ISSN (impresso/printed) 0103-5657
ISSN (on-line) 2178-7875

Revista Brasileira de Ornitologia

Volume 24 / Issue 24
Número 2 / Number 2
Junho 2016 / June 2016

www.museu-goeldi.br/rbo

Publicada pela / Published by the
Sociedade Brasileira de Ornitologia / Brazilian Ornithological Society
Rio Grande - RS

Revista Brasileira de Ornitologia

SOCIEDADE BRASILEIRA DE ORNITOLOGIA
(Fundada em 1987 / Established in 1987)
www.ararajuba.org.br

A ***Revista Brasileira de Ornitologia*** (ISSN 0103-5657 e ISSN 2178) é um periódico de acesso livre editado sob a responsabilidade da Diretoria e do Conselho Deliberativo da Sociedade Brasileira de Ornitologia, com periodicidade trimestral, e tem por finalidade a publicação de artigos, notas curtas, resenhas, comentários, revisões bibliográficas, notícias e editoriais versando sobre o estudo das aves em geral, com ênfase nas aves neotropicais. Todos os volumes da ***Revista Brasileira de Ornitologia*** podem ser acessados gratuitamente através do site http://www.museu-goeldi.br/rbo

The ***Revista Brasileira de Ornitologia*** (ISSN 01035657 e ISSN 2178-7875) is an open access journal edited by the Elected Board and Councilors of the Brazilian Ornithological Society and published four times a year. It aims to publish papers, short communications, reviews, news, and editorials on ornithology in general, with an emphasis on Neotropical birds. All volumes of ***Revista Brasileira de Ornitologia*** can be downloaded for free at http://www.museu-goeldi.br/rbo

Projeto Gráfico e Editoração Eletrônica / Graphics and electronic publishing: Regina de S. Bueno (e-mail: mrsbueno@gmail.com).

Capa: Tesourinha (*Tyrannus savana*) fotografada na Estação Ecológica de Itirapina, estado de São Paulo, em setembro de 2010. Machos da espécie foram rastreados ao longo de um ano com geolocalizadores e suas áreas de parada e de invernagem identificadas. Autor da imagem: José Carlos Motta-Junior.

Cover: Fork-tailed Flycatcher (*Tyrannus savana*) photographed at Itirapina Ecological Station, São Paulo state, in September 2010. Males were tracked during a whole year with geolocators, and their staging and wintering grounds identified. Photo Author: José Carlos Motta-Junior.

ISSN (impresso/printed) 0103-5657
ISSN (on-line) 2178-7875

Revista Brasileira de Ornitologia

Volume 24 / Issue 24
Número 2 / Number 2
www.museu-goeldi.br/rbo
Junho 2016 / June 2016

Publicada pela / Published by the
Sociedade Brasileira de Ornitologia / Brazilian Ornithological Society
Rio Grande - RS

Revista Brasileira de Ornitologia

Impact Factor: 0.356
This is a Qualis CAPES B3 journal.

A Revista Brasileira de Ornitologia é publicada com recursos de:

CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico

CAPES

Artigos publicados na *Revista Brasileira de Ornitologia* são indexados por:
Biological Abstract, Scopus (Biobase, Geobase e EMBiology), Zoological Record e Web of Science®.

Manuscripts published by Revista Brasileira de Ornitologia are covered by the following indexing databases:
Biological Abstracts, Scopus (Biobase, Geobase, and EMBiology), Zoological Records and Web of Science®.

Registro no ZooBank
urn:lsid:zoobank.org:pub:6F023490-1FF1-41FD-A720-84F548E5D65C

ZooBank Register
urn:lsid:zoobank.org:pub:6F023490-1FF1-41FD-A720-84F548E5D65C

FICHA CATALOGRÁFICA

Revista Brasileira de Ornitologia / Sociedade Brasileira de Ornitologia. Vol. 20, n.1 (2012) -
Belém, A Sociedade, 2005 -
v. : il. ; 30 cm.

Continuação de:. Ararajuba: Vol.1 (1990) - 13(1) (2005).

ISSN: 0103-5657 (impresso)
ISSN: 2178-7875 (on-line)

1. Ornitologia. I. Sociedade Brasileira de Ornitologia.

Revista Brasileira de Ornitologia

Issue 24 – Number 2 – June 2016

CONTENTS

BEHAVIOR

Behavioral repertoire of the poorly known Red-legged Seriema, *Cariama cristata* (Cariamiformes: Cariamidae)
Aline N. Silva, Rhewter Nunes, Dieferson C. Estrela, Guilherme Malafaia and André L. S. Castro *73*

Parental care of Chestnut-capped Puffbird *Bucco macrodactylus* on the middle Juruá River, Amazonas, Brazil
Gabriel Augusto Leite, Izeni Pires Farias and Carlos Augusto Peres *80*

Description of the nest of two Thamnophilidae species in Brazilian Amazon
Gabriel Augusto Leite, Marcelo Henrique Mello Barreiros, Izeni Pires Farias and Carlos Augusto Peres *83*

Extreme use of feathers for nest construction by the Chilean Swallow (*Tachycineta leucopyga*) in the sub-Antarctic forests of southern Chile
Esteban Botero-Delgadillo and Rodrigo A. Vásquez *86*

First record of the White-chinned Swift *Cypseloides cryptus* in the state of Acre, Brazil, with notes on its breeding biology
Renata Neves Biancalana and Agimiro Magalhães *90*

ECOLOGY

Breeding seabird populations in Brazilian oceanic islands: historical review, update and a call for census standardization
Patrícia L. Mancini, Patrícia P. Serafini and Leandro Bugoni *94*

Intra-tropical migration and wintering areas of Fork-tailed Flycatchers (*Tyrannus savana*) breeding in São Paulo, Brazil
Alex E. Jahn, Nathaniel E. Seavy, Vanesa Bejarano, Marcela Benavides Guzmán, Ivan Celso Carvalho Provinciato, Marco A. Pizo and Maggie MacPherson *116*

Diet of the Burrowing Owl *Athene cunicularia*, in two locations of the inter-Andean valley Ecuador
Héctor Cadena-Ortíz, César Garzón, Santiago Villamarín-Cortéz, Glenda M. Pozo-Zamora, Gabriela Echeverría-Vaca, Javier Yánez and Jorge Brito-M. *122*

Stomach contents of some poorly known Brazilian birds with focus on species from the Caatinga biome
Nelson Buainain and Giovanna Forcato *129*

SYSTEMATICS, TAXONOMY, AND DISTRIBUTION

Birds from Cáceres, Mato Grosso: the highest species richness ever recorded in a Brazilian non-forest region
Leonardo Esteves Lopes, João Batista de Pinho, Aldo Ortiz, Mahal Massavi Evangelista, Luís Fábio Silveira, Fabio Schunck and Pedro Ferreira Develey *137*

