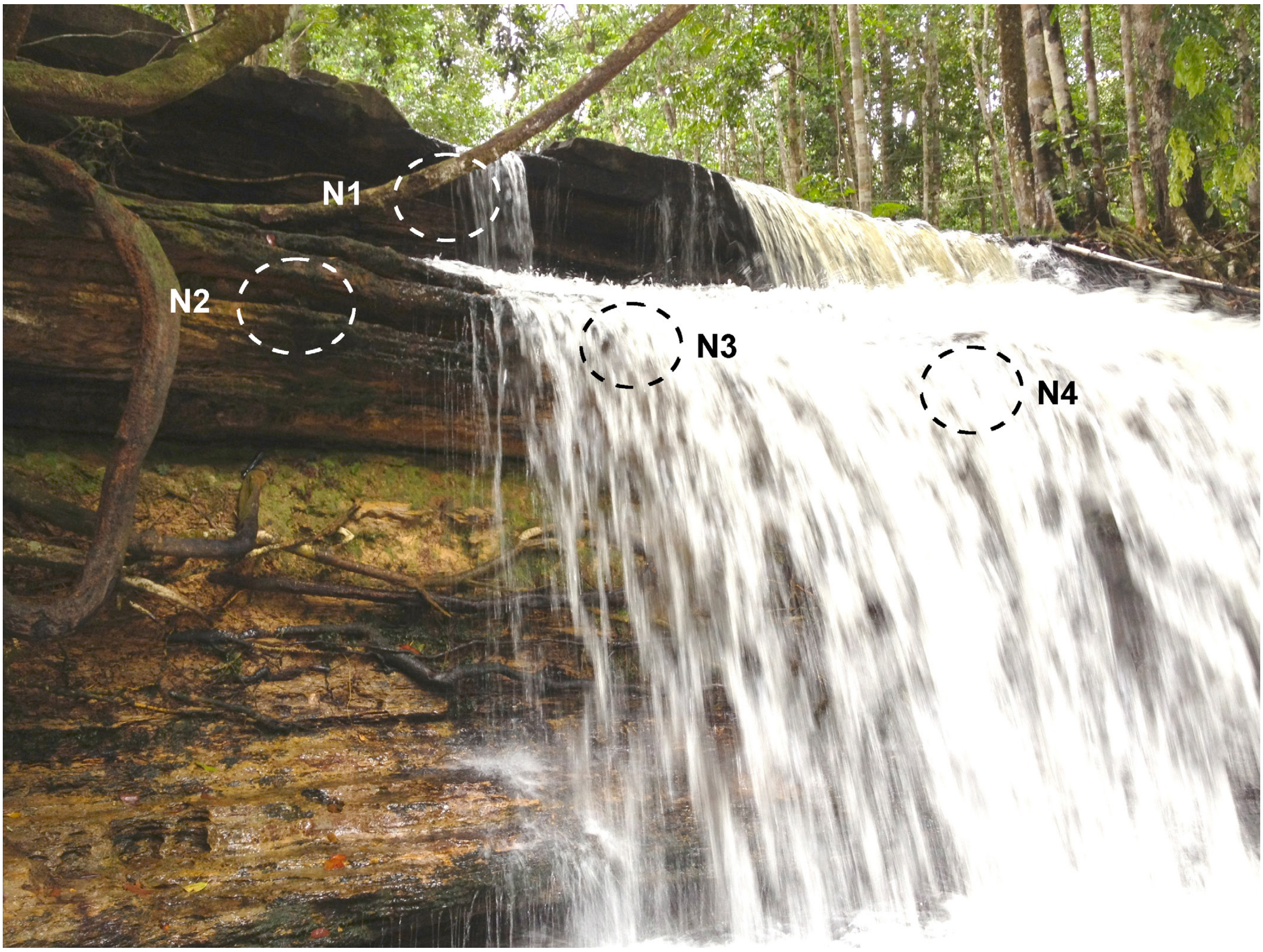

FIGURE 3. A. White-chinned Swift chick in N3 and, in the back, an adult in N4 (dashed circle). B. Chick with downy plumage in N4. Chicks with approximate age of ten to fifteen days (N3 younger than N4). Asframa Falls, Rio Preto da Eva – Amazonas (Photos: R. Biancalana).

clutch for both White-chinned and Spot-fronted Swifts, *Cypseloides cherriei* Ridgway, 1893.

As expected for Cypseloidinae swifts, the nests were in dark and constantly humid areas, and the morphology, composition and placement of the structures coincide with previous observations of this species and closely related ones (*e.g.* Spot-fronted Swift), where bryophytes, mud and other vegetable fibers were used (Knorr 1961, Foerster 1987, Marin & Stiles 1992, 1993). Also, these elements have usually been assigned as differentiating characters between *Cypseloides* and the remaining genera within Apodidae, which do not use this particular kind of vegetation associated with mud (Lack 1956, Whitacre 1989).

Based on Marín & Stiles (1992) description of White-chinned Swifts nestling development, we calculate that both chicks were around ten days to two weeks old, with the chick in N3 probably younger than the other. Therefore, considering the known nestling period for this species (55–58 days, Marín & Stiles 1992), we estimate the fledging period of these chicks to be around late September–mid October.

The presence of one adult in the nest when chicks are young, usually no more than three weeks old and with the body mainly covered with downy feathers is a common characteristic of other *Cypseloides* species, such as the Sooty Swift (Biancalana 2015).

Our records from March to September and multiple observations in the region between Manaus and Presidente Figueiredo from July to November (Guy M. Kirwan, pers. comm.) testify the presence of White-chinned Swift for at least nine months (March–November) in Brazil, with strong indications of successful breeding (used nests from previous breeding seasons and fledging individual pictures in Whittaker & Whittaker 2008), and absence of seasonal migratory movements. Our results point to the importance of Hemiptera (Psyllidae) and Hymenoptera (Formicidae) insects in the diet, and confirm the importance of waterfalls for nesting, which might prove helpful for further amplifying the knowledge about the distribution and natural history aspects of this elusive species.

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ARTICLE

Detailed description and seasonal variation in the diet of the Silvery-Cheeked Antshrike *Sakesphorus cristatus* (Wied, 1831) (Aves: Thamnophilidae) in a Brazilian semi-arid forest

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ABSTRACT: Despite being an important area for endemic species of birds, the *Caatinga* biome is highly fragmented due to anthropogenic influences and there is a lack of study on many aspects of its birds' biology. In this semiarid environment, rainfall is highly seasonal, with two different and well-defined periods: a long dry season, and a short rainy season. This study aimed to qualify and quantify the diet of *Sakesphorus cristatus*, an endemic thamnophilid bird of the *Caatinga*, as well as to determine whether there was temporal variation between two different seasons and between dry seasons of two consecutive years. Surprisingly, this was the first study to have focused on describing and quantifying items found of any bird species' diet in the *Caatinga*. We analyzed the stomach contents of 72 specimens collected in the municipality of São Felix do Coribe, Bahia, Brazil. Data analysis included relative abundance and occurrence, average consumption/sample and alimentary importance index of each food category. Sampling adequacy was assessed using cumulative curves constructed with diversity index and coefficient of variation. In general there is a high predominance of ants and termites, with seasonal shifts in the proportion of each item, and a high contribution of caterpillars during the breeding season. During the dry season, the most predominant prey categories in the diet were Formicidae, Isoptera and Coleoptera (adult, A), while during the rainy season, there was an increase in the proportion of Isoptera, Coleoptera (A) and Lepidoptera (larvae) consumption and a decrease in Formicidae. There was no significant difference between consumption of prey items between the two dry seasons. The overall analysis suggests that *S. cristatus* feeds mainly on the aforementioned insects and is an opportunistic species, adjusting its diet according to their prey availability.

KEY-WORDS: *Caatinga*, feeding biology, insectivory, stomach contents, temporal variation.

INTRODUCTION

Research on the feeding biology of Brazilian birds was mainly shaped by pioneers more than half a century ago, such as Moojen *et al.* (1941), Hempel (1949) and Schubart *et al.* (1965), who analyzed stomach contents of various species based on few specimens. However, the interest of Brazilian ornithologists on the diets of birds was not revived until the 1990's. Since then, publications about avian diets have seen a significant increase. In general, more recent studies either focus on questions regarding herbivory/frugivory (Francisco & Galetti 2001, Chatellenaz 2008, Silva & Melo 2011), community studies, especially in Atlantic Forest (Durães & Marini 2005, Lopes *et al.* 2005, Lima *et al.* 2010), or place their focus on unusual food items found in the stomach of a small number of specimens (*e.g.*, Andrade *et al.* 2001), while collecting data for other purposes (Pacheco & Gonzaga 1995).

Other areas of interest, such as the detailed description and quantification of items found in the diet of Neotropical bird species as well as their correlations with environmental variables, have been neglected (but see Chapman & Rosenberg 1991, Biondi *et al.* 2005, Zilio 2006, Cabral *et al.* 2006, Fernandes 2007). Especially significant aspects of avian diets, such as seasonality, often fail to be addressed. However, birds in seasonally well–defined environments may change their diet (Bucher *et al.* 2003) and/or foraging strategy (Hejl & Verner 1990) according to changes in food availability. This theme is already well known for temperate birds, where changes in environmental aspects are considered to be more dramatic. Nevertheless, it is still poorly discussed in Neotropical ornithology despite the diversity of species and environments of this region. Most tropical biomes have more stable conditions regarding changes in the environment when compared to temperate ones. However, some suffer abrupt changes of conditions along the year especially related to rainfall, as it is the case of the Brazilian Cerrado and *Caatinga* dry forests.

Within this framework, the Silvery-Cheeked Antshrike, *Sakesphorus cristatus* (Wied, 1831), is a bird species endemic to the Brazilian driest biome, the *Caatinga*. It is locally common at the understory and mid-story stratum (Stotz *et al.* 1996) of lower growth and edges of deciduous woodlands and arid scrubs (Ridgely & Tudor 2009) that typically compose the *Caatinga*. These birds are usually seen in pairs in mixed flocks next to *Megaxenops parnaguae* Reiser 1905*, Myrmorchilus strigilatus* (Wied, 1831), *Taraba major* (Vieillot, 1816)*, Herpsilochmus pileatus* (Lichtenstein, 1823), *Cantorchilus longirostris* (Vieillot, 1819) and *Formicivora melanogaster* Pelzeln, 1868 (Sick 1985, Teixeira *et al.* 1991, Olmos 2010). The Silvery-Cheeked Antshrike is considered a typical insectivorous bird, however, there is no research on its diet and foraging behavior. Available information is deduced from research on diverse species within the genus *Sakesphorus* (Zimmer & Isler 2003) and therefore based on speculation. In order to address this gap, the present paper qualifies and quantifies food items found in the diet of the *Sakesphorus cristatus* during the rainy as well as the dry season. Moreover, the paper aims to outline a correlation between the findings and the extreme environmental conditions specifically found in the *Caatinga*. Besides being the first record on *S. cristatus*' diet, the present paper is also the first to analyze the diet and its seasonal variation based on stomach contents of a bird in the *Caatinga* biome.

METHODS

Study area

The area of the *Caatinga* is estimated to cover 800,000 km² (IBGE 1985), encompassing all northeastern states of Brazil as well as the northern part of Minas Gerais (Figure 1A). Historically, the area has been considered a poor environment regarding species richness (compared to other Brazilian biomes), neglecting the significant number of endemic species. The *Caatinga* has an extreme and irregular rainfall regime, with dry periods lasting up to eight months (Sick 1985, IBGE 2010). Dry and rainy seasons are clearly distinct, but rainfall is irregular and seasonal, leading to a complex dynamic environment. This biome is still poorly studied in many aspects, among them, avian diet as well as feeding adaptations to survive in those extreme conditions.

The analyzed bird specimens were collected in the municipality of São Félix do Coribe, Bahia State, not specifically for the purpose of this study. The study site is located at 13°20'3.19"S 43°48'24.12"W, near the Corrente River, a tributary of the São Francisco River (middle region of São Francisco). The local vegetation is characteristic of the *Caatinga* morpho-climatic domain (Veloso *et al.* 1991) and comprises a native secondary vegetation of shrubby dry forests in early stages of development. (Figure 1B, C).

Collection of data

For the study, the contents of 72 stomachs, which are housed at the collection of Museu Nacional, Universidade Federal do Rio de Janeiro, were analyzed. Twenty nine of these were collected in April 2010, 29 in April 2011 at the beginning of the dry season, and 14 in November 2010 at the beginning of the rainy season. The complete list of specimens can be found in the Appendix. As a reference for the rainfall index, the city of Correntina, Bahia, was chosen as the area closest to the data collection site. Data were collected from the INMET (Instituto Nacional de Meterologia / National Institute of Meteorology) website.

The stomach contents of each specimen were analyzed with a stereo microscope *hund Wetzlar h* 33/10x. Prey items in each sample were identified, counted and preserved in 70% alcohol. Some of the fragments were photographed in the Laboratório de Entomologia, Universidade Federal do Rio de Janeiro, to support the identification of arthropods in future works.

Food items were identified to the lowest possible taxonomic level and categorized to Order level for statistical analysis. Formicidae (within Hymenoptera) and seeds had their own categories. The category Hymenoptera included the non-Formicidae and possible Formicidae that could not be accurately identified. The identification was done based on specialized literature (Borror *et al.* 1989, Costa *et al.* 2006, Rafael *et al.* 2012), visits to the entomological collection of the Universidade Federal do Rio de Janeiro, as well as photographs and illustrations of fragments presented in other works on the diet of birds (Ralph *et al.* 1985, Chapman & Rosenberg 1991, Gomes *et al.* 2001, Manhães *et al.* 2010). Most of the arthropods were very fragmented, so body parts were associated by morphological similarities and counted to estimate the minimum number of individuals of each category present in the sample. Seeds were counted individually. Each seed or individual prey was counted as one item.