A collection of birds from Presidente Kennedy and adjacent areas, Tocantins: a further contribution to knowledge of Amazonian avifauna between the Araguaia and Tocantins Rivers
Guilherme R. R. Brito, Guy M. Kirwan, Claydson P. Assis, Daniel H. Firme, Daniel M. Figueira, Nelson Buainain and Marcos A. Raposo *168*

Confirmation of the hybridization of *Chiroxiphia* Cabanis, 1847 and *Antilophia* Reichenbach, 1850 (Passeriformes: Pipridae) using molecular markers
Wagner Brito Alves, Ciro Albano, Weber Andrade de Girão e Silva, Juliana Araripe and Péricles Sena do Rêgo *185*

How many genera of Stercorariidae are there?
Caio J. Carlos *191*

Instructions to Authors *197*

Revista Brasileira de Ornitologia, 24(2), 73-79
June 2016

ARTICLE

Behavioral repertoire of the poorly known Red-legged Seriema, *Cariama cristata* (Cariamiformes: Cariamidae)

Aline N. Silva[1], Rhewter Nunes[2], Dieferson C. Estrela[1], Guilherme Malafaia[3] and André L. S. Castro[3,4]

[1] Instituto Federal Goiano – Câmpus Urutaí, CEP 75790-000, Urutaí, GO, Brazil.
[2] Universidade Federal de Goiás, CEP 74690-900, Goiânia, GO, Brazil.
[3] Programa de Pós-Graduação em Conservação de Recursos Naturais do Cerrado, Instituto Federal Goiano – Câmpus Urutaí, CEP 75790-000, Urutaí, GO, Brazil.
[4] Corresponding author: andre.castro@ifgoiano.edu.br

Received on 16 October 2014. Accepted on 16 September 2015.

ABSTRACT: The Red-legged Seriema (*Cariama cristata*) is a typical bird of the Cerrado biome and widely distributed in Brazil. Despite the absence of population studies and information regarding its biology, the species is considered non-threatened. The present study describes behaviors of *C. cristata* observed in natural areas of the Brazilian Cerrado in the state of Goiás. Seventeen individuals, belonging to five family groups, were observed for a total of 110 h. Overall, 41 behaviors were described and grouped into the following categories: resting, locomotion, ingest/excretory, comfort/maintenance, social behavior, vocalization and reproduction. The description of behaviors performed by *C. cristata* provides a valuable foundation for further behavioral and management studies on the species.

KEY-WORDS: behavior, Brazil, Cerrado.

INTRODUCTION

The family Cariamidae belongs to the order Cariamiformes (CBRO 2014) and is represented by two species, *Cariama cristata* and *Chunga burmeisteri*. The Red-legged Seriema (*Cariama cristata*) is widely distributed in South America, occurring in Argentina, Uruguay, Paraguay, Bolivia, and in Brazil, from the northeast to the southeast (Redford & Peters 1986, Sick 1997). The species can measure up to 90 cm, weights up to 1.5 Kg (Sick 1997), and lacks sexual dimorphism, with males and females presenting gray plumage with the base of the beak and legs in red (Gwynne *et al.* 2010). Individuals of *C. cristata* can be found isolated or in family groups of up to four birds (Redford & Peters 1986), and despite its common occurrence throughout Brazil, the species remains poorly studied. Redford & Peters (1986) described aspects of the natural history and vocalizations of seriemas, based on occasional observations in the Emas National Park. Almeida (1994) described general aspects of nest building, mating, egg-laying and incubation behaviors of a Red-legged Seriema pair. More recently, Padget (2010), studying the structure and function of the vocalizations of captive *C. cristata*, described basic behaviors of the species. Brooks (2014), while studying ecological aspects of *C. burmeisteri* in the Paraguayan Chaco, reported the positive correlation between wind speed and *C. cristata* activities.

The global population of *C. cristata* is considered stable and relatively abundant, although there are no empirical population studies that support the current conservation status of the species (BirdLife International 2015). *Cariama cristata* is among the most commonly sighted large bird in central Brazil and its call is frequently heard from long distances (Redford & Peters 1986), making this non-threatened species (Machado *et al.* 2008, IUCN 2014) to be considered a symbol of the Brazilian Cerrado.

Information concerning *C. cristata* remains scarce and is mostly based on observations of a few individuals in natural environments (Redford & Peters 1986, Almeida 1994) and zoos (Padget 2010). In this context, the present study describes behaviors of *C. cristata* performed in a natural area of the Brazilian Cerrado. Behavioral descriptions can be a valuable basis for systematic and quantitative studies (Lehner 1996) and contribute to the development of further management and conservation measures for the species (McDougall *et al.* 2006, Watters *et al.* 2009).

METHODS

Study area

The study was conducted in the municipality of Urutaí, located in the southeastern state of Goiás, Brazil, at the Federal Institute of Goiás (*Instituto Federal Goiano*) on the Urutaí Campus (17°29'S; 48°12'W, 736 m a.s.l.). The campus covers an area of 512 ha in a rural zone, with the land used predominantly for grazing and farming. Furthermore, the study area includes several Cerrado vegetation types, forming a mosaic of savanna, countryside and forest formations. This region is part of the Goiás Massif, with a predominance of plateaus and a topography ranging in elevation between 685 and 988 m a.s.l. The climate is tropical humid, with a mean temperature between 18 and 23°C (Costa 2005).

Study subject, preliminary study and observation sessions

A preliminary study was conducted to identify areas and groups to study, totaling 22 h of observations. Five resident groups were recognized and classified according to the sites where individuals occur throughout the study, either to sleep or nest. Additionally, the number of chicks, oviposition and hatching periods and the size of the individuals helped identify the groups (pairs without offspring; or with one or two offspring) as no individual marking or other type of identification was used.

Observations were performed by two previously trained researchers, between 5:00 and 19:00 h using *ad libitum* and focal animal sampling (Lehner 1996, Martin & Bateson 2007). Observations initiated randomly by *ad libitum* and focused on one individual when a new behavior started. Only behaviors observed at least twice and in two groups were reported.

Behavior description and categorization were established based upon the behavioral morphology of the species, as reported in previous studies and from field observations. Behavior terminology was adapted from a closely related species, the Kory Bustard *Ardeotis kori* (Lichtenberg & Hallager 2008). Throughout the observation period, a minimum distance of 10 m was maintained between the observer and the animals. Binoculars (10 × 50 m) aided the location and observation of the animals.

RESULTS

Seventeen individuals of Red-legged Seriema from five family groups (including pairs and pairs with offspring) were observed. From those, three groups were composed of a pair and one offspring and two groups were composed of a pair and two offspring. Observations were made from August 2011 to June 2012, during 26 observation sessions, which a total of 110 h. Each group was observed for a minimum period of 20 h, in sessions of at least 4 h.

A total of 41 behavior types were observed and grouped into the following 7 categories: resting (n = 5), locomotion (n = 6), ingest/excretory (n = 4), comfort/maintenance (n = 14), social behavior (n = 4), vocalization (n = 3), and reproduction (n = 5) (Table 1). Categories and respective behaviors are described as follows:

TABLE 1. Behaviors grouped by categories of Red-legged seriemas (*Cariama cristata*) in the Cerrado biome of southeastern state of Goiás, Brazil.

Category	Behavior
Resting	Observing Resting Sleeping in the nest Sleeping on a branch Hiding
Locomotion	Walking Short flight Long flight Short run Long run Climbing on a branch
Ingest/excretory	Drinking Eating Eating crouched Defecating
Comfort/maintenance	Preening the chest feathers Preening the wings feathers Preening the thighs feathers Preening the tail Preening the cloaca Preening the dorsum Preening the abdomen Dust bathing Scratching the head Scratching the neck Scratching the beak Ruffling Repositioning the wings Stretching
Social behavior	Agonistic interspecific interaction Agonistic intraspecific interaction Air contact Juvenile chasing
Vocalization	Short vocalization Agonistic vocalization Full vocalization
Reproduction	Nest building Copulating Incubating Caring for nestlings Feeding nestlings

Category 1 - Resting

Observing: occurs when an animal approaches or invades the territory. With the legs stretched and the neck held erect at a 90° angle relative to the beak, the bird directs the head toward the visual field of the invader, remaining static (Figure 1a).

Resting: the bird bends its legs until touching the abdomen to the ground and remains at rest with the neck outstretched, as in the observation behavior (Figure 1b).

Sleeping in the nest: the bird bends the legs until they touch the abdomen and rests the tail on the nest, with wings partially open. The neck is bent backward, without allowing it to touch the dorsum, and placed on the nest; then, the bird closes its eyes (Figure 1c).

Sleeping on a branch: in a tree, the bird bends its legs until they touch the abdomen, lowers the tail with the wings partially open, bends the neck backward until it touches the dorsum and closes its eyes. The abdomen of the bird does not contact the branch (Figure 1d).

Hiding: in threatening situations, the bird bends its legs until they touch the abdomen, lowers the tail, maintains the wings semi-open and bends the neck to touch its dorsum while hiding amid herbaceous vegetation. This behavior was observed in hatchlings and juveniles (Figure 1e).

FIGURE 1. Behaviors of *Cariama cristata* in the resting category: (**A**) Observing; (**B**) Resting; (**C**) Sleeping in the nest; (**D**) Sleeping on a branch; (**E**) Hiding.

Category 2 - Locomotion

Walking: the animal moves with semi-bent legs, keeping one foot in contact with the ground and the wings close to the body, while the neck is semi-bent and accompanies the body with each step. The tail remains lowered, forming a 30° angle with the body axis, and the beak is parallel to this same axis (Figure 2a).

Short flight: these flights begin with a push of the legs, which are semi-bent initially and subsequently stretched concurrently with the flapping of the wings. This behavior is used to climb fences, termite nests, and branches, both in interspecific and intraspecific interactions (Figure 2b).

Long flight: such flights can begin on the ground or in a nest. When on the ground, the body is propelled, as in the short flights, but the animal soars for a longer period of time and flaps the wings until alighting. From a nest, the flight orients toward the less dense parts of the tree; the animal jumps, opens the wings completely with the feet facing forward and soars until reaching the ground (Figure 2c).

Short run: short runs occur when a bird finds food or during intra- and/or interspecific interactions. During food finding, there is an increase in the speed of the steps, the wings are pushed slightly away from the body, and the food is captured. During the interactions, the short runs can be followed by wing flapping or short flights (Figure 2d).

Long run: the stepping speed increases during a long run, the body is suspended between two steps, and the wings are slightly open, with stops between runs followed by observation and further movement. This behavior usually occurs in threatening situations (Figure 2e).

Climbing on a branch: an individual approaches a tree, performs a short flight and climbs the tree using its claws. When necessary, new short flights are performed to reach the branch. The climb is preceded by the observation behavior and may be interspersed with long runs (Figure 2f).

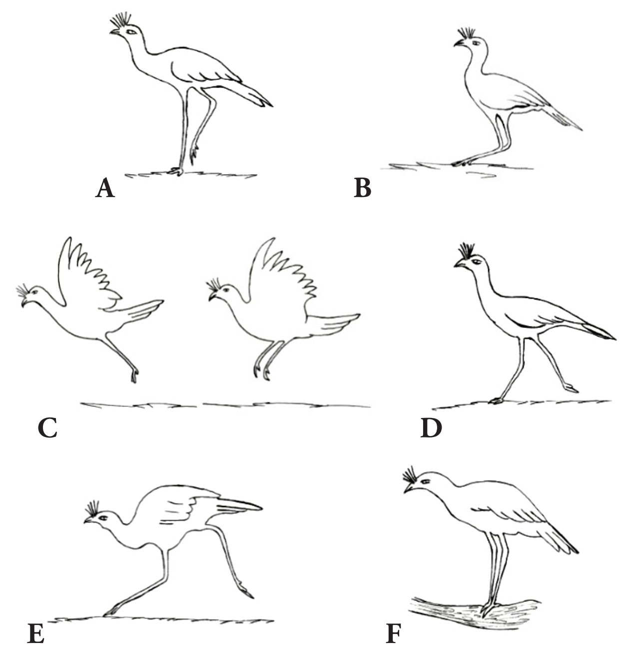

FIGURE 2. Behaviors of *Cariama cristata* in the locomotion category: (**A**) Walking; (**B**) Short flight; (**C**) Long flight; (**D**) Short run; (**E**) Long run; (**F**) Climbing on a branch.

Category 3 - Ingest/excretory

Drinking: the bird bends its legs, touching the tarsal-metatarsal areas to the ground, with the wings and the tail slightly lowered. Next, the bird moves its beak to the water source, takes in the water and points the beak upwards, opening and closing the beak while moving its neck vertically up and down until complete deglutition (Figure 3a). This behavior occurred at natural sources of water and at cattle water troughs.

Eating: upon finding a food item, the bird lowers its neck and tail, keeping the head aligned with the body, moves the wings away from the body and stretches the neck until capturing the food item. When the sighted food item is out of reach, the bird performs short runs. For large food items, vertical movements are performed with the head until complete deglutition (Figure 3b). The following food items were observed: arthropods (insects, arachnids and myriapods), grains (corn, soybean and sorghum), seeds, fruits and vertebrates (amphibians, small rodents, eggs and nestlings of other bird species, and small reptiles, including *Amphisbaena* sp.).