A natural bias of diet studies based on stomach

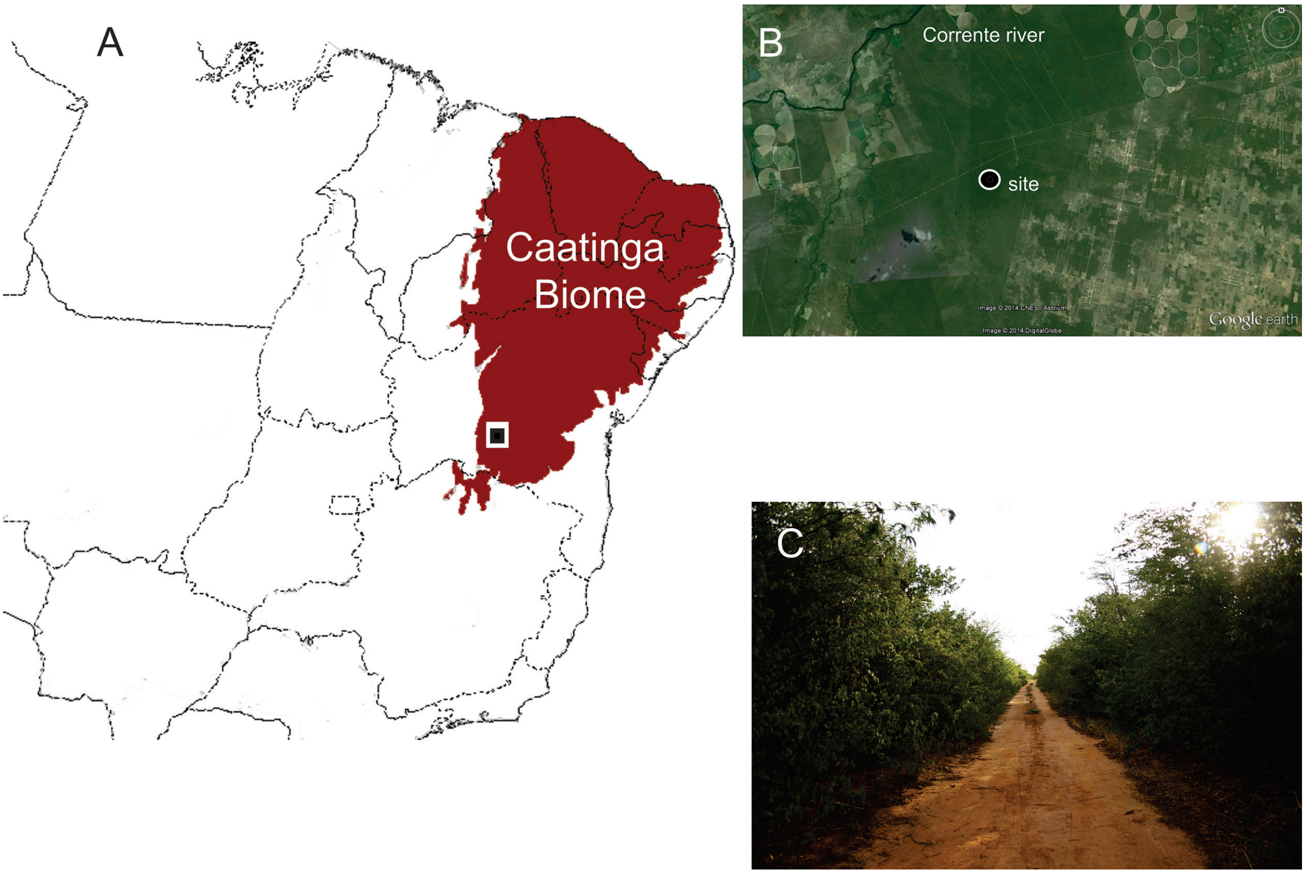

FIGURE 1. Map showing the study site and the extension of the *Caatinga* Biome in Brazilian territory (A). Close up of Google Earth satellite view of the study site location (B). Picture of the shrubby *Caatinga* forest fragment at the study site (C).

contents cannot be avoided, as the digestion of soft bodied arthropods, such as termites, is faster than the digestion of hard bodied arthropods, such as beetles (Dillery 1965, Rosenberg & Cooper 1990). Nevertheless, sclerotized parts, such as the jaws of termites and the chelicerae of spiders, remain in the sample even after the rest of the body was digested (Chapman & Rosenberg 1991).

Statistical analyses

The method proposed by Durães & Marini (2005) was applied to verify if the sampling was properly representing the diet of the species. Using *Estimates version 8.2*, sampling adequacy of each season was assessed by building cumulative curves with two different parameters: diet diversity (DD) (using Shannon index) and the associated coefficient of variation (CV) (Shannon index standard deviation/DD). Firstly, a sample was selected randomly and its diet diversity index was calculated. Secondly, a second sample was added and the index of both samples was calculated. The procedure was repeated without replacements of samples until all samples were added. After 100 runs, the DD of each round was calculated based on their mean value. The CV was calculated from the DD mean values. Adequacy was inferred by visual inspection of diet diversity curve and by the hypothesis of Durães & Marini (2005), which states that samples are adequate when the coefficient of variation reaches 15%. The importance of each category in the diet was estimated using a modified Alimentary Importance index (AI$_i$) of Kawakami & Vazzoler (1980). This index considers the relative abundance and occurrence of each category, thus reducing the bias caused by items that either occur frequently, but in small numbers or items that occur sporadically, but in great quantities. This index was calculated by the equation stated below, in which RO$_i$ is the relative occurrence and $\overline{RA_i}$ the mean relative abundance of each category (${}_i$). The RO$_i$ was calculated by dividing the number of samples occurring in one category by the total sample number (${}_n$). The relative abundance (RA$_i$) was calculated by dividing the number of items of a certain category by the total of items of that sample. In a next step, the $\overline{RA_i}$ of each category was obtained by adding the RA$_i$ among the samples and dividing it by the total sample number.

$$AI_i = \left(RO_i \text{x } \overline{RA_i} / \sum_{i=1}^{n} (RO_i \text{x} \overline{RA_i}) \right) \text{x } 100$$

The software *PAST 2.17c* (Hammer *et al.* 2001) was used to verify the suspected existence of annual diet variations between the dry seasons of 2010 and 2011, and seasonal diet variations between dry and rainy season of 2010. A multivariate Non-Parametric MANOVA

(PERMANOVA), which explores the power of a multivariate analysis and Mann-Whitney's U test of each category, was used to assess the level of significance of variations. A *P* level of 0.05 was used for all statistical tests and Bonferroni correction was applied when multiple statistical comparisons were done. A Non-Parametric test was used because data did not meet the homoscedastic and normality assumption.

Regarding the evaluation of sampling adequacy methods, our coefficient of variation was in agreement with the parameters of Durães & Marini (2005). In both periods the coefficient of variation was 10% or less when the diversity curve stabilized, thus below the proposed 15% threshold (Figure 2). Our results match the ones obtained by Durães & Marini (2005) for Atlantic Forest birds and those by Chapman & Rosenberg (1991) for Amazonian Woodcreepers. According to the method, eight to ten samples were enough to statistically estimate the diet of Silvery-Cheeked Antshrike in the shrubby *Caatinga* in both periods.

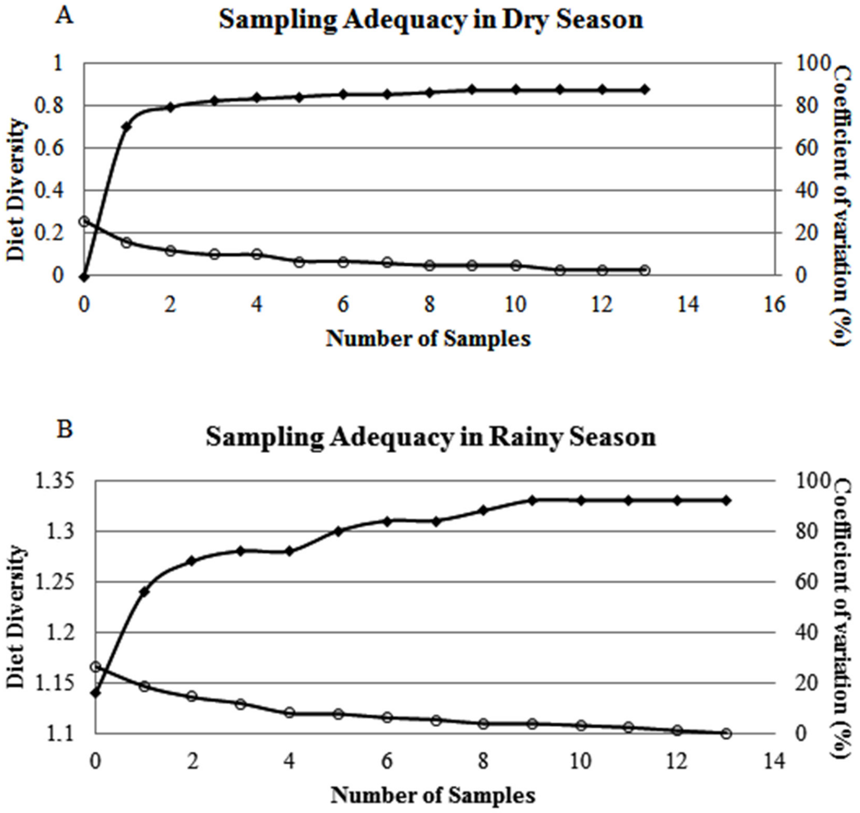

FIGURE 2. Diet diversity (DV, black squares) and coefficient of variation (CV, white circles) of the diet of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*) in the dry and wet seasons. The graphs show that both seasons had adequate minimum sampling to estimate the species diet during those periods. The greater index of diet diversity during the rainy season when compared to the dry season, shows a greater equitability between the different categories consumption rate in the diet during the rainy season.

RESULTS

A total of 6,244 items belonging to 16 categories were identified. In both seasons, there was a predominance of the following categories: Formicidae (ants), Isoptera (termites) and Coleoptera (beetles: A, Adult). Relative abundance and occurrence, food importance index and average items per sample of the different categories are shown in Table 1.

Dry season

We recorded 5,630 items in the 58 dry season samples. The minimum number of items found in one sample was 15, the maximum was 293, and the average was 95.03 items/sample.

Formicidae had the highest rates for all indexes during the dry season. It was present in all samples, which is an extremely significant result considering that 58 stomachs were analyzed. The maximum number recorded was 258 ants in a single specimen. Isoptera was the second most representative category; it also showed high numbers for all analyzed indexes and the maximum number of individuals in a single sample was 181. Coleoptera (A) had much lower index values compared to the previous two categories; nevertheless, beetles were present in 54 of 58 samples.

The other categories had an AI_i equal or less than 1% and were considered rare or sporadical items, including the following: seeds, Coleoptera (L, larvae), Lepidoptera (adults, A, and larvae, L), Hemiptera, Araneae, Pseudoscorpiones, Neuroptera (larvae), Diptera, Chilopoda, Thysanoptera, Acari and Hymenoptera. Five

TABLE 1. Arthropods in the diet of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*). All parameters calculated for each season and category based on 72 stomach samples. (A) adult, (L) larvae.

Category	Importance Index (%)		Relative abundance (%)		Relative occurrence (%)		Average of consumption (Items/sample)	
	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
Formicidae	64.19	29.69	58.30	27.85	100	93	56.60	12.21
Isoptera	31.63	50.26	36.89	50	97	100	35.81	21.79
Coleoptera (A)	3.34	12.26	2.71	10	93	93	2.64	4.14
Hymenoptera	0.73	0.24	1.20	0.82	48	29	1.17	0.29
Lepidoptera (L)	0.06	6.05	0.24	7	24	64	0.24	3.07
Araneae	0.01	0.69	0.14	0.89	10	29	0.14	0.36
Pseudoscorpiones	0.01	0.19	0.09	0.82	7	21	0.09	29
Chilopoda	0.01	0.00	0.09	0	9	0	0.07	0
Coleoptera (L)	0	0.24	0.04	0.99	3	21	0.04	0.43
Lepidoptera (A)	0	0	0.02	0	2	0	0.02	0
Hemiptera	0	0.06	0.05	0.33	5	14	0.05	0.14
Neuroptera (L)	0	0.17	0.04	0.82	3	14	0.03	0.29
Diptera	0	0.16	0.04	0.33	3	0	0.04	0.14
Thysanoptera	0	0	0.02	0	2	0	0.02	0
Acari	0	0	0.04	0	3	0	0.04	0

seeds in four of 58 samples were found, all apparently being of the same species considering the morphological similarity. The diet diversity index was 0.87.

The NP-MANOVA did not show significant difference in consumption of prey between dry seasons on different years (p<0.56), neither did Mann-Whitney's U test for the categories individually. Consumption of items was slightly higher in 2011 than in 2010. We recorded 2,983 items in 2011 (mean = 102.86 individuals/sample) versus 2,648 in 2010 (mean 91.31 individuals/sample).

Rainy season

We identified 614 items in 14 samples. The minimum number of items per sample was eight, the maximum was 82, and the average was 39.74. Isoptera was the most important category (AI_i), occurring in all samples, followed by Formicidae and Coleoptera (A). Another important category was Lepidoptera (L, larvae) (Table 1), even though its indexes were not as significant as the latter categories. Their average consumption was 3.07 individuals/sample, a number similar to that of adult beetles. The other categories summed up 6% of the items found. Chilopoda, Thysanoptera, Lepidoptera (A) and seeds were not recorded in this season. The diet diversity index was 1.33.

Seasonal variation

The NP-MANOVA showed a significant difference in consumption of prey between seasons (p<0.00). The categories that had an acceptable significance level of variation by Mann-Whitney's *U* test were Formicidae (*U* = 42, Z= 4.98 , p <0.00), Coleoptera (A) (*U* = 250.5, Z= -1.88, p <0.04), Lepidoptera (L) (*U* = 190, Z= -3.37, p <0.00) and Araneae (*U* = 293.5, Z= -2.15, p <0.03). The basic statistics can be found in Table 2. There was an abrupt decrease of the total average consumption per specimen with fewer items being consumed during the rainy season than the dry season. The two main categories (Formicidae and Isoptera) had considerable reduction in the average consumption, while Coleoptera (A) and Lepidoptera (L) increased significantly. Regarding consumption of ants, the relative abundance (from 58 to 28%) and the average consumption (from 56.60 to 13.15 individuals/sample) reductions were dramatic. Despite the reduction of average consumption, the second most abundant and important (AI_i) category during dry season, Isoptera, had one of the highest rates in the rainy season. Regarding Lepidoptera (L), this increase is particularly striking: the AI_i increased from 0.06 to 6.05% and the average consumption from 0.24 to 3.07 individuals/sample. There was also an increase in the importance index of nine out of 16 prey categories, indicating a greater diversity of the diet during the rainy season. This increase in the diet diversity is also supported by the diet diversity index variation (dry = 0.87; rainy = 1.33) (Figure 2A, B).

Sampling adequacy

The curves of sampling adequacy showed that both, the dry and the rainy season samplings, were stabilized and thus properly estimated the diet of *S. cristatus* during those periods (Figure 2A, B). In the dry season, the curve began to stabilize with only three or four samples, when the coefficient of variation (CV) reached 10% and completely stabilized with nine samples (CV = 5%). For the rainy season, sampling was stabilized with nine samples, when the CV was 5%.

TABLE 2 (1). Basic statistics for each item in dry and rainy season in the diet of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*).

	Isoptera	Formicidae	Hymenoptera	Coleoptera	Lepidoptera	Hemiptera	Araneae
Dry season							
n	58	58	58	58	58	58	58
Min	0	7	0	0	0	0	0
Max	181	259	7	7	1	1	3
Sum	2069	3189	63	147	15	3	7
Mean	35.67	54.98	1.08	2.53	0.25	0.05	0.12
Standard error	4.89	4.77	0.22	0.22	0.05	0.02	0.06
Variance	1391.13	1324.47	2.95	2.81	0.19	0.04	0.21
Standard deviation	37.29	36.39	1.71	1.67	0.44	0.22	0.46
Coefficient of variation	104.55	66.19	158.32	66.19	170.79	431.91	382.62
Rainy season							
n	13	13	13	13	13	13	13
Min	1	0	0	0	0	0	0
Max	56	48	1	9	8	1	2
Sum	248	156	4	54	38	2	5
Mean	19.07	12.00	0.30	4.15	2.92	0.15	0.38
Standard error	4.62	3.4	0.13	0.77	0.87	0.1	0.18
Variance	278.07	150.66	0.23	7.8	9.91	0.14	0.42
Standard deviation	16.67	12.27	0.48	2.79	3.14	0.37	0.65
Coefficient of variation	87.41	102.28	156.12	67.26	107.69	244.09	169.11

TABLE 2 (2). Basic statistics for each item in dry and rainy season in the diet of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*).