Eating crouched: the bird bends the legs, touching the tarsal-metatarsal area to the ground and keeping the wings close to the body; captures the food on the ground with the beak; and swallows. This behavior occurs when the food items are grains, seeds or fruits (Figure 3c).

Defecating: the bird keeps the legs semi-bent, raises the tail, bristles the cloacal feathers and expels the feces (Figure 3d).

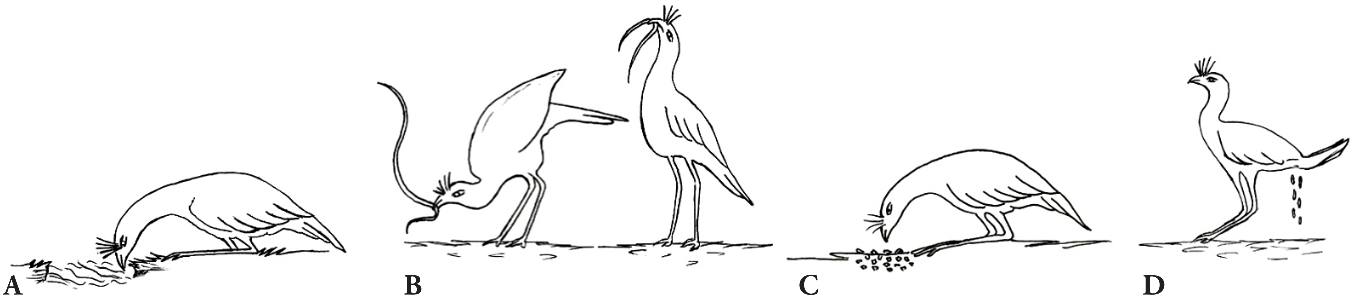

FIGURE 3. Behaviors of *Cariama cristata* in the ingest/excretory category: (**A**) Drinking; (**B**) Eating; (**C**) Eating crouched; (**D**) Defecating.

Category 4 - Comfort/maintenance

Preening the chest feathers: the bird bends the head down and uses the beak to preen the chest feathers while keeping the legs straight and the tail completely downward, following the trunk axis, which stays in the vertical position. This grooming begins by moving the beak from the base to the tip of the feather, repeating the movement along other feathers in the same region. In all grooming behaviors, the direction of beak movement is always from the base to the tip of the feather (Figure 4a).

Preening the wings feathers: this activity can occur on the inner or outer side of the wings. During the external cleaning, the bird curves its neck sideways toward one of the wings, which is slightly stretched; the legs are stretched; the tail is lowered, forming an approximately 45° angle with the legs; and the beak is used to preen the wing feathers from the base toward the tip. During the internal preening, the bird stretches the wing to be cleaned and bends the neck toward the inner part of the wing, allowing the use of the beak to preen the feathers (Figure 4b).

Preening the thighs feathers: the bird tilts the head toward the thigh, keeping the legs straight and the tail lowered to form an angle with the legs of approximately 45°, and uses the beak to preen the feathers (Figure 4c).

Preening the tail: the bird stretches the tail feathers like a fan, keeping them in alignment with the body; the neck turns backward over one of the wings; and the beak is used to preen feathers (Figure 4d).

Preening the cloaca: the bird raises its tail, bristles the cloacal feathers and moves the head in the direction of the cloaca, preening feathers with its beak (Figure 4e).

Preening the dorsum: the bird turns its head toward the dorsum and uses its beak to preen feathers in this region, while keeping its tail at an angle of approximately 45° relative to the legs (Figure 4f).

Preening the abdomen: the bird tilts its neck, turning the lashes downward, with the tail lowered at an angle of approximately 45° with the legs; the wings follow the tail line; and the beak is used to preen feathers (Figure 4g).

Dust bathing: the bird scratches the ground and flexes its legs, touching the legs to the ground; moves the legs from side to side; lowers one of its wings; and lies on it. Using its neck, the bird moves sand to its dorsum. Next, the bird opens its wings slightly, places the dorsum in contact with the ground while moving side to side, and then rises promptly; these movements are repeated several times (Figure 4h).

Scratching the head: the bird closes an eye, raises a leg, lowers its head and scratches its head by moving its claws from the neck toward the beak (Figure 4i).

Scratching the neck: the bird flexes one leg and moves it toward the neck with the head lowered, bristles the neck feathers and moves the claws in the direction opposite to the arrangement of the feathers, keeping the tail lowered (Figure 4j).

Scratching the beak: the bird flexes one leg and moves it toward the beak, lowers both the head and the tail and uses the claws to scratch from the lashes toward the tip of the beak (Figure 4k).

Ruffling: this behavior begins with the bristling of the neck feathers, followed by the ventral and dorsal feathers, and gradually moves toward the tail feathers; the bird opens the wings slightly and shakes the body to the right and left, starting at the head and moving toward the tail (Figure 4l).

Repositioning the wings: one wing is moved away from the body, raised, circumferentially displaced backward and then repositioned (Figure 4m).

Stretching: stretching begins with the body erect and the tail lowered at a 45° angle, with the legs and the beak facing forward. The bird raises one leg, flexes the leg against the abdomen and extends it backward with the toes bent; this movement can occur concurrently with the full opening of the wing on the same side (Figure 4n).

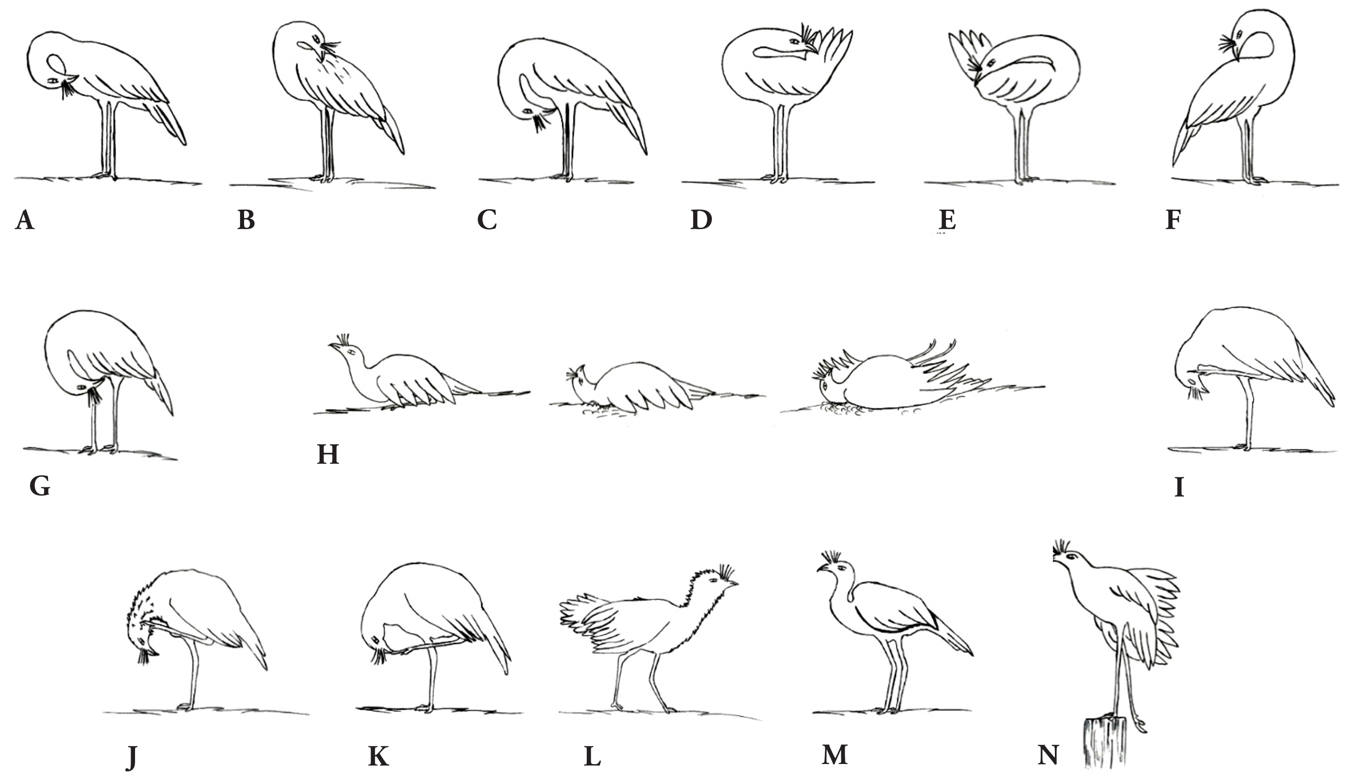

FIGURE 4. Behaviors of *Cariama cristata* in the comfort/maintenance category: (**A**) Preening the chest feather; (**B**) Preening the wings feather; (**C**) Preening the thigh feathers; (**D**) Preening the tail; (**E**) Preening the cloaca; (**F**) Preening the dorsum; (**G**) Preening the abdomen; (**H**) Dust bathing; (**I**) Scratching the head; (**J**) Scratching the neck; (**K**) Scratching the beak; (**L**) Ruffling; (**M**) Repositioning the wings; (**N**) Stretching.

Category 5 - Social behavior

Agonistic interspecific interaction: with the approach of animals from a different species, especially toward the nests or chicks, there is a bristling of the neck feathers, opening of wings, agonistic vocalization, short runs toward the animal and attacks with the talons and beak; interspersed short and long flights may also be performed toward the intruder (Figure 5a). We observed agonistic interactions towards a Scaled Dove (*Scardafella squamata*) and a Six-banded Armadillo (*Euphractus sexcintus*).

Agonistic intraspecific interaction: there is bristling of the neck feathers followed by a series of short runs toward the opponent. This interaction may occur between individuals of the same group, ending upon the withdrawal of the opponent (Figure 5b).

Air contact: occurs between a juvenile and a parent; both perform a short flight toward one another, projecting the talons forward so that the talons of the juvenile crash frontally in the air with those of the adult, and then return to the ground (Figure 5c).

Juvenile chasing: an adult performs successive ascents and descents from trees and is always chased by a chick, which repeats the movements of the parent (Figure 5d).

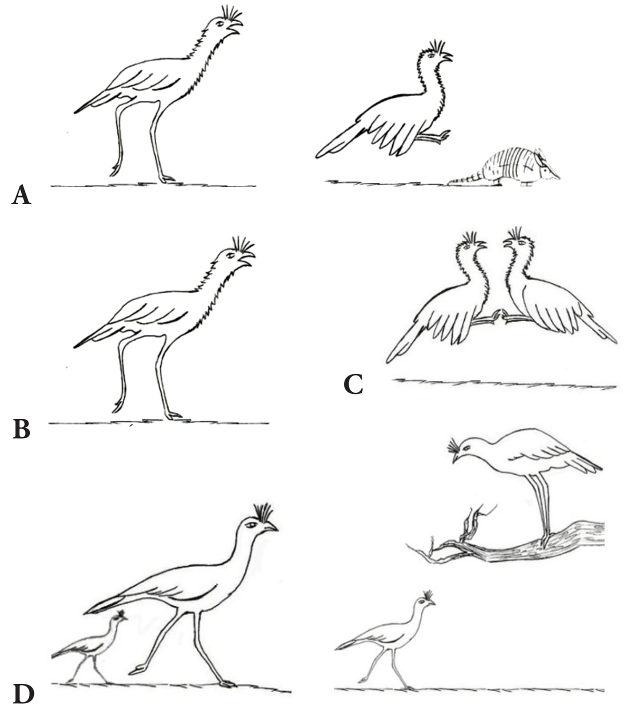

FIGURE 5. Behaviors of *Cariama cristata* in the social behavior category: (**A**) Agonistic interspecific interaction; (**B**) Agonistic intraspecific interaction; (**C**) Air contact; (**D**) Juvenile chasing.

Category 6 - Vocalization

Short vocalization: this sound occurs in the form of a single strophe (glô), which is repeated several times during other behaviors, such as vigilance and agonistic and non-agonistic intraspecific interactions, and also represents the beginning of full vocalization. This behavior is typically observed when a group member (or members) is lost from sight (Figure 6a).

Agonistic vocalization: this activity occurs in the form of a single strophe (grrééêh), with the neck feathers ruffled, the beak opened (approximately 80°) and the neck and beak facing the territorial intruder. The vocalization is repeated and can be directed toward intra- or interspecific intruders (Figure 6b). This behavior took place in situations of agonistic intraspecific interaction.

Full vocalization: the bird emits a series of strophes (glô, glô, glô, gli, gli, gli, i, i, i, i, i, i) that are accompanied by vertical up and down movements of the neck, an open beak facing upward, straight legs, wings close to the body and the tail lowered. The vocalization can be performed during intraspecific interactions between individuals of the same group or different groups and is usually performed as a duet but can also occur as a solo (Figure 6c).