	Pseudoscorpiones	Neuroptera	Diptera	Chilopoda	Thysanoptera	Acari	Seeds
Dry season							
n	58	58	58	58	58	58	58
Min	0	0	0	0	0	0	0
Max	2	1	1	1	1	1	1
Sum	5	2	2	4	1	2	3
Mean	0.08	0.03	0.03	0.06	0.01	0.03	0.05
Standard error	0.04	0.02	0.02	0.03	0.01	0.02	0.02
Variance	0.11	0.03	0.03	0.06	0.01	0.03	0.04
Standard deviation	0.33	0.18	0.18	0.25	0.13	0.18	0.22
Coefficient of variation	393.79	533.77	533.77	370.63	761.57	533.77	431.91
Rainy season							
n	13	13	13	13	13	13	13
Min	0	0	0	0	0	0	0
Max	2	3	1	0	0	0	0
Sum	4	4	2	0	0	0	0
Mean	0.3	0.3	0.15	0.00	0.00	0.00	0.00
Standard error	0.17	0.23	0.1	0.00	0.00	0.00	0.00
Variance	0.39	0.73	0.14	0.00	0.00	0.00	0.00
Standard deviation	0.63	0.85	0.37	0.00	0.00	0.00	0.00
Coefficient of variation	204.88	277.82	244.09	0.00	0.00	0.00	0.00

Arthropod composition

We identified at least 13 ant morphotypes. Among the identified genera, there were *Cephalotes* (Figure 3A), *Pheidole* (Figure 3B) and *Odontomachus* (Figure 3C). At least three morphotypes of *Cephalotes* were identified, making it one of the most frequent and abundant preys in the diet of *S. cristatus*. In contrast, winged ants were rare. Regarding termites, we found the castes of workers (Figure 3D) and soldiers (Figures 3E and 4D), with workers being the most frequent and abundant. No winged termite was found. Among the families of beetles, Curculionidae (Figures 3F and 4E), Chrysomelidae, Cerambycidae, Nitidulidae, Tenebrionidae and Scarabaeoidea (superfamily) were found. Among these taxa, Tenebrionidae, Scarabaeoidea and Nitidulidae are predominantly detritivores and the others are phytophagous. The most common beetle taxa were Curculionidae, Chrysomelidae and Cerambycidae, and among these, two morphotypes of the tribe Naupactini (Curculionidae) (Figure 3F) were extremely common and identified in most samples. Among the non-Formicidae Hymenoptera, wasps (Vespidae) and bees (Apidae) were found.

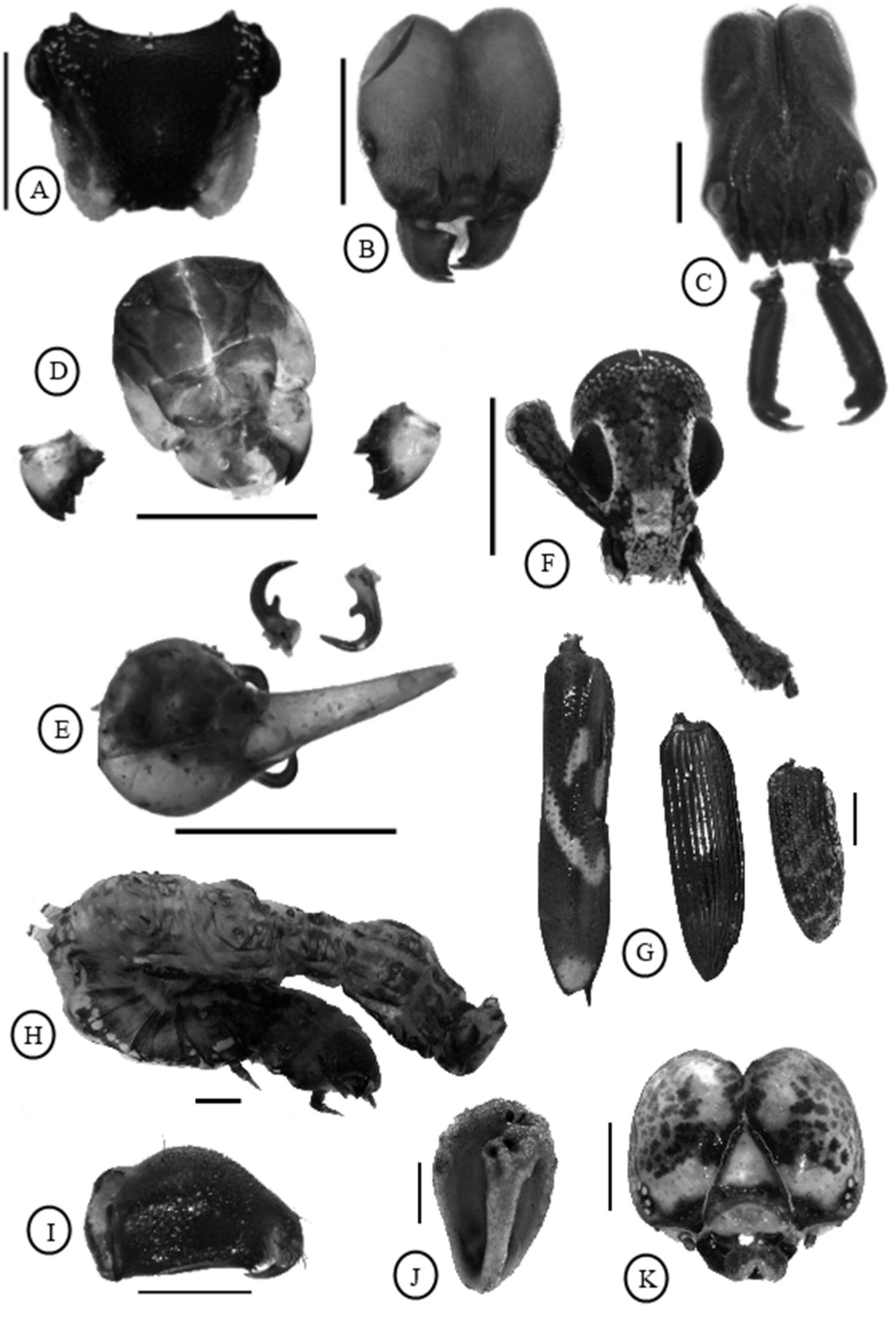

FIGURE 3. Arthropod fragments from the stomach contents of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*). A total of 72 stomachs were sampled. A: *Cephalotes sp.* (Formicidae); B: *Pheidole sp.* (Formicidae); C: *Odontomachus* sp. (Formicidae); D: Worker termite (Isoptera); E: Soldier termite (Isoptera); F: Weevil's head (Curculionidae: Naupactini); G: Sorts of elytra (Coleoptera); H: Caterpillar (Lepidoptera, L); I: Chelicerae (Araneae); J: Seed; K: Caterpillar's head (Lepidoptera, L). Scale bar = 1mm.

The identified spiders belong to Theraphosidae (tarantulas) (Figure 4I), one of them remarkably large, as well as Salticidae (jumping-spiders) and Thomisidae (crab spiders). The hemipterans were rare and very fragmented but the ones we could identify were either lace Tingidae (bugs) or Auchenorrhyncha (cicadas), both typically sap-sucking phytophages. The only dipteran found was a Brachycera (fly) (Figure 4H).

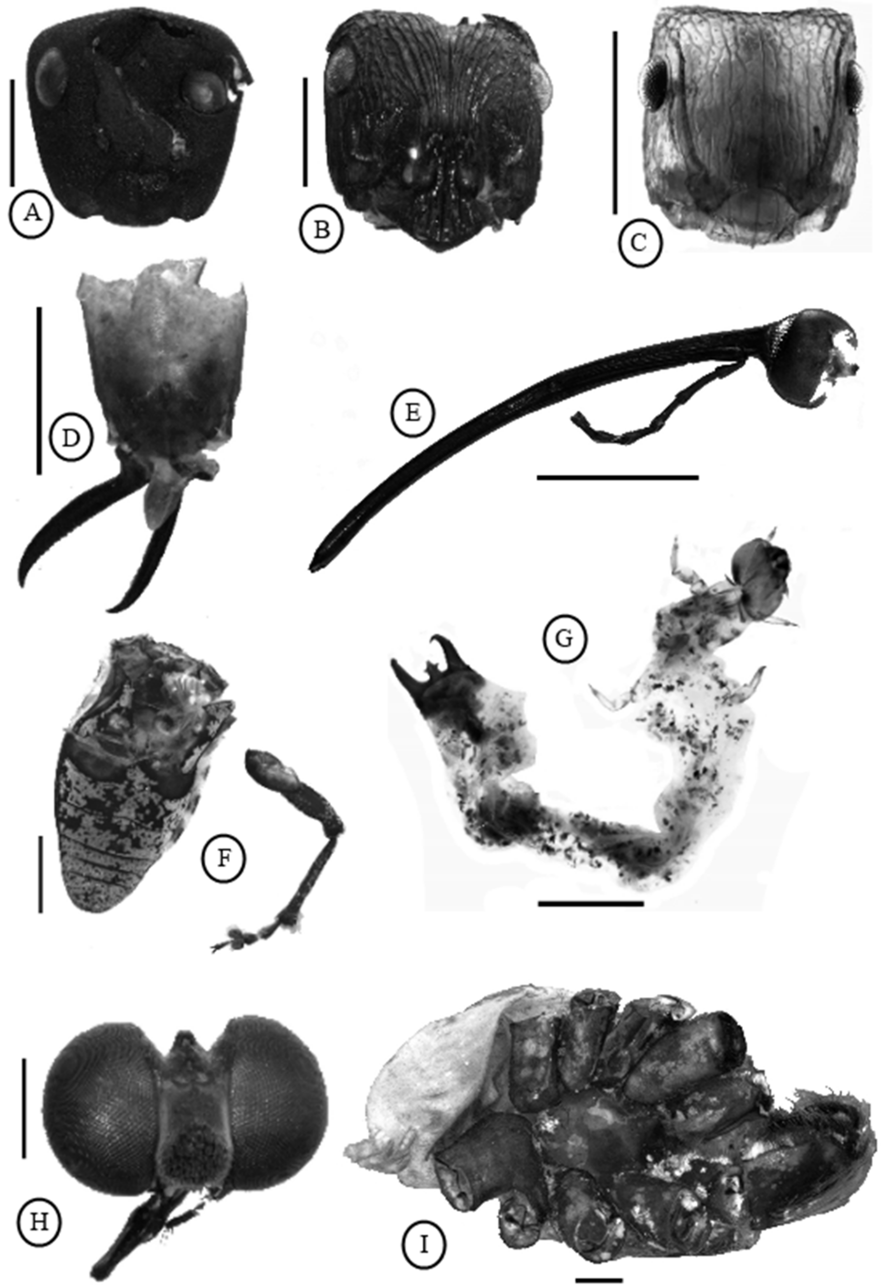

FIGURE 4. Arthropod fragments from the stomach contents of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*). A total of 72 stomachs were sampled. A-C: Ants (Formicidae); D: Soldier termite (Isoptera); E: Weevil's head (Curculionidae: Erodiscinae); F: Weevil's abdomen and leg (Curculionidae); G: Coleoptera larva; H: Fly (Diptera: Brachycera); I: Tarantula (Araneae: Theraphosidae). Scale bar = 1mm.

DISCUSSION

Our data confirmed that the Silvery-cheeked Antshrike is a predominantly insectivorous species. We found that the proportion and occurrence of consumption of the different categories of prey varies significantly between seasons. The taxa most commonly identified were Formicidae, Isoptera, Coleoptera (A) and Lepidoptera (L). Three of these are reported as typical food for Thamnophilidae (Gomes *et al.* 2001, Durães & Marini 2005, Lopes *et al.* 2005, Aguiar & Coltro-Júnior 2008, Manhães & Dias 2008, Lima *et al.* 2010), while apterous termites, one of the most important categories in our study, have not been commonly mentioned in the literature so far, especially not in such great quantities/proportions.

Our results show that ants are one of the key resources to the bird species under study and probably to other birds in *Caatinga*. Their importance was already suggested in previous studies on neotropical birds (Gomes *et al.* 2001, Aguiar & Coltro-Júnior 2008, Lopes *et al.* 2005) and is attributed to their natural abundance (Poulin & Lefebvre 1997, Durães & Marini 2005). Nevertheless, they were the most consumed category during the dry season, when availability of insects and other arthropods in *Caatinga* is extremely low. For nearly all arthropods studied in this biome, there was much greater abundance during rainy season (Vasconcellos *et al.* 2007, Santos *et al.* 2009, Araújo *et al.* 2010a, Araújo *et al.* 2010b, Vasconcellos *et al.* 2010, Oliveira *et al.* 2011) with strong positive correlation with rainfall and relative humidity. The ant populations, however, have an abundance pattern opposite of other insects. Their peak of abundance and activity is during the dry season (Nunes *et al.* 2011, Medeiros *et al.* 2012), which makes them an extremely important resource during this time of the year.

Although apterous termites are not commonly reported in diet studies of neotropical birds as important prey, we found them in our study to be an essential food resource. These insects play a very important role not only in the diet of the Silvery-cheeked Antshrike but in the other *Caatinga* birds since many other bird species of the same area consume them widely (NBN unpublished data). This matches the findings of other vertebrates previously studied in arid/semi-arid environments, including birds, reptiles, amphibians and bats (Advani 1982, Poulin *et al.* 1994, Griffiths & Christian 1996, Gibson 2001, Cabral *et al.* 2006, Hardy & Crnkovic 2006, Kolodiuk *et al.* 2010). Its absence in diet studies is probably due to the difficulty of identifying them, or perhaps the small number of studies made with semi-arid environments' species. Because their body is extremely soft and thin, body parts are quickly digested leaving only their mandibles, which may be confounded with the ones of other insects.

Despite their low abundance, coleopterans were identified in 93% of all samples in both seasons. Their ubiquitousness in studies on the diet of thamnophilids shows that coleopterans are, indeed, essential resources for these birds. Nevertheless, even though they were very frequent in this study, their relative abundance in the diet of Silvery-cheeked Antshrike was very low compared to those obtained in studies of thamnophilid birds in other biomes such as the Amazon and Atlantic Forests (Lopes *et al.* 2005, Vasconcelos *et al.* 2007, Aguiar & Coltro-Júnior 2008). Their presence and predominance in diet studies of birds is often attributed to their hard bodies and the difficulty of digestion of the elytra, which would facilitate the detection of this group (Willis & Oniki 1978). However, that did not happen in the case of *S. cristatus*, where Formicidae and Isoptera were much more abundant. Beetles are either less important for the diet of *S. cristatus* compared to other birds, or underestimated by the lack of a method concerning the mass of each category.