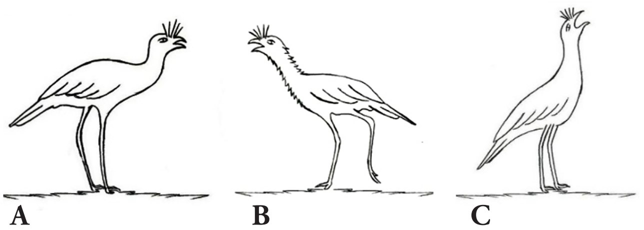

FIGURE 6. Behaviors of *Cariama cristata* in the vocalization category: (**A**) Short vocalization; (**B**) Agonistic vocalization; (**C**) Full vocalization.

Category 7 - Reproduction

Nest building: the bird pair collects materials on the ground (*e.g.*, twigs, dry grass and cattle manure) with the beak and transports them to the nest, performing short flights. The beak and toes are used to allocate the materials within the nest (Figure 7a).

Copulating: the female opens her wings, bends her legs, places her abdomen on the ground and raises her tail; the male jumps on the dorsum of the female, opens his wings, lowers his tail and rubs his cloaca on that of the female. Copulation lasts approximately 7 s (Figure 7b).

Incubating: the parents take turns incubating the eggs, spending most of the day performing this behavior. While one parent remains at the nest incubating eggs, the other approaches and performs the behaviors of observing and climbing on a branch. The parents exchange their tasks 3 times per day, on average (Figure 7c).

Caring for nestlings: both parents care for the nest, exchanging functions periodically. While one parent searches for food, the other stays on top of nestlings, performing frequent body suspensions. Chicks can walk around the nest and are pulled under the adult with the beak (Figure 7d).

Feeding nestlings: the adult brings food to the nest in the beak and places the food on the nest or directly in the beak of the chick, often breaking the food into small pieces with the help of its talons and beak; the chick lifts its head and opens its beak to receive the food and can vocalize (Figure 7e).

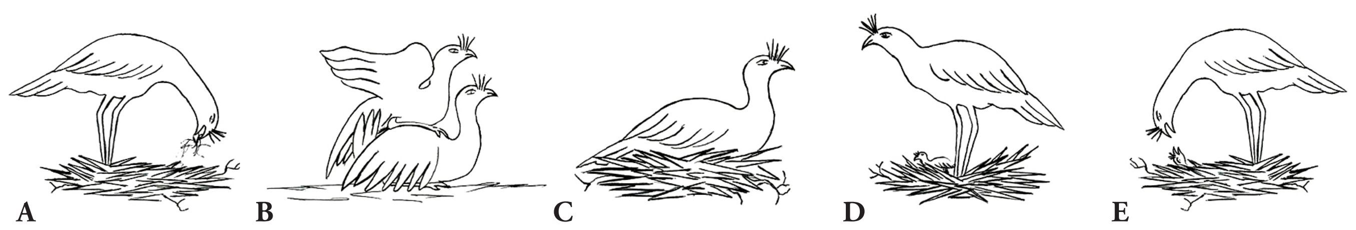

FIGURE 7. Behaviors of *Cariama cristata* in the reproduction category: (**A**) Nest building; (**B**) Copulating; (**C**) Incubating; (**D**) Caring for nestlings; (**E**) Feeding nestlings.

DISCUSSION

The present study is the first to describe in detail the behavioral repertoire of *C. cristata* in the wild, providing information for further studies on the behavior of the species. Although observations were conducted for approximately one year, it is possible that other behaviors occur, especially in contexts or periods not observed in the present study or during other developmental stages.

Some behaviors described in the present study were not observed by Padget (2010) in captivity, such as "climbing on a branch", "juvenile chasing" and "air contact", which suggests a need to adjust the artificial habitats provided for *C. cristata* to allow the species to freely express its behaviors and to improve the well-being of birds (Dawkins 2004). However, certain behaviors described by Padget (2010) for the captive birds were not observed in the present study, such as "pacing", "object pass", "sun bathing lying" and "sun bathing standing". According to Mason *et al.* (2007), animals in captivity may show stereotyped behaviors, such as pacing, and other abnormal repetitive behaviors. It is possible that the object pass and the sun bathing behaviors are also abnormal behaviors, performed only by captive birds and related to a lack of environmental enrichment.

A variant of the intraspecific agonistic interaction behavior was observed in only one group of birds. On several occasions, a bird directed this agonistic behavior toward its own image reflected in a metal water trough and directed toward the reflective portions of automobiles. This behavior was performed vigorously and without interruption even when humans approached seriemas, reinforcing the territorial feature of the species, as reported by Redford & Peters (1986).

During the incubation period, there was parental exchange in the nest, which contradicts the observation by Almeida (1994). However, the absence of sexual dimorphism prevents further description of parental roles.

The daily occurrence of at least one group of *C. cristata* in urban areas highlights the opportunism of the species in relation to anthropogenic activities. These individuals were observed ingesting leftover human foods, arthropods during grass trimming, grain crops and eggs from animal production. However, the proximity of seriemas to humans and urban areas exposes the animals to several risks, including hunting, road kill (Carvalho *et al.* 2014), poisoning and the spread of diseases transmitted by domestic birds. The process of urbanization is expected to threaten biodiversity; therefore it is necessary to understand the mechanisms of behavioral plasticity of an animal exposed to environmental alterations (Sol *et al.* 2013).

The description of behaviors performed by *C. cristata* presented may be useful for proposing management strategies for this species.

ACKNOWLEDGEMENTS

The authors thank biologist Karina R. A. Santos for helping in the field, three anonymous reviewers for improving the manuscript, and the National Council of Technological and Scientific Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico* – CNPq) for the scholarship awarded to A. N. Silva.

REFERENCES

Almeida, A. C. C. 1994. Notas sobre a biologia reprodutiva da Seriema *Cariama cristata* (Linnaeus, 1766) (Gruiformes-Cariamidae). *Revista Nordestina de Biologia*, 9: 49–59.

BirdLife International. 2015. Species factsheet: *Cariama cristata*. http://www.birdlife.org (access on 28 August 2015).

Brooks, D. M. 2014. Ecological notes on Seriema species in the Paraguayan Chaco, with observations on *Chunga* biology. *Revista Brasileira de Ornitologia*, 22: 234–237.

Carvalho, N. C.; Bordignon, M. O. & Shapiro, J. T. 2014. Fast and furious: a look at the death of animals on the highway MS-080, southwestern Brazil. *Iheringia, Série Zoologia*, 10: 43–49.

CBRO (Comitê Brasileiro de Registros Ornitológicos). 2014. *Listas das aves do Brasil*. Disponível em: http://www.cbro.org.br/CBRO/listabr.htm (access on 17 August 2014).

Costa, E. J. 2005. Impactos ambientais no córrego Palmital no município de Urutaí-GO. *Enciclopédia Biosfera*, 1: 1–23.

Dawkins, M. S. 2004. Using behaviour to assess animal welfare. *Animal Welfare*, 13: 3–7.