Caterpillars were the fourth most consumed category during the rainy season, but still very relevant in *S. cristatus* diet. Because they are energetically rich and soft bodied they are considered one of the most important food sources for nestlings (Yard *et al.* 2004), as well as for the diet of many adult birds during rainy periods. The importance in the consumption of lepidopteran larvae during the breeding season has already been discussed by several authors, including studies in arid regions (Holmes 1990, Poulin *et al.* 1994, Yard *et al.* 2004, Biondi *et al.* 2005, Lopes *et al.* 2005). The higher consumption of lepidopterans during the rainy season was also observed in stomach contents of other bird species from the same study area (NBN unpublished data). Based on these results we suggest that these insects are also important for the breeding biology of *Caatinga* birds.

The other food categories consumed by Silvery-Cheeked Antshrike were much less numerous. Nevertheless, special attention should be given to the presence of fruits. Poulin *et al.* 1994) observed a higher consumption of fruits by many bird species in an arid region of Venezuela during the dry season, when arthropod abundance and water availability is critical. Even though consumption was very low and probably not significant to *S. cristatus* diet, this may be an evidence of opportunism and plasticity in the feeding behavior of species that live in extreme conditions of survival, such as food or water scarcity (Wendelken & Martin 1988, Poulin *et al.* 1994). Opportunistic and sporadic consumption of fruits during the dry season in other *Sakesphorus* as well as Thamnophilidae species has already been reported (Haverschmidt 1968, Poulin *et al.* 1994, Lima *et al.* 2010).

The diet of Silvery-Cheeked Antshrike seems to be associated with availability of food, which in turn, is most positively correlated with rainfall and relative humidity (except for Formicidae). During the dry season, its diet relies mainly on resources that are able to maintain their population, as in the case of ants and termites. On the other hand, during the rainy season, it consumes more energy-rich food, such as caterpillars and beetles. Even though we did not conduct an insect survey of the area, other studies on insect population fluctuation in the *Caatinga* support our results confirming that the insects consumed by *S. cristatus* are in fact quite abundant during those periods of time (Vasconcellos *et al.* 2007, Santos *et al.* 2009, Araújo *et al.* 2010a, Araújo *et al.* 2010, Vasconcellos *et al.* 2010, Oliveira *et al.* 2011, Nunes *et al.* 2011, Medeiros *et al.* 2012).

Studies on feeding biology, along with others such as breeding biology, taxonomy, and distributional patterns, provide the most basic knowledge about a bird's natural history. This, in turn, comprises the fundamental resource for the conservation of species and environments. The fact that our results are the first information based on stomach contents of any bird in *Caatinga*, being the species addressed one of the most common in the biome, draws attention to a bigger, problematic scenario. Even though our scientific collections and study methods have significantly improved since the work of Moojen *et al.* (1941), many species lack basic information about their natural history. Although this is especially true for birds in *Caatinga*, there still remains a gap for many other species. Thus, we emphasize the need to increase the number of studies focusing on the basic knowledge of Neotropical birds as well as the use of specimens housed in scientific collections.

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APPENDIX

Access numbers of specimens of the Silvery-Cheeked Antshrike (*Sakesphorus cristatus*) whose stomachs were analyzed in this study.

Dry season - 2010: MNA 5169; MNA 5172; MNA 5195; MNA 5219; MNA 5228; MNA 5256; MNA 5266; MNA 5270; MNA 5279; MNA 5286; MNA 5309; MNA 5312; MNA 5319; MNA 5322; MNA 5332; MNA 5333; MNA 5336; MNA 6422; MNA 6445; MNA 6488; MNA 6519; MNA 6520; MNA 6713; MNA 6730; MNA 6742; MNA 6872; MNA 7043; MNA 7061. **2011**: MNA 7065; MNA 5268; MNA 7067; MNA 7056; MNA 7055; MNA 7054; MNA 7045; MNA 6901; MNA 6898; MNA 6896; MNA 6735; MNA 6727; MNA 7060; MNA 7059; MNA 6909 ; MNA 6899; MNA 6893; MNA 6739; MNA 6738; MNA 7382; MNA 7258; MNA 7254; MNA 7066; MNA 7051; MNA 6921; MNA 6741; MNA 6733; MNA 6736.
Rainy season - 2010: MNA 5272; MNA 7024; MNA 7025; MNA 7028; MNA 7030; MNA 7032; MNA 7035; MNA 7036; MNA 7039; MNA 7047; MNA 7048; MNA 7049; MNA 7057; MNA 7062.

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ARTICLE

Population estimate of *Mergus octosetaceus* in the Jalapão region, Tocantins, Brazil

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ABSTRACT: The Brazilian Merganser is a threatened species and classified as Critically Endangered. Its world population is estimated to be fewer than 250 individuals surviving in the wild. Currently, the species is known from disjunct populations distributed in the states of Minas Gerais, Goiás, and Tocantins (in the Jalapão region). For this study, the stretches of the Preto, Novo, Soninho, and Sono Rivers were surveyed by airboat to better estimate the species distribution in the region. Brazilian Mergansers were found only on the Novo River along a stretch upstream from *Da Velha* waterfall. Four pairs and a few other adult individuals were identified there. A 50 km stretch of the Novo River was selected for monthly censuses (n = 13) from August 2009 to October 2010 to estimate the relative abundance and population size of the Brazilian Merganser. The Abundance Kilometric Index was 0.125 individuals/km. The Novo River, from *Da Velha* waterfall until near its headwaters, is 145 km long and our survey estimated a population of 13.7 individuals. Changes caused by uncontrolled tourist activities on the Novo River, such as rafting during the species' breeding season, riparian forest deforestation, and proposed hydropower projects, can negatively impact this small Brazilian Merganser population putting it in great risk of local extinction.

KEY-WORDS: Brazilian Merganser, censuses, river width, Novo River, relative abundance.

INTRODUCTION

The Brazilian Merganser (*Mergus octosetaceus* Vieillot, 1817) is a globally and locally endangered species (MMA 2014, IUCN 2015). It is one of the most threatened waterfowl species of the Neotropical region (Bartmann 1988, Collar *et al.* 1992), with probably less than 250 individuals surviving in the wild (Birdlife 2015). Monogamous and sedentary, it feeds on small fish (Characidae), which are captured during fast dives (Silveira & Bartmann 2001). Its nests are made in tree or rock cavities (Bruno *et al.* 2010, Barbosa *et al.* 2011) right beside water bodies (Lamas & Santos 2004), and its breeding season usually ranges from June to September. It inhabits only shallow, clear water rivers or small streams, with stretches of rapids, and bordered by riparian vegetation. Due to its low population densities and high sensitivity to environmental disturbance, the species is most threatened by the loss of suitable habitat and/or reduction of water quality, complicating the species' conservational status.

Historically, this species occurred in Paraguay, Argentina and Brazil, but is presently only found in the latter country. In Paraguay, the species occurred at the headwaters of the Paraná river basin, where it is currently considered to be extinct in the wild. In Argentina, the species occurred within the Paraná river basin in Misiones, but the last sightings there and within that country as a whole were made in 2002 (Giraudo & Povedano 2003). In Brazil, the species exists as disjunct small populations, occurring in tributaries of the upper São Francisco River, in the state of Minas Gerais (Silveira 1998, Silveira & Bartmann 2001, Lamas & Santos 2004) and right bank tributaries of the Tocantins River Basin, in the states of Goiás and Tocantins (Braz *et al.* 2003, Bianchi *et al.* 2005, Barbosa & Almeida 2010, Barbosa *et al.* 2011). The first records of the species at Jalapão State Park (*Parque Estadual do Jalapão*), eastern Tocantins, were made as recently as 2002 along the Novo River (Braz *et al.* 2003), a tributary of the Sono River basin, at the border of the Jalapão State Park (Figure 1), where it was subsequently recorded (Pacheco & Olmos 2010). Between 2007 and

2010 the species was studied along the Novo River by first author (Barbosa & Almeida 2010, Barbosa *et al.* 2011). Considering the critical status of the Brazilian Merganser and the little knowledge about it at the Jalapão region, we have studied its occurrence and distribution on the main suitable rivers present in the region, estimating population sizes and evaluating the local availability of the species' habitat requirements.

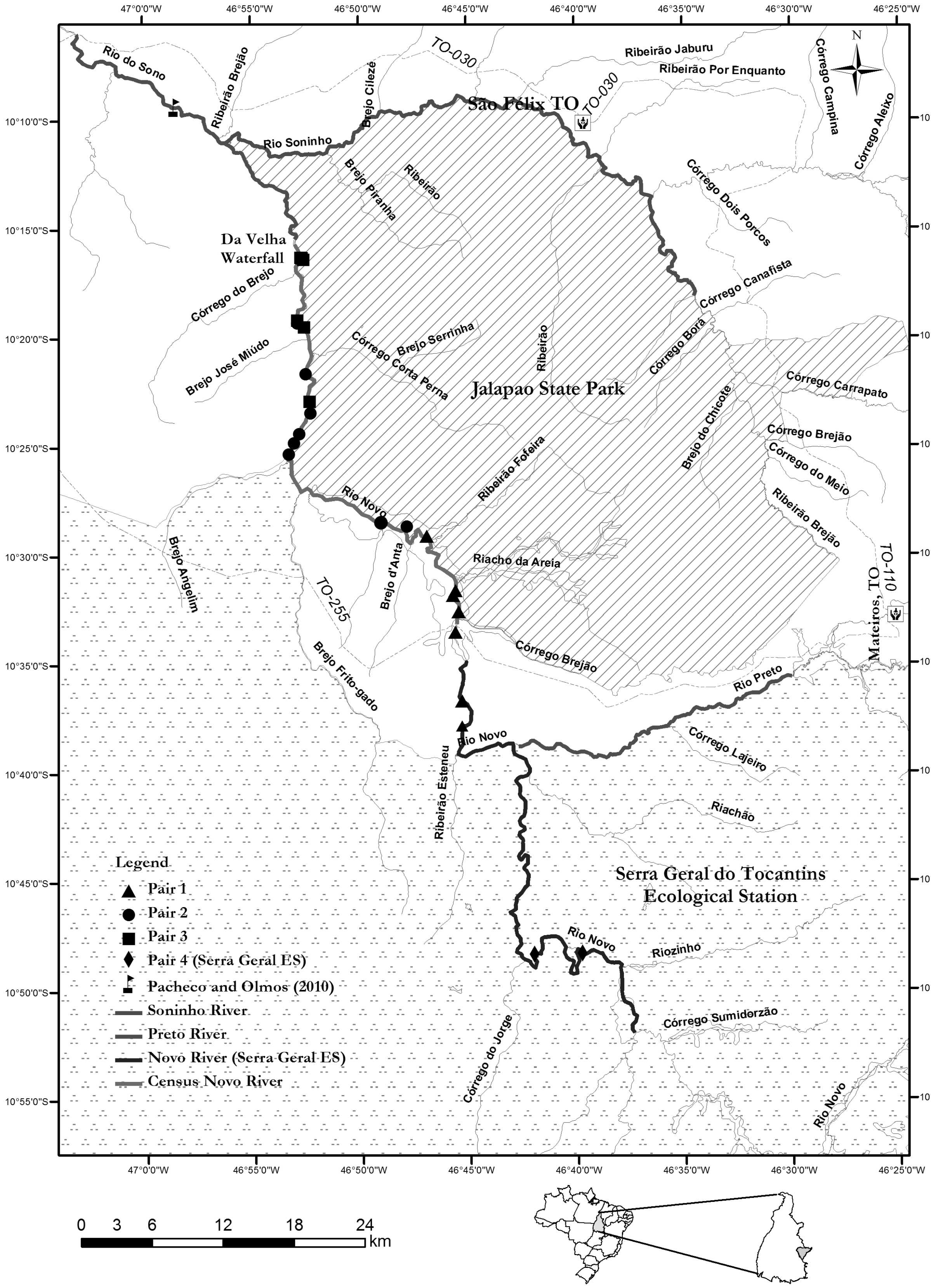

FIGURE 1. Map of the study area showing the distribution of four pairs of the Brazilian Merganser *Mergus octosetaceus* identified along the Novo River during this study as well as a pair on the Sono River (Pacheco & Olmos, 2010). The stretches of rivers surveyed are highlighted in black and grey.

METHODS

Study area

The study was conducted at the Jalapão State Park, located in the eastern portion of the State of Tocantins (10°30'34.87''S; 46°34'36.40''W). The region where the Jalapão State Park was created represents one of the best preserved areas of *Cerrado* in Brazil and it is formed by the different protected areas that together constitute a total area of roughly two million hectares. The largest protected areas are Jalapão State Park (158.885 ha), Serra Geral do Tocantins Ecological Station (645.378 ha), and Nascentes do Parnaíba National Park (645.378 ha).

The climate in the region has two markedly distinct seasons, with a rainy season extending from October to April and a dry season from May to September. The vegetation is *Cerrado* with prevalence of grasslands, which grow on poor (oligotrophic) and sandy soils. The region is characterized also by the presence of plateaus that can reach 800 m, where the headwaters of many watercourses that flow to the Tocantins river basin are located (Von Behr 2004).

Local range

We conducted searches for this species along the Novo, Preto, Soninho and Sono Rivers (this latter river named after the confluence of Novo and Soninho Rivers) by boat. The stretches of Novo and Soninho rivers were surveyed during two days whereas the Preto and Sono along a single day only. These rivers were selected because they present potential habitat conditions for the Brazilian Merganser such as clear water, rapids, and well-preserved vegetation along their banks. The choice of river sections sampled was made based on: 1) previous visits to the study area; 2) previously known observation localities for the species (Braz *et al.* 2003, Barbosa & Almeida 2010, Pacheco & Olmos 2010); and 3) satellite images.

The following stretches were surveyed: 24 km (representing 35% of the total river length) along the Preto River (n = 1), with a starting point at the municipality of Mateiros (10°34'33.96''S; 46°28'21.06''W), in September 2009; 69 km (76%) along the Soninho River (n = 1), with the starting point at the *Chácara da Gildete* (10°20'24.47''S; 46°32'53.02''W), in October 2010; 20 km (9%) along the Sono River (n = 1), with the starting point at the confluence with the Novo River (10°10'58.98''S; 46°56'21.04''W), in October 2010, which included a previously known locality for the species (Pacheco & Olmos 2010); and a total of 130 km (85%) along the Novo River (Ecological Station [n = 2]; *Da Velha* downstream [n = 1]; *Da Velha* upstream [censuses stretches [n = 13]), with the starting point located 25 km downriver from its headwaters (10°51'57.22''S; 46°37'24.75''W) and extending toward its confluence with the Sono River. The different distances surveyed were determined by habitat suitability along each river as well as access and navigability issues.

Characterization of the rivers

In order to characterize each section of the surveyed rivers, we measured variables of the environment and structural differences each 1.5-2.0 km along the Novo (28 points in 50 km), Preto (12 points in 24 km) and Soninho/Sono Rivers (14 points in 27 km). Geographic coordinates and elevation were taken using a Garmin Map60CSx GPS, this being the second measure used to verify the declivity (relative drop in elevation) for each stretch of the rivers sampled. Variables such as vegetation type and clarity of the water, were used to further characterize each river section. We photographed river banks and satellite images were used to aid vegetation analyses at each sampling point. Vegetation types were characterized on both banks according to the classification of Coutinho (1978), i.e., *campo limpo* (open fields), *campo úmido* (wetland), *campo Cerrado* (cerrado field), *cerrado sensu stricto*, *mata ciliar* (riparian forest), and *cerradão* (woods). The clearness of the water was classified in three categories, according to the capacity for clear vision of the river bottom, and ranging from low visibility (dark water) to moderate visibility and high visibility (extremely clear water).