Gwynne, J. A; Ridgely, R. S.; Tudor, G. & Argel, M. 2010. *Aves do Brasil*: *Pantanal & Cerrado*. São Paulo: Horizonte.

IUCN. 2014. *The IUCN red list of threatened species*. http://www.iucnredlist.org (access on 16 March 2015).

Lehner, P. N. 1996. *Handbook of ethological methods*. New York: University Press.

Lichtenberg, E. M. & Hallager, S. 2008. A description of commonly observed behaviors for the Kori Bustard (*Ardeotis kori*). *Journal of Ethology*, 26: 17–34.

Machado, A. B. M.; Drummond, G. M. & Paglia, A. P. (eds.). 2008. *Livro vermelho da fauna brasileira ameaçada de extinção*. Brasília: Ministério do Meio Ambiente.

Martin, P. & Bateson, P. 2007. *Measuring Behaviour: an introductory guide*. Cambridge: Cambridge University Press.

Mason, G.; Clubb, R.; Latham, N. & Vickery, S. 2007. Why and how should we use environmental enrichment to tackle stereotypic behaviour? *Applied Animal Behaviour Science*, 102: 163–188.

McDougall, P. T.; Réale, D.; Sol, D. & Reader, S. M. 2006. Wildlife conservation and animal temperament: causes and consequences of evolutionary for captive, reintroduced, and wild populations. *Animal Conservation*, 9: 39–48.

Padget, A. E. 2010. *Structure and possible function of vocalizations of captive Red-legged Seriemas* (Cariama cristata). M.Sc. Dissertation. Knoxville: University of Tennessee.

Redford, K. H. & Peters, G. 1986. Notes on the biology and song of the Red-legged Seriema (*Cariama cristata*). *Journal of Field Ornithology*, 57: 261–269.

Sick, H. 1997. *Ornitologia brasileira*. Rio de Janeiro: Nova Fronteira.

Sol, D.; Lapiedra, O. & González-Lagos, C. 2013. Behavioural adjustments for a life in the city. *Animal Behaviour*, 85: 1101–1112.

Watters, J. V.; Margulis, S. W. & Atsalis, S. 2009. Behavioral monitoring in zoos and aquariums: a tool for guiding husbandry and directing research. *Zoo Biology*, 28: 35–48.

Associate Editor: Carlos A. Bianchi.

Revista Brasileira de Ornitologia, 24(2), 80-82
June 2016

SHORT-COMMUNICATION

Parental care of Chestnut-capped Puffbird *Bucco macrodactylus* on the middle Juruá River, Amazonas, Brazil

Gabriel Augusto Leite[1,2,4], Izeni Pires Farias[2] and Carlos Augusto Peres[3]

[1] Instituto Nacional de Pesquisas da Amazônia, Programa de Pós-Graduação em Genética, Conservação e Biologia Evolutiva, Av. André Araújo, 2936, CEP 69067-375, Manaus, AM, Brazil.
[2] Laboratório de Evolução e Genética Animal, Departamento de Genética, Universidade Federal do Amazonas, Av. Gen. Rodrigo Octávio Jordão Ramos, 3000, CEP 69077-000, Manaus, AM, Brazil.
[3] Centre for Ecology, Evolution and Conservation, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK.
[4] Corresponding author: gabrielzoobio@hotmail.com

Received on 05 January 2016. Accepted on 15 July 2016.

ABSTRACT: Chestnut-capped Puffbird *Bucco macrodactylus*, like other members of the Bucconidae family, nest in arboreal termitaria. Here we described a nest of the species, found in the floodplain of the Juruá River in December 2014. It was built inside an arboreal termite mound, 2.45 m above the ground. We determined the type and frequency of prey consumed by chicks over six days: during this time adults brought food to the nest 147 times. Prey included both vertebrates and invertebrates, though the most frequent were insects of the Order Orthoptera. Fledging may have been directly stimulated by a predation attempt made by a marsupial.

KEY-WORDS: feeding, nest, Orthoptera, parental care, prey.

Chestnut-capped Puffbird (*Bucco macrodactylus*) is the smallest of the Amazonian Bucconidae, with no sexual dimorphism. It occurs in forested regions of upper Amazonia east to the Negro and Tapajós Rivers (Sick 1997, Piacentini *et al.* 2015), and is usually found in the understorey, often near water (Rasmussen *et al.* 2016a). The diet of the species consists of small vertebrates and large arthropods, with adults foraging alone (Rasmussen *et al.* 2016a).

Puffbirds build nests by digging tunnels in either the ground or arboreal termitaria (Sick 1997, Greeney *et al.* 2004, Greeney 2010). They lay two or three eggs, and the incubation period is typically about 15 days (Sick 1997). Both parents care for the chicks, sometimes with the assistance of an additional adult (Sick 1997). Breeding is well known for only a few bucconids, while for most puffbird species there are few, if any, records of nesting and parental care. The aim of this study was to determine the frequency and type of food fed to chicks of *B. macrodactylus*, a species where these aspects are poorly-known.

The nest was found on the left bank of the Juruá River in the Reserva de Desenvolvimento Sustentável Uacari, in the municipality of Carauari, Amazonas, Brazil (5°44'2.75"S; 67°46'29.93"W). Though mean annual rainfall is 2400–2800 mm, the region has a well-defined seasonal rainfall pattern with highest pluviosity between January and May and the lowest between July and October. This results in a marked seasonal oscillation in the river water levels, with the period of low water occurring between July and October (Sombroek 2001).

Nest monitoring was conducted via direct observation and video recordings made by two camera traps, for a total of 43 h over six days, during daylight hours (6:00–18:30 h). The frequency with which the adults delivered food to the chicks and the types of prey brought were of particular interest. Additionally, the standard deviation (SD) and mean rate of feeding between morning and afternoon periods were calculated. To identify prey filmed by camera traps images obtained were later subject to detailed analysis. Measurements of nest and nest location were taken after chicks left the nest.

On 5 December 2014 an adult *B. macrodactylus* was observed with a grasshopper in its bill. It then flew to a tree and returned to the same branch shortly afterwards without the insect. A few minutes later the same behavior was recorded again, and thus we discovered a nest cavity within an arboreal termite mound holding two well-developed chicks. The arboreal termite mound was located over a *Ficus* sp. tree, and was 2.45 m above the ground. The nest entrance diameter was 5 cm and its depth 19 cm (Figure 1A). Over the six day study period, both adults brought food to the chicks a total of 147 times, at a mean rate of 3.41 feeds/h during daylight hours. The first feeding of the day occurred at 06:00 h, and the last at 18:30 h. Over three full days the feeding rate was similar in the morning (46.5%, mean = 15.33 ± 2.49) and in the afternoon (53.5%, mean = 17.66 ± 4.64).