To test how the structural differences on the landscape may affect the presence of the species, we generated probabilistic models based on the presence/absence of the species at the survey points in relation to the following variables: river width, type of flow and flow level. The width of the river was measured through analyses of high-resolution satellite images. Type of flow was classified as "remanso" (slowly-flowing water) or "corredeira" (rapids), and the level of flow was obtained by eye according to the intensity and declivity of each rapid, being attributed the following levels: 1 – low; 2 – moderate; and 3 – high.

Populational data

To estimate the relative abundance of the Brazilian Merganser along the Novo River, we selected a section with nearly 50 km, located between the bridge on the TO-255 road (10°33'02.43''S; 46°45'34.73''W) and *Da Velha* waterfall (10°16'17.29''S; 46°52'44.51''W), where the species had already been documented (Braz *et al.* 2003, Barbosa & Almeida 2010). Monthly censuses (n = 13) were conducted between August 2009 and October 2010 by boat in a controlled speed between 4 and 7 km/h, during five to eight hours per day. Each census started around 08:00 h and lasted for two days.

The identification and classification of the individuals (number of individuals, sex, pairs, groups, and pairs with young) were made from direct sightings using binoculars (Nikon 8 x 42). Each point was georeferenced using Garmin Map60CSx GPS. The difference in elevation on each 5 km at the Novo River was measured in order to verify a possible correlation between the presence of the species and the river gradient of descent. The exact point of each individual/group recorded on the river was taken right after the sighting and they were counted only when parallel to the boat to avoid errors.

In order to determine the proportion of each river section (50 km) that was effectively occupied by the species and to obtain an accurate estimate of the number of individuals that occupy the Novo River, we estimated the Proportion of Occupied Area (Ψ). We selected 28 equidistant points (every 1.5–2 km), defined as surveying sites (the same points used to obtain the variables through the section at the Novo River); therefore, we obtained the records of presence (1) and absence (0) of the species at each of the surveying sites during the censuses. The observation of any individual located 750 m up or down river from each survey site was interpreted as presence at that particular site.

Statistical analyses

In order to identify possible differences in the mean width of the sampled rivers, we conducted a Kruskal-Wallis, non-parametric test. The differences between types of flow were evaluated using CHI-Square Test (χ^2). The correlation between Brazilian Merganser presence and altitude every 5 km along the sampled rivers was obtained by the Pearson Linear Correlation Test, performed using BioEstat 4.0. The significance of each test was $\alpha = 0.05$ (Zar 1999).

Relative abundance of Brazilian Mergansers along the Novo River was estimated using the Kilometrical Abundance Index (KAI) (Telleria 1986), which consists of determining the number of individuals detected per kilometer of survey; here we considered only adult individuals detected on the census section (50 km). That index was estimated for each census period in order to verify possible seasonal variations.

The proportion of the 50-km area that was occupied by the species was obtained using PRESENCE 3.0 (Hines 2006). That algorithm estimates the proportion of area occupied or the probability of a given site being occupied, through comparing the number of sites where the species was recorded in relation to the total number of surveyed sites (MacKenzie *et al.* 2002). The models generated by the software were ranked according to the Akaike's Information Criterion (AIC: Akaike 1974). We used the single-season analysis and the model pre-defined by the software, which considers the proportion of occupied area (Ψ) and a detection probability (P) constant.

In order to verify which landscape features are related to the presence of the species (e.g. river width, type of flow and flow level), we created seven probabilistic models (Table 1) through a simple regression (with one of the variables), including a null model, and using the statistical package *R* 2.13.2, we made simple and multiple regressions. The models were calculated using the AIC, adjusted to small samples (Burnham & Anderson 1998). This method is useful for comparing similar models with different complexity levels; AIC is an index that rank models according to their probability of being selected given the proposed variables, i.e., the smaller the value, the more likely the model to explain the observed data.

TABLE 1. Models of occurrence of the Brazilian Merganser *Mergus octosetaceus* along rivers of the Jalapão region, TO run by software *R*. R Development Core Team. 2012.

Models	Variables	AICc	R²	Δi AIC	AICw	Evidence weight
Model 0	No variables	73.423	0	4.709	0.041	10.534
Model 1	River width	68.714	0.094	0	0.441	1
Model 2	Flow type (rapids)	75.045	0.005	6.33	0.018	23.695
Model 3	Flow level	74.948	0.006	6.233	0.019	22.578
Model 4	River width + Flow type	70.186	0.101	1.471	0.211	2.087
Model 5	River width + Flow level	70.582	0.096	1.867	0.173	2.544
Model 6	Flow type + Flow level	76.941	0.006	8.226	0.007	61.151
Model 7	River width + Flow type + Flow level	71.983	0.104	3.268	0.086	5.126

AICc; value related to the correction for small samples; ΔiAIC (delta) refers to the relative difference of a model to the lowest AIC value, being more representative those values lower than 2.; AICw (evidence weight) is the chance of a model being selected, varying between 0 and 1, on which the highest values represent a higher chance of the model best respond to the species' presence.

RESULTS

Regional distribution

Brazilian mergansers were recorded only in the Novo River at the section located above the *Da Velha* waterfall; no records were obtained along the Preto, Soninho and Sono rivers. During a total sampling effort of 132 hours and 130 km along the Novo River, 125 contacts with Brazilian mergansers were obtained along a 115 km stretch between *Da Velha* waterfall and inside the Serra Geral do Tocantins Ecological Station (Figure 1).

Rivers characterization

The river sections surveyed presented similar features, and in general showed well preserved marginal vegetation with predominance of *Cerrado sensu stricto*, *Campo* and *Mata Ciliar*, and good water quality; however, the river sections are structurally distinct. The Soninho River is relatively narrow, with a total width varying between 26 and 105 m, with a mean of 46.9 m (SD = 22.3 m); that river flows through a steep gradient along its length, with a predominance of rapids (85.7%, $\chi^2 = 7.14$, df = 1, P = 0.007) over smoothly-flowing waters. The flow of rapids was predominately low (66.7%) to moderate (25%), with a low visibility of the river bottom due to the presence of humus related compounds that confer a dark color to the water.

The Preto River was the narrowest one sampled, with a width varying from 10 to 37 m (mean = 14.4 m, SD = 7.73 m). It is a fast river, with 66.7% of the surveyed points composed of rapids, mainly at its central portion, with rapids proportionately distributed with the calmer water sections ($\chi^2 = 1.33$, df = 1, P = 0.24 rather than P = 0.05 or ns). In general, the rapids were moderate (62.5%) to low (37.5%). This river presents a moderate visibility of the bottom, due to the dark color of the water mainly near its confluence with the Novo River.

The Novo River was the widest one sampled, with the width varying between 36 and 170 m (mean = 87.2 m, SD = 32.5 m). The presence of rapids is relatively equal to the presence of smooth current water (46.4% versus 53.6%, respectively), with long sections of each type and no significant difference at the proportions of each type ($\chi^2 = 0.14$, df = 1, P = 0.70 rather than P = 0.05 or ns). That river presents a sandy bottom and very clear water, which confers a high visibility to the river, and sandy banks formed mainly during the rainy season from the sand carried by the smaller tributaries whose headwaters are located in regions dominated by sandstone.

Factors related to the species occurrence

The model that best explained the species occurrence according to the landscape features was model #1, which is represented by the variable river bank/river width (Table 1). However, models #4 and #5, representing variables river width plus type of flow and river width plus level of flow, respectively, presented delta AIC values lower than two. In fact, the width significantly varied among rivers (H = 35.36, P < 0.0001), the Novo River being the widest (mean width = 87.2 m) and the Preto River the narrower (mean width = 14.4 m); moreover, the target species was detected primarily at wider sections of the sampled rivers, where the width varied between 50 and 100 m (Figure 2).

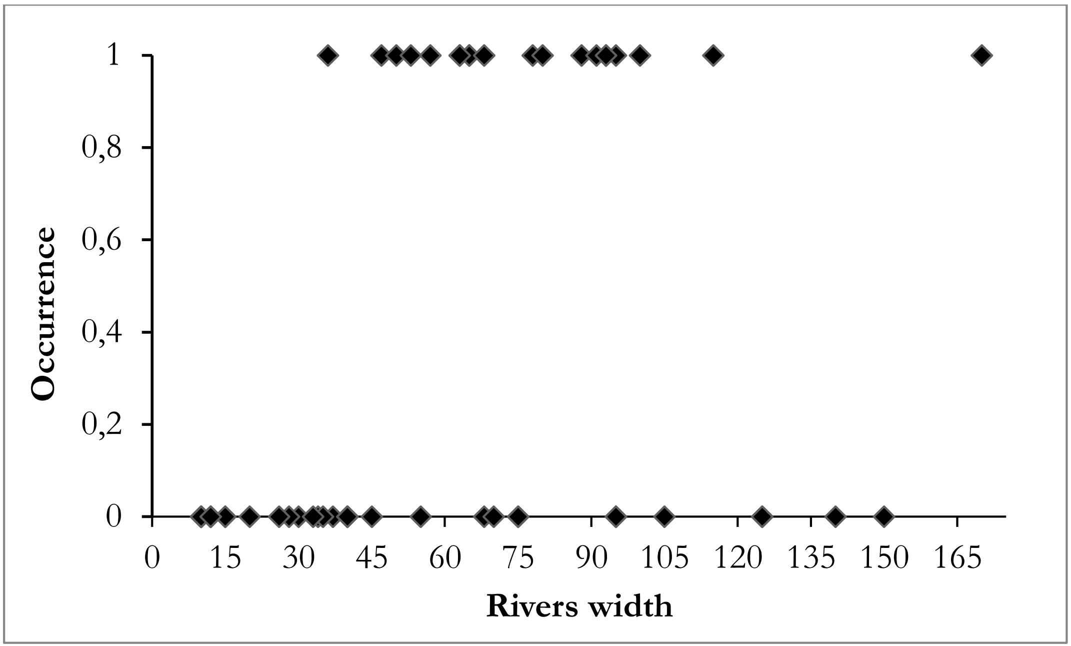

FIGURE 2. Occurrence of the Brazilian Merganser *Mergus octosetaceus* at sampling points along the Novo, Soninho and Preto Rivers, relative to the width of rivers in the Jalapão region, TO. Present = 1 and Absence = 0.

The Brazilian Merganser was recorded only on the Novo River, with most of the contacts (87.3%) made within the lotic section, an area of highest gradient descent and with presence of rapids (Figures. 3A and B). At that section, there is a positive correlation (P = 0.0077) between the number of contacts and the difference of river gradient calculated at each five kilometers (Figure 4). Even though there was no significant correlation found, in general the species was more frequently recorded in river sections with presence of rapids (χ^2 = 2.18, df = 1, P = 0.13 rather than P = 0.05 or ns) than in calm waters, and with a predominance observed within low intensity rapids. The contacts obtained in rapids level 1 (70.59%) were significantly more frequent (χ^2 = 24.06, df = 1, P < 0.0001) than those obtained in remaining levels. The results agree with the other two selected models (#4 and #5), which associate the variable "river width" with type and level of flow (Table 1).

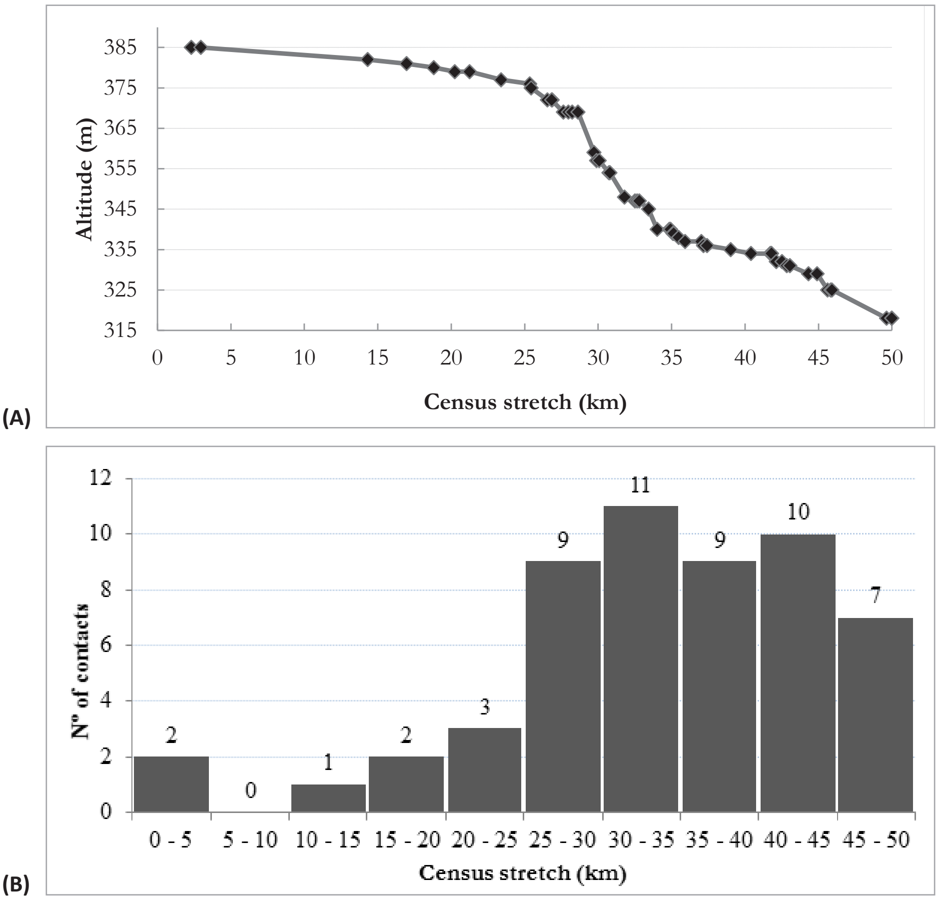

FIGURE 3. (A) Altimetry of contact points with the Brazilian Merganser *Mergus octosetaceus* along a stretch of Novo River (50 km), Jalapão, TO. (B) Frequency of contacts with the Brazilian Merganser *Mergus octosetaceus* at intervals of 5 km along a stretch of Novo River (50 km), Jalapão, TO.

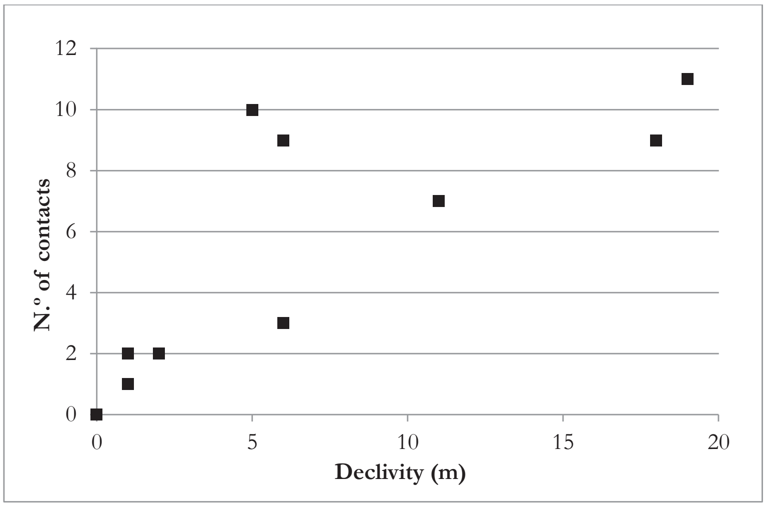

FIGURE 4. Correlation between the number of contacts with the Brazilian Merganser *Mergus octosetaceus* and declivity difference calculated at every 5 km of surveyed stretch of the Novo River (50 km), Jalapão, TO (Pearson r = 0.7876, P = 0.0077).

Populational data

Relative abundance of the Brazilian Merganser along the Novo River was 0.125 individuals/km. Based on that value, we estimate a total of 6.23 individuals for the 50 km section of the Novo River selected for the censuses. Considering the length of 145 km between *Da Velha* waterfall and *Riacho Verde* (near its headwaters) – the only section where the species were confirmed – we estimate a population of 18 adult individuals inhabiting the Novo river, which has a total length of roughly 160 km (Table 2).

Estimation of Occupied Area Proportion of the Novo River was Ψ = 0.7563, i.e., 75.6% of the surveyed section was occupied (Table3). Based on these data and considering that the estimate for the 145-km section with the species occurrence is equivalent to that obtained at the sections where the censuses were made, we estimate a population of 13.7 individuals for the Novo River. Subsequent surveys conducted in September and October 2009 and July and August 2010 in a 115-km section of the Novo River (including the sections of census and at the Serra Geral do Tocantins Ecological Station), the observed population size is similar to the estimated, with 12 individuals recorded in 2009 and 14 in 2010.

Species' distribution at the Novo River

Brazilian Mergansers were present in all censuses at the Novo River, and a total of four distinct pairs were identified, with three of them (Pairs 1, 2 and 3) being previously recorded (Barbosa & Almeida 2010). A total of 14 ducklings were recorded for those three pairs (see Barbosa & Almeida 2010 for 2007–2009 data). However, it was observed that there appeared to be a reduction of the survival of the ducklings of pairs 2 and 3, which occupy an area in which local people use to practice rafting (Table 4). The fourth pair was recorded at Serra Geral do Tocantins Ecological Station (Pair 4, Figure 1). During the survey throughout the Novo River, located inside the Serra Geral do Tocantins Ecological Station, during the reproductive seasons of 2009 and 2010, no ducklings were recorded accompanying that pair. The characteristics used to define a pair were the presence of a close relationship between individuals and the presence of a worn nuchal crest on the female, regarded as evidence of recent mating. Single individuals and/or groups of up to three individuals presenting adult plumage were observed on the Novo River as well, sometimes occupying the same river section as the pairs.

TABLE 2. Relative abundance and population estimates of the Brazilian Merganser, *Mergus octosetaceus*, along the Novo River, Jalapão, TO.

Census	N.° of adults observed per census	KAI (50 km)	PopEst (145 km)	PopEst*Ψ
Aug 2009	7	0,14	20,3	15,4
Aug 2009	9	0,18	26,1	19,8
Sep 2009	4	0,08	11,6	8,8
Nov 2009	7	0,14	20,3	15,4
Dec 2009	4	0,08	11,6	8,8
Feb 2010	9	0,18	26,1	19,8
Mar 2010	5	0,1	14,5	11
Apr 2010	5	0,1	14,5	11
May 2010	8	0,16	23,2	17,6
Jun 2010	7	0,14	20,3	15,4
Jul 2010	5	0,1	14,5	11
Sep 2010	6	0,12	17,4	13,2
Oct 2010	5	0,1	14,5	11
Mean (±SE)	**6,23** (±0,48)	**0,125** (±0,01)	**18,07** (±1,40)	**13,7** (±1,06)

(KAI) Kilometric Abundance Index for the census stretch - 50 km; (PopEst) Populacional Estimate for a stretch of 145 km; (Ψ) Proportion of Area Occupied (PAO) obtained at the census stretch (Ψ = 0,7593).

TABLE 3. Modeling of the proportion of area occupied by the Brazilian Merganser *Mergus octosetaceus* on a stretch (50 km) of the Novo River, Jalapão, TO, obtained with the software PRESENCE.

Model	AIC	AIC wgt	*P* (± SE)	Ψ (± SE)	Ψ Observed
Constant *P*	300,97	1.0	0.1954 (0.0266)	0.7593 (0.0931)	0.7142

AIC - Akaike's Information Criterion; AIC wgt – model weight; *P* - probability of detection; Ψ – Proportion of area occupied (Ψ Observed, i.e, ration between the total sampled sites by the number of sites with presence of species).

TABLE 4. Number of ducklings recorded of three pairs of the Brazilian Merganser *Mergus octosetaceus* on a stretch of Novo River during 2009 and 2010.

Year	Pairs	N.º of ducklings	Date	Locality/stretch	Coordinates (Datum WGS 84)	Details/observation
2009	Pair 1	?	?	Pair not detected on the stretch. It was occupying the stretch of river (APA Jalapão) upstream of bridge over TO-255 road, out of the census stretch.		
	Pair 2	1 *	02 August 2009 20 August 2009	Novo River, 3 km downstream of Corta Perna stream (700 m away from Pair 3).	10°19'S, 46°52'W 10°21'S, 46°52'W	(*) Pair observed on September 23 without ducklings.
	Pair 3	2 *	02 August 2009 20 August 2009 23 August 2009	Novo River, 2.3 km downstream of Corta Perna stream.	10°19'S, 46°52'W 10°19'S, 46°52'W 10°16'S, 46°52'W	(*) On November 25, the pair was observed without ducklings.
2010	Pair 1	5	12 August 2010	Novo River/APA Jalapão, upstream of Korubo camping.	10°36'S, 46°45'W	Pair observed during survey into the Serra Geral do TO (SGTES).
	Pair 2	6 *	27 July 2010 16 September 2010 15 October 2010	Novo River, 3 km downstream of Praia dos Crentes.	10°28'S, 46°47'W 10°24'S, 46°52'W 10°24'S, 46°53'W	Ducklings with about a week of age; (*) On 16 September 2010 the pair was found with 5 ducklings (with about two months of age) and on 15 October 2010 4 ducklings already capable of flight were observed.
	Pair 3	x	28 July 2010 16 September 2010 15 October 2010	Novo River, stretch near the nest.	10°19'S, 46°52'W 10°19'S, 46°52'W 10°18'S, 46°52'W	Nest found on 10 June 2010 with a female inside it. Probable nest desertion due to the presence of the boat.

(*) Observed decrease in the number of surviving ducklings during subsequent surveys.

DISCUSSION

The Jalapão region includes an important portion of the water courses that converge within the Sono river basin, which flows into the Tocantins River. Considering the exceptional features of the streams in this region, the low density of human population (Mamede *et al.* 2002) and the vast portion of protected, well preserved riparian areas, we expected that the region could shelter a larger population of Brazilian Merganser than what we found, as observed at Serra da Canastra, in the State of Minas Gerais, where approximately 80 individuals are known to occur (Lamas 2006). Most of the water courses in the Jalapão region represent small to narrow streams, forming the typical *veredas* and with marginal vegetation and low water volume, thus not providing the most favorable conditions for the species occurrence. Therefore, we believed the larger streams would represent areas of greater potential occurrence of the species in the study site. However, we observed this greater presence only on the Novo River.

The Novo River presents some distinctive features that distinguish it from the others surveyed (Preto, Soninho and Sono), especially concerning its width. It is considerably wider than the others, which we believe is an important condition for the presence of the Brazilian Merganser in the Jalapão region. Nevertheless, in other sites where the species is known to occur (e.g. Serra da Canastra and Chapada dos Veadeiros) it reportedly occurs in narrower streams than the Novo River. It is important to highlight that the river width itself is not an essential feature for the presence of the species throughout its range. In general, records were obtained in portions of the River Novo that varied between 50 and 100 m in width (Figure 2), an interval distinct from the mean width of Preto and Soninho Rivers. Wider sections allow birds to have a wide visual field, which would facilitate protection from natural predators and of humans disturbance (humans are commonly present at Novo River, mostly due to the practice of rafting and of camping in river banks).

Clearness of the water is also an important factor that distinguishes the Novo River from the others present at the region. The low depth and presence of sand and sandstone sediment favor seeing and capturing prey by the mergansers, which could also be a important factor for presence of the species along this river. The Novo River differs from the other rivers in the region also in the higher percentage of rapids along its course, due to having more sections with higher gradient descent. Due to the fact that the lotic parts of the river correspond to the sites where the species was detected, it is important to highlight that the presence of rapids itself is not an essential feature for the presence of the species, as all the other rivers surveyed presented rapids on their courses as well. However, when variables such as type of flow, flow level and river width are associated (models #4 and #5), it becomes evident that the merganser selects a set of landscape features as their habitat.

A few studies highlight that the Brazilian Merganser occurs exclusively on upland rivers, inhabiting the upper portions of rivers where the presence of large, aquatic predators (*ictiofauna*) would be a limiting factor (Partridge 1956, Willis & Oniki 2003). On the upper Novo River, the *Da Velha* waterfall works as a natural barrier to large predatory fishes, preventing the occurrence of species such as Jaú (*Zungaro zungaro*) and Caranha (*Pyaractus brachipomus*), among others that occur at Soninho, Sono and the lower portions of the Novo River. Thus, the absence of those predators along Novo River, upstream from *Da Velha* waterfall, may play some role in the observed presence of the species on that portion of the river.

Pacheco & Olmos (2010) mention the presence of a pair of Brazilian Merganser on a sandy bank at the Sono River, roughly 5 km downstream from the confluence of Novo and Soninho Rivers. The pair was spotted during a flyby, as part of a rapid ecological assessment of the region. In the present study, we surveyed 69 km along the Soninho River and 20 km along the Sono River, including the spot where Pacheco & Olmos (2010) obtained the aforementioned record, but without observing any Brazilian Merganser there. Considering that the species was detected in all censuses along the Novo River, and that it has been reported along the Sono River as well, we expected that the species would be recorded there too.

Beginning in 2011, new fruitless searches were made along the Soninho River (Valtécio Carvalho *pers. comm.*). Moreover, during a study for the implementation of a hydroelectric plant at Perdida River, an important tributary of the Sono River, intensive searches for the species were also unsuccessful. Although our sampling effort has been small (n=1), these data and information seem to indicate the absence of the species at Sono and Soninho Rivers is real and may mean they are extinct there at present.

Conservation at the Jalapão region

Among the main factors that can potentially threaten the local population of the Brazilian Merganser at Jalapão region are the establishment of hydroelectric plants and the practice of rafting. The modification of the flow is considered the most serious and permanent threat to the ecological sustainability of rivers and their banks (Sparks 1995, Lundqvist 1998, Ward *et al.* 1999). The impoundment of a river represents the interruption of an open-end transport system to a closed and accumulation system (Junk & Mello 1990). According to Bunn & Arthington (2002), the modification of the water flow changes the habitat and influences the species' distribution and abundance, as well as the diversity and composition of the aquatic communities. Regarding the rivers in the Jalapão region, changes in water flow by impoundment caused by future hydroelectric ventures planned for the Novo and Sono rivers, similar to eight plants constructed on the Palmeiras River (at the outskirts of Serra Geral do Tocantins Ecological Station) and two under construction on the Perdida River (tributary of the Sono River), could affect and threaten the survival of the already small population of Brazilian Mergansers that inhabits the region.

An important threat to the species' survival within the Novo River is the practice of rafting by tourists where the species was previously known to reproduce (Barbosa & Almeida 2010, Barbosa *et al.* 2011). The peak of that sporting activity coincides with the species' reproductive season and the disturbance caused by such activity may affect the species' reproductive dynamics and interfere with mating, nest construction, incubation, and duckling survival. We have witnessed that during approach by boats, ducklings disperse and are temporarily abandoned by the parents. In some cases the disturbance keeps the ducklings away from the parents for a prolonged time, with the risk of getting lost and/or being more exposed to predation. We also noticed an extensive degree of movements along the river of adults and ducklings following disturbance by rafting that may contribute to a lower efficiency of ducklings' foraging and lower reproductive success and recruitment.

The fact that the Brazilian Merganser presently occurs only on the Novo River upstream from *Da Velha* waterfall in the Jalapão region, reinforces the importance of that river section for the survival of the species at its northernmost range limit. Concerning the pairs we recorded, only one can be considered to be protected, since it occurred inside the Serra Geral do Tocantins Ecological Station. The other three pairs inhabit stretches at Área de Proteção Ambiental do Jalapão (reserve of sustainable use), or at the borders of Jalapão State Park, which are not entirely protected. For the effective protection of such pairs it seems important to enlarge the area of the Jalapão State Park, or create new protected areas that encompass the left bank of the Novo River, as suggested by Barbosa and Almeida (2010). It is also important that an effective control of the practice of rafting is established to avoid high disturbance especially during the reproductive season, and that education initiatives focused on informing tourists and local communities about the importance of conservation of the Brazilian Merganser in the Jalapão region be put in place.

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ARTICLE

An intratropical migratory passerine can quickly improve its physiological condition during post migration, reproduction and departure phases on the breeding site in the *Cerrado*

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ABSTRACT: Migration and reproduction are energetically expensive processes that migratory animal species must confront during their life-cycle. The relationship between hematocrit and mass in birds highlight their ability to invest energy in activities such as reproduction and migration and face costs linked to all subphases. We tested three hypotheses to evaluate the relationship between hematocrit and mass for an intratropical migrant bird, the Lesser Elaenia (*Elaenia chiriquensis*): (1) In the arrival phase, we expected that there would be a decrease in mass accompanied by a drop in hematocrit levels in a negative linear relationship; (2) during the reproduction phase we expected, at most, a weak relationship and a decrease in mass and hematocrit, due to the physiological complexity of this phase; (3) on the departure phase, we expected an increase in mass complemented by an increase in hematocrit as a positive linear relationship. We found that the Lesser Elaenia has average mass and hematocrit levels in the arrival phase similar to those in the other phases, thus not showing the expected trend as predicted above. On the other hand, during the reproduction phase, as expected, there was no significant relationship between mass and hematocrit levels, whereas a strong relationship between these variables was detected during the departure phase. Overall, the Lesser Elaenia arrives in good condition in their breeding sites, then it undergoes some physiological stress during the breeding period, but later is able to rapidly recover optimal physiological conditions upon departure to wintering grounds.

KEY-WORDS: breeding, body condition, *Elaenia chiriquensis*, hematocrit, life cycle phases, intratropical migration.

INTRODUCTION

Migration and reproduction are the two most energetically expensive processes that migratory species must face during their annual life-cycle. These processes impose drastic changes in energy demands, which require a series of physiological adjustments. Before migration, birds increase in body mass principally by storing fat for later use as fuel during flight (Newton 2008). However, other birds build muscle while reducing fat reserves. Muscle augmentation occurs as a consequence of hypertrophy of muscle tissue involved in flight (e.g. heart muscles and the pectorals), providing an alternative source of fuel and increased muscle strength and endurance (Whittow 2000, Arizmendi-Mejía *et al.* 2013). Migration is related to the status of a bird's physiological condition, thus birds in bad conditions tend to migrate later (González-Prieto & Hobson 2013). In addition, species that migrate without stopping rely solely on their endogenous resources to supply the energy during migration. Therefore, the nutrients and energy supplies are severely depleted as the bird arrives to its destination (Battley *et al.* 2001).