Among prey brought to the nest, 61% were identified, with the majority being invertebrates (56%), and a minor proportion of vertebrates (5%) (n = 89). Among invertebrates, Orthoptera was the single most abundant prey (76%), minor contributions of Mantodea (3%), Lepidoptera (2%), Arachnida (1%) and Hymenoptera (1%). Vertebrates were all of the Order Squamata, of which four were individuals of the genus *Cercosaura* (Gymnophthalmidae) and one a *Varzea* sp. (Mabuyidae) (Figure 1B).

During the morning of 11 December, the camera trap recorded two unsuccessful nest predation attempts by an unidentified marsupial. On the morning of the same day, the adults were observed encouraging chicks to fledge. One of the adults arrived with food in its bill, but rather than go to the nest to deliver the food, as usual, it flew quickly to the entrance but without entering the nest. After several attempts the chicks left the nest (Figure 1C). Soon afterwards, they flew into the canopy along with their parents and were not observed again.

A single nest of *B. macrodactylus* has been described previously, from Peru, also sited in an arboreal termite mound 2.5 m above ground (Hilty 2003). However, there are no records of clutch size or information on parental care. In Ecuador, the Collared Puffbird *Bucco capensis* has also been recorded to have a clutch size of two (Rasmussen *et al.* 2016b). Monitoring nests during the period that adults feed chicks requires time, and is most easily conducted using camera traps, even though their use can make it more difficult to identify some food items. This is because when camera traps are present adults fly straight to the nest, while when researchers watch a nest, adults often pause for a few seconds near the entrance, and this allows identification of material or prey in the bill.

Orthoptera was the most commonly prey brought to the nest. This might be related to the fact that the nest was rather close (30 m) to a corn field and an area of vegetation known as Canarana (*Gynerium* sp.), where this type of prey is especially common. Rasmussen *et al.* (2016a) reported that the species feeds on small vertebrates, but during observations, parents captured lizards comparatively larger than chicks, which they apparently fed to their chicks without problems. Other species of puffbirds feed on vertebrates of a variety of sizes, including rodents, snakes and lizards (Schubart *et al.* 1965, Sigrist 2006, Crozariol & Gomes 2010). The frequency with which adults brought food to the chicks was similar throughout the day. In reporting parental care in Long-wattled Umbrellabird *Cephalopterus penduliger*, Greeney *et al.* (2012) observed that the single chick was fed more frequently in the early morning and late afternoon. The time between feeds varied from less than

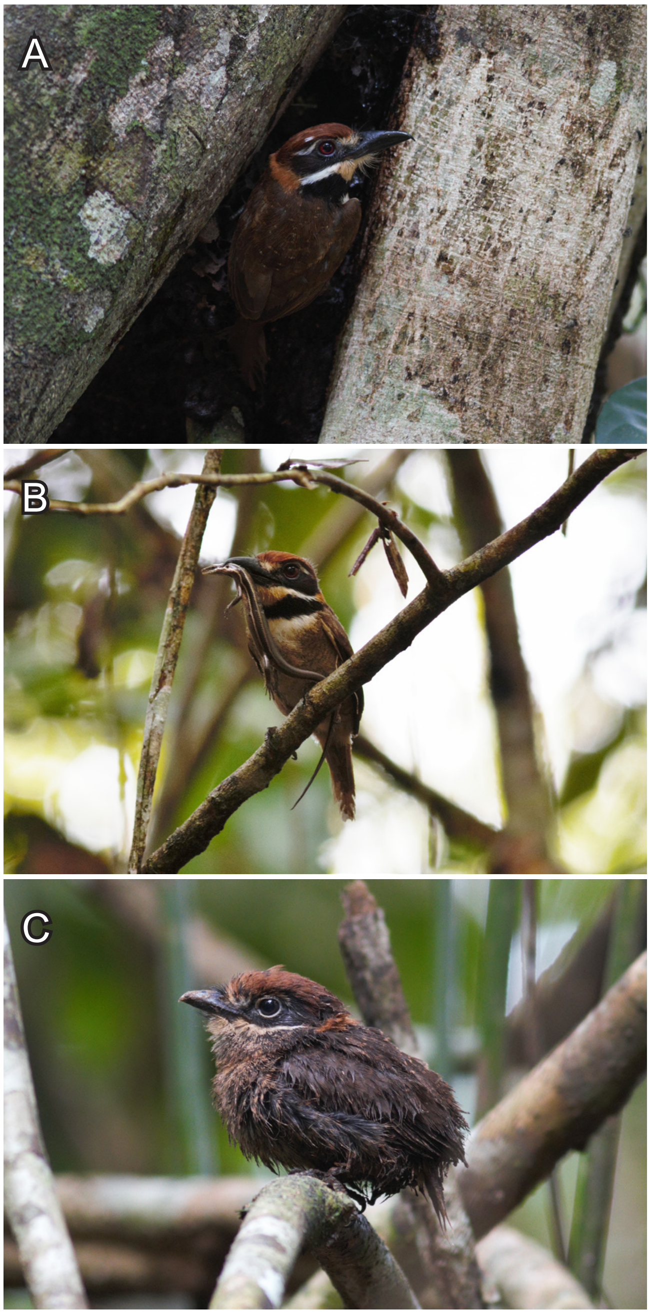

FIGURE 1. (**A**) Adult *Bucco macrodactylus* in nest entrance after feeding their chicks, Reserva de Desenvolvimento Sultentável Uacari, Carauari, Amazonas, 06 December 2014; (**B**) Lizard (*Varzea* sp.) captured by adult to feed one of the chicks, Reserva de Desenvolvimento Sultentável Uacari, Carauari, Amazonas, 06 December 2014; (**C**) Chick after it leaves the nest, but still dirty due to termite mound, Reserva de Desenvolvimento Sultentável Uacari, Carauari, Amazonas, 11 December 2014. Photos: Gabriel Augusto Leite.

a minute to more than one hour, with the difficulty of capturing prey, the effects of rain and also foraging for their own consumption presumably accounting for this variation. Rasmussen & Collar (2016) stated that when adult puffbirds take larger prey such as lizards, they may then go some hours without delivering fresh prey to their nests, but we found that the adults returned with other prey just minutes later.

The behavior of adults in attempting to make chicks fledge may have been a direct response to the predation attempted on the previous night. Predation on Bucconidae nestlings is often attributed to snakes, especially those nests in burrows on the ground (Rasmussen & Collar 2016). Such events are unlikely to occur in the presence of a human observer and underscore the value of camera traps in this kind of monitoring.

ACKNOWLEDGEMENTS

This work was conducted during the period that G.A.L. was receiving a FAPEAM scholarship, while the Darwin Initiative