Understanding the underlying physiological processes necessary to achieve an adequate nutritional state for reproduction is essential, as it can have important consequences for individual fitness and future reproductive success. The ecophysiology of the post-migratory period preceding breeding (e.g. from arrival on the breeding grounds to egg-laying) has received relatively little attention (Arizmendi-Mejía *et al.* 2013) compared to the ecophysiology of the pre-migratory period (e.g. Marsh 1984, Jenni-Eiermann & Jenni 1991, Bairlein & Gwinner 1994). After arriving at the breeding grounds, migratory birds must recover their body condition and prepare for reproduction (e.g. defense of breeding territory, searching for mates, copulation, nest construction, and caring for nestlings and fledglings). These breeding activities impose additional energetic costs to birds already exhausted from migration (Arizmendi-Mejía *et al.* 2013). In addition, females need a substantial amount of lipids and proteins for the formation of eggs (Navarro *et al.* 2007, Eichhorn *et al.* 2010). Females in the best condition, generally characterized by high body mass, produce more offspring, while heavier males have higher survival rates than lighter individuals (Chastel *et al.* 1995). Moreover, conditions during reproduction and just before migration are also critical factors that influence survival, reproductive decisions and future reproductive success (Chastel *et al.* 1995). These decisions are particularly important for birds because individuals that are in poor condition may restrict investment in current reproduction in order to lessen its impact on future reproductive attempts (Williams 1966, Stearns 1992, Crossin *et al.* 2012). For example, Black-browed Albatross (*Thalassarche melanophris*) females that delay reproduction are in poor condition and have lower levels of steroids and yolk precursors (Crossin *et al.* 2012). Research on the condition of birds during phases of arrival, reproduction, and departure on a subsequent migration have focused mainly on some temperate passerines, marine birds, and other waterfowl, whereas tropical birds have received relatively little attention.

Avian body condition can be studied by measuring biochemical metabolites in the blood plasma and other hematological parameters (Vanderkist *et al.* 2000, Jenni-Eiermann *et al.* 2002). One of the most widely used hematological parameters is hematocrit, which serves as a good indicator of an individual's metabolic activity, nutritional status, and ability to transport oxygen (Ots *et al.* 1998, Whittow 2000, Lisečić *et al.* 2013). Hematocrit is the relative volume of erythrocytes in the total volume of blood (Bearhop *et al.* 1999). The lowest hematocrit levels for females occur during ovulation and hormones such as estrogen may diminish hematocrit (Rehder & Bird 1983, Whittow 2000). Although variation in hematocrit is incompletely understood in birds, it is greatly influenced by levels of dehydration and nutritional status (Hill *et al.* 2008). The relationship between blood volume and body mass is well-known for healthy humans and is widely utilized in hematological calculations in the treatment of diseases. Blood composes approximately 7 to 8.5% of an animal's body weight (Prosser & Weinstein 1950). In small mammals, hematocrit is correlated with body size, and is generally elevated due to high cardiorespiratory rates and lower body surface (Sealander 1964). In birds, differences between the values are based primarily on body size (Hatch & Smith 2010). Factors like age, sex, reproduction, elevation, parasitism, and nutritional status have been hypothesized to influence hematocrit values among wild birds (Fair *et al.* 2007).

Thus, different predicted relationships between body condition (as indicated by mass) and hematocrit levels exist during different phases of the life cycle, such as migration and reproduction. High levels of hematocrit are principally associated with an increase in intense physical exercise (Hõrak *et al.* 1998). For instance, low hematocrit levels (e.g. anemia) are associated with bacterial infections, the presence of parasites, and insufficient levels of micronutrients such as iron, copper, and vitamin B12 (Coles 1997). Hematocrit indicates intense aerobic and metabolic activities with relationship with the loss and gain of mass of an organism and overall health condition (Burkhard *et al.* 2001, Navarro *et al.* 2007). Hematocrit levels are highest as birds arrive on the breeding sites, and change substantially during the reproductive season, being expected to increase before departure for the wintering grounds (Jenni-Eiermann & Jenni 1994, Morton 1994). During the arrival phase at breeding grounds, for example, Montane Sparrows (*Zonotrichia leucophrys*) show relatively high levels of hematocrit until the end of nest construction (Morton 1994). Another research showed that hematocrit could be used to predict changes in body mass of migrants (Jenni-Eiermann & Jenni 1994).

Here, we examine the variation in body condition during three phases of the life cycle of a migratory Neotropical bird, the Lesser Elaenia (*Elaenia chiriquensis*). We analyze variation in body mass and hematocrit during: 1) arrival (post-arrival/pre-reproduction); 2) reproduction; and 3) departure (post-reproduction/pre-departure) on the breeding grounds. We hypothesize that phase and mass are related and affect hematocrit values on different periods of Lesser Elaenia breeding and migration, being a proxy of its ecophysiological condition. We predict that in the arrival phase, there will be a decrease in mass accompanied by a drop in hematocrit; during the reproductive phase there will be a weak or no relationship between mass and hematocrit levels due to the physiological complexity of this phase, with expected low levels for both hematocrit and mass; and finally, during the departure phase we expect an increase in mass accompanied by an increase in hematocrit (Morton 1994, Jenni-Eiermann & Jenni 1994, Arizmendi-Mejía *et al.* 2013).

METHODS

Study Species

The study species, the Lesser Elaenia (*Elaenia chiriquensis*), is a tyrant flycatcher, 11 centimeters in length, distributed from Costa Rica to Argentina (Ridgely & Tudor 1994). The species breeds in central-southeastern Brazil and migrates north apparently to the Amazon region (Marini & Cavalcanti 1990). Its breeding biology is well-known. In Distrito Federal, central Brazil, reproduction occurs from mid September until early December, when it constructs a cup-shaped nest and generally deposits two primarily white and spotted eggs (Medeiros & Marini 2007, Paiva & Marini 2013).

The Study Area

Data were collected within a 100-hectare grid at the Estação Ecológica de Águas Emendadas (hereafter ESECAE) in the Distrito Federal (15°29'S to 15°36'S, 47°31'W to 47°41'W; 1040 m altitude), central Brazil. ESECAE is an important protected area within central Brazil that is surrounded by other smaller protected areas, agriculture lands, and housing areas (Marinho-Filho *et al.* 1998). The area is characterized by both open and dense savannahs, as well as patches of forest and grasslands typical of the *Cerrado* region of Brazil. The climate of the region is strongly seasonal with a rainy season that extends from September to April, and a strong dry season during the other months of the year (Nimer 1989). More details about the area and about *Cerrado* are presented in Borges & Marini (2010) and Duca & Marini (2011).

Lesser Elaenia Captures

Birds were caught weekly with 5 mist-nets from August to December 2012, totaling 1,140 net-hours (19 weeks, four days a week and 3 hours a day). The first Lesser Elaenia of 2012 arrived on August 10. We considered the preceding 15 post-arrival days as the “Arrival phase” of the life cycle. In addition, the first individual with a brood patch was recorded on 3 of September, signifying start of breeding activities. The proportion of individuals with brood patches increased from the third week of September to the third week of November, thus we considered this period as the “Reproductive phase”. As birds begin to depart by the third week of December, we considered the period from 15 to 30 December as the “Departure phase”. During this period, few individuals maintained brood patches, implying in cessation of breeding activities. The Lesser Elaenia has very predictable departure dates (Paiva 2008, Paiva & Marini 2013).

Blood collection

Captured individuals had a small volume of their blood collected (70 to 140 μL) and were marked with a uniquely numbered aluminum band. Mass of the individual and the presence of a brood patch were recorded. Blood samples were obtained through the puncture of the brachial vein and collected via a heparinized capillary tube. The collection of blood conformed to ethical standards dealing with manipulation of wild animals, and the total blood collected from an individual did not exceed 1% of the individual’s body mass (Thrall 2004). After collection, capillary tubes were sealed at one end and stored on ice. The blood samples were centrifuged for 10 minutes in a micro-hematocrit centrifuge at 12,000 rpm. Hematocrit was measured immediately after centrifugation of the samples with a micro-hematocrit table. The hematocrit values reported here represent averages of two or three micro-hematocrit capillary tubes per individual.

Statistical Analysis

To achieve the objectives, an ANCOVA model was used to assess the effects of different phases of the life cycle, body mass and the interaction between these variables on the hematocrit levels (hematocrit~phase+mass+phase*mass). Normality of the residuals for mass and hematocrit level across the life cycle phases was assessed via Shapiro-Wilk tests and values are presented in mean and standard deviation format. Post-hoc comparisons were performed using Tukey’s test to compare average hematocrit values between different life cycle phases. All analyses were performed in Program R.

RESULTS

Contrary to expectations, hematocrit levels were not low when the Lesser Elaenia arrived at the breeding site. They were, however, relatively balanced compared to the average presented by the species during the departure phase (Table 1). In the reproductive phase, as expected, hematocrit showed low levels, which increased during the departure phase, also corroborating initial expectations (Table 1). In fact, there were significant differences in hematocrit for the different phases and the Tukey test indicated a significant difference during the departure period in relation to the arrival ($t = 2.76$, $P < 0.001$) and reproductive ($t = 4.39$, $P < 0.001$) periods. Hematocrit values averaged 54.44 ± 3.35% ($n = 99$), and surprisingly, nine individuals preparing to depart for the non-breeding grounds had hematocrit levels between 60 and 62%, a high value not recorded during other phases of the Lesser Elaenia sampling period. It is important to mention that plasma, the blood component remaining after centrifugation to access hematocrit, changed equally showing equilibrium on arrival, a small decrease in reproduction and an increase during the departure phase (Table 1).

The mass of the Lesser Elaenia in the arrival phase diverged from what was expected because it was relatively high compared to the averages exhibited during the total period (Table 1). There was a small decrease in mass during reproduction, but still close to average, and an increase in mass, as expected, during the departure phase (Table 1). Mass averaged 15.85 ± 1.29 g (n = 99), and differences between the phases are significant (F = 16.71, $P < 0.001$), especially relative to the departure phase, with individuals weighing approximately 16 g, and with little variation in the population.

The linear model explained variations in hematocrit levels of the Lesser Elaenia, including different phases (arrival, reproduction and departure), mass and the interaction between these variables (Table 2). Based on these relationships, the model demonstrated that the mass effect on hematocrit levels in the Lesser Elaenia was significant during the departure phase, and that the relationship between hematocrit level and the departure phase itself was highly significant (Table 3).

The effect of mass is demonstrated by the significant linear relationship between this parameter and hematocrit ($F_{2,98} = 50.06$; r = 0.13; $P < 0.001$) (Figure 1A). There was no significant correlation in the arrival ($F_{2,27} = 0.27$, r = 0.03, P = 0.402) (Figure 1B) and reproductive phases ($F_{2,45} = 5.03$, r = 0.003, P = 0.479) (Figure 1C). However, in the departure phase, although the mass of individuals increase, there is a significant increased in hematocrit, with a robust relationship between mass and hematocrit ($F_{2,24} = -47.98$, r = 0.51, $P < 0.001$) (Figure 1D).

TABLE 1. Average values of Lesser Elaenia hematocrit, plasma and mass in different phases while on the breeding grounds (arrival, reproduction and departure) in the Brazilian *Cerrado*. HCT=hematocrit, PLS=plasma, MS=mass.

Phase	**Parameter**			**n**
	HCT (%)	**PLS (%)**	**MS (g)**	
Arrival	54.43±2.03	45.57±2.03	16.19±1.47	28
Reproduction	52.89±2.32	47.11±2.32	15.30±1.17	46
Departure	57.19±4.26	42.81±4.26	16.45±0.89	25
Total period	54.44±3.35	45.56±3.35	15.85±1.29	99

TABLE 2. ANCOVA results explaining variation in hematocrit levels of Lesser Elaenia as a function of phase while on the breeding grounds (arrival, reproduction and departure), mass and their interaction.

Variable	**df**	**Sum Sq**	**Mean Sq**	**F**	**P**
Phase	2	295.2	147.58	27.08	**< 0.05**
Mass	1	44.7	44.69	8.20	**< 0.05**
Phase×Mass	2	255.1	127.57	23.41	**< 0.05**
Residual	93	506.8	5.45		

TABLE 3. Model estimates of ANCOVA explaining variation in hematocrit levels of Lesser Elaenia as a function of phase while on the breeding grounds (arrival, reproduction and departure), mass and their interaction.

Coefficients	**Estimates**	**SE**	**F**	**P**
Intercept	50.069	4.950	10.114	**<0.05**
Departure phase	-60.454	10.803	-5.874	**<0.05**
Reproduction phase	4.490	6.730	0.667	0.506
Mass	0.269	0.305	0.884	0.379
Departure ×mass	3.999	0.655	6.102	**<0.05**
Reproduction phase ×mass	-0.378	0.425	-0.889	0.376

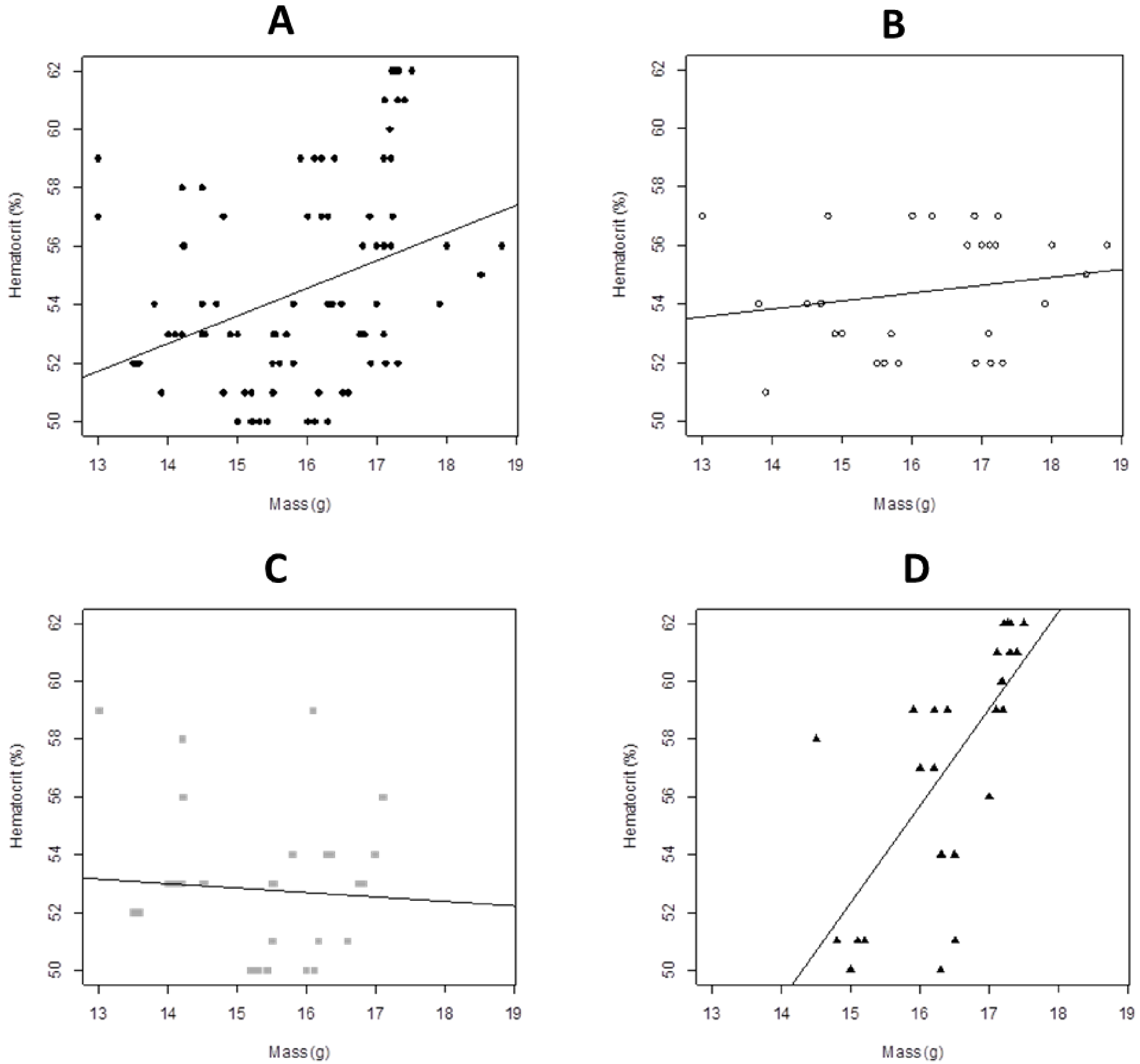

FIGURE 1. The relationship and correlation between hematocrit and mass of Lesser Elaenia in the *Cerrado* of Brazil. The phases were separated into: total period (A, closed circles), arrival phase (B, open circles), reproductive phase (C, gray squares), and departure phase (D, black triangles).

DISCUSSION

The temporal variation in hematocrit in the Lesser Elaenia is indicative of several expected physiological changes related to migration and reproduction. The relationship between hematocrit and mass, though specifically strong during the departure phase, was modest during the arrival and reproduction phases. Lesser Elaenia arrives at breeding grounds in good conditions, what does not support our prediction that they would have low hematocrit and mass, and that there would be a negative relationship between both. Unexpectedly, their mass does not notably decrease during the reproductive phase. In support of our prediction, we found that Lesser Elaenia departs for the wintering area in good condition.

Just after arrival to the breeding grounds, birds are in good condition but delay reproduction for a few weeks. Thus, they use this period between arrival and reproduction (approximately a month) to further improve their condition before nesting. This behavior might explain why mass does not decrease as expected during reproduction. That they arrive in relatively good condition suggests that this species has stopover sites during migration to the breeding grounds, possibly to refuel. Given that the Lesser Elaenia arrives in the *Cerrado* region in August, when weather is hot and very dry (Nimer 1989), making stopovers might improve its physiological condition as a strategy to withstand the harsh *Cerrado* climate. Some birds greatly improve their condition when they stopover. For example, the American Redstart (*Setophaga ruticulla*), increase their mass from 0.5–3.5% during stopover. Likewise, the Common Yellowthroat (*Geothlypis trichas*) can increase between 4.4–7.2%, and the Chestnut-sided Warbler (*Setophaga pensylvanica*) can extraordinarily increase its mass from 13.8–16.1 % before departing from stopover site (Winker *et al.* 1992). In the Gray Catbird (*Dumetella carolinensis*), some individuals arrive on the breeding grounds with lower hematocrit levels, which has been associated with dehydration and lower than average body condition (Hatch *et al.* 2010), and thus supports the hypothesis that successful arrival depends on the bird's condition (Morton 1994).

Even if these migrating birds stop along the route, the energetic cost of migration is still very large, given the total distance birds must fly. Lesser Elaenia apparently occur in the Amazon region during the non-breeding season, from where they migrate to the *Cerrado* to reproduce (Marini & Cavalcanti 1990, Medeiros & Marini 2007). The species may, therefore, move a few thousand kilometers between breeding and wintering sites. Although we do not have measures of hematocrit levels during the non-breeding season, we can compare values between individuals preparing to depart with those of individuals that had just arrived within 15 days to the breeding grounds. The departure group maintained hematocrit levels around 56% and up to 62%, while those arriving maintained levels around 54%. The opposite occurred in White-crowned Sparrows (*Zonotrichia leucophrys oriantha*), which arrive on the breeding grounds in the United States with hematocrit levels of 58 - 60% and departs to non-breeding areas in Mexico with levels of 54 - 55% (Morton 1994).

Lesser Elaenia might also not come from too far away, so it is possible that the population express different levels of hematocrit on arrival phase simply due to differences related to the effort of the distance traveled. Besides the distance, food resources and time of year can interfere with Neotropical migration effort and general bird migration (Rohwer *et al.* 2005). This relationship in the arrival phase is still unclear and may depend on the distance traveled, levels of water and mass loss during the trip. Future studies should investigate what is really happening in this population to answer if the connection of migration with its physiological condition, as presented here, is because it stops during migration, because it travels short distances to the breeding site, or due to other reasons.

Hematocrit values vary greatly among bird groups. Known avian hematocrit levels are derived primarily from the study of poultry, and provide reference values between 35–55% (Whittow 2000, Fair *et al.* 2007). In comparison, the values recorded in this study are high, especially considering that the Lesser Elaenia is a small tyrant flycatcher, with hematocrit levels of up to 62% during the departure phase. Other species of similar size and mass exhibit hematocrit levels of around 51–53.5%, such as the Lugre (*Carduelis spinus*) with 51%, the American Goldfinch (*Carduelis tristis*) with 53.5%, the Goldfinch (*Carduelis carduelis*) with 51%, the Yellow-rumped Warbler (*Dendroica coronata*) with 51.1%, the Eurasian Wren (*Troglodytes troglodytes*) with 53%, and 54% for the White-crowned Sparrow (Viscor & Fuster 1987, Morton 1994). Other hematocrit levels from wild birds are known to vary across groups and years, ranging from 44–48% in Cory's Shearwater (*Calonectris diomedera borealis*), 48% for the Red-tailed Hawk (*Buteo jamaicensis*) and 52% for the American Kestrel (*Falco sparverius*) (Hunter & Powers 1980). Despite the limited number of studies that have investigated hematocrit levels, it is becoming increasingly studied (Fair *et al.* 2007) and most of them support a positive relationship between hematocrit levels and bird mass. The relationship between hematocrit and body mass for Gray Catbird during the arrival phase, for example, was linear and negative, but in this species the hematocrit of migrants that arrived first was higher than migrants that arrived later (Hatch & Smith 2010, Hatch *et al.* 2010).

The Lesser Elaenia showed an uncommon pattern of body mass gain-loss during the analyzed period. In general, migratory birds can suffer a 26% reduction in mass during migration (Butler *et al.* 1998, Whittow 2000). The Least Flycatcher (*Empidonax minimus*), for example, is similar in size to the Lesser Elaenia, loses 0.30 g per day after arriving from migration, and over time, can gain 6–8% (0.05 g) of its mass per day while in residence at stop-over sites (Winker *et al.* 1992). Here, we show that body mass of the Lesser Elaenia decreases little during the reproductive period after arrival but increases again before departure to the non-breeding grounds. During the pre-departure period, adults that recently reproduced and juveniles require muscles associated with flight and the physiological machinery that supports aerobic activities for the return migration (Whittow 2000). Interestingly, it has been estimated that one week of weight gain may be necessary for one night of sustained flight during migration of a granivorous bird (Kendeigh *et al.* 1977). Muscle hypertrophy also occurs in Barnacle Goose (*Branta leucopsis*), resulting in a 1.1% increase in mass, and Snow Bunting (*Plectrophenax nivalis*) increases the muscle mass of the pectoral region before migration (Fry & Ferguson-Lees 1972, Marsh 1984). The Lesser Elaenia does not store much fat in preparation for migration, so most of its weight gain is probably associated with muscle hypertrophy and lean tissue gain (ZPP and MÂM *pers. obs.*).

The energetic cost of reproduction in birds is enormous and, as a result, they need to intake sufficient nutrients and energy reserves before egg formation, initiation of egg-laying and incubation. At the beginning of the reproductive phase, the hematocrit levels and body mass of Lesser Elaenia decrease. Females must form the eggs, which require large amounts of nutrients, especially lipids and proteins (Ankney & Alisauskas 1991). A relationship between sex hormones and hematocrit levels has been demonstrated for some species, with an elevation of androgens and estrogens, concomitant with a reduction of hematocrit levels (Rehder & Bird 1983). Both the energetic demands of reproduction and hormone levels could contribute to hematocrit reduction in the Lesser Elaenia during the reproductive phase. Moreover, hematocrit declines among certain bird species during the formation of egg yolk and before egg-laying, periods in which there is a reduction in blood volume that is associated with osmoregulatory adjustments for the formation of egg yolk precursors (Williams 2005, Fair *et al.* 2007, Navarro *et al.* 2007). For Great Tit (*Parus major*) the experimentally augmented clutch sizes influenced the condition of parents, with a decrease in leucocyte counts associated with reduced immunocompetence, increased hematocrit levels associated with greater muscular activity, and a reduction in mass (Hõrak *et al.* 1998).

With the scenario described in this study, the migration of the Lesser Elaenia perhaps demands more energy to maintain or improve body condition than reproduction does. This is also reinforced by another study with an immunological focus, which confirms that the immune status of this species changes more with migration than reproduction (Machado-Filho *et al.* 2010). Furthermore, immune conditions also seem to improve with better climatic conditions (Dubiec *et al.* 2005), so maybe this is the reason why the Lesser Elaenia has one of the shortest periods of occurrence in the reproductive area recorded for migratory neotropical flycatchers—about 132 days (Paiva & Marini 2013). This is approximately a four-month period and is the time necessary to adapt to climate (end of the drought and the beginning of the rainy season), breed and get physiologically prepared to migrate back to the wintering areas. Despite the short residence time, the species has a fecundity of 1.1 nestlings per female and produces 0.48 nestlings per nest in only 77 days (Medeiros & Marini 2007). However this seems to be their physiological limit, as their efficiency decreased with experimentally increased brood size (Sousa & Marini 2013). Thus, immunological and breeding data are in agreement with our results, with a diminished physiological condition during breeding, but higher values during arrival and principally in the departure phase.

We expected temporal changes in the relationship between hematocrit and mass in the Lesser Elaenia according to the requirements of reproduction in the *Cerrado*. However, we found a pattern whereby individuals arrived in relatively good condition, spent energy to breed, and were able to recover relatively quickly and depart to the wintering grounds. This study focused in that period, but it would be interesting to study other periods of the species' life cycle as well, when the bird departs to distinct places in nearby *Cerrado* areas and even far into Amazonia. Performance of capture-recapture studies of these birds in different migratory sites would also be interesting, as was done for the Common Tern (*Sterna hirundo*) in Brazil. At the Parque Nacional da Lagoa do Peixe in Rio Grande do Sul, the Common Tern also showed mass gain when individuals depart for breeding sites (Nascimento & Santos 2010).

Concluding Remarks

In the arrival phase, increase in average mass was also accompanied by increase in average hematocrit level. During the reproduction phase there was no relationship between these two variables. Finally, during the departure phase, an increase in mass was accompanied by an increase in hematocrit level. We found that this species undergoes changes in its mass and hematocrit level during its residence on the breeding grounds, but, as expected, in the reproductive phase there was no relationship between these two parameters. Nonetheless, these birds exhibit unique characteristics, such as arrival in very good condition and with enough time to adjust to the *Cerrado* climate in preparation for reproduction. This suggests that future studies should focus, for example, on how reproductive hormones (estradiol, luteinizing hormone, follicle stimulating hormone, prolactin, and others) influence hematocrit levels and body mass of this species at the onset of preparation for reproduction. The relationships we found suggest that increases in mass and hematocrit are tightly coupled during this phase of the lifecycle, demonstrating that the majority of individuals of the Lesser Elaenia preparing to depart to the non-breeding areas are in good physical condition.

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SHORT-COMMUNICATION

New record of *Tyrannus dominicensis* for Brazil

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ABSTRACT: *Tyrannus dominicensis*, a boreal migrant from the northern hemisphere, was observed and photographed in an area of "terra firme", at Tefé, Amazonas state, substantiating the presence of this species in the state. This is the southernmost record of the Grey Kingbird in Brazil.

KEY-WORDS: Amazon, Grey Kingbird, Migrant, North America, Tefé.

The Grey Kingbird, *Tyrannus dominicensis,* is a boreal migrant with populations migrating from south-east North Carolina, Georgia, south-east Mississippi and Florida (USA) to the Caribbean, Panama and northern South America (Dittmann *et al.* 2006, Doyle 2013). Besides the southern USA, its breeding range covers the Antilles, including Bahamas, Cuba, Jamaica and Turks and Caicos (Phillips, 1994), where the species is largely resident; some authors include northern Colombia and Venezuela as well (Post, 2013).

The first record in Brazil was made by Moscovits *et al.* (1985) in Roraima state, but as it lacked documentation it was included by the Brazilian Ornithological Records Committee in its secondary list (Naka *et al.* 2006). Recently, Olmos *et al.* (2013) obtained the first documented record for Brazil in Amapá state. Here, we present a new record of *T. dominicensis* for Brazil from Tefé, Amazonas state, northern Brazil.

The region of Tefé holds several important conservation units in the central Amazon, such as the Tefé National Forest (NF), Catuá-Ipixuna Extractive Reserve (ER), Amanã Sustainable Development Reserve (SDR), and Mamirauá SDR. The first three reserves are mostly on "terra firme" forest and the last on a floodplain forest or "várzea" (Ayres, 2006; Amazonas, 2010). Both SDR´s and the ER have been surveyed for birds and species lists are available, although the NF has only a preliminary one (Mamirauá 2014). None of the bird surveys made in these conservation units so far mention *T. dominicensis* in their lists.

On 27 February 2015, a *T. dominicensis* individual was seen on the grounds of the Mamirauá Sustainable Development Institute (3°21'S, 65°16'W), located in the town of Tefé, Amazonas state. The area is a mix of secondary and mature "terra firme" forest surrounding the black water Tefé Lake (Figure 1). The bird was perched on the edge of a secondary forest, behaving as other congeners of the genus *Tyrannus* and foraging by sailing for insects in an open area.

FIGURE 1. A Grey Kingbird, *Tyrannus dominicensis*, recorded on 27 February 2015 at Mamirauá Sustainable Development Institute, Tefé, Amazonas. Photo" P. M. Nassar.

The diagnosis of the species was possible through the gray belly, chest and throat, grey cap contrasting with the black mask, light yellow crissum and broad thick bill (Figure 1), the bird being very distinctive from other species of *Tyrannus* (*T. melancholicus, T. albogularis,* and *T. savanna*) recorded in the area.

Our record documents the presence of the *T. dominicensis* in the Amazonas state and so far is the southernmost one for Brazil. All previous three records of the Grey Kingbird in Brazil are from the Amazon region (Moscovits *et al.* 1985, Olmos *et al.* 2013, present paper).

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Articles

Fargione, J.; Hill, J.; Tilman, D.; Polasky, S. & Hawthornez, P. 2008. Land clearing and the biofuel carbon debt. *Science,* 319: 1235-1238.
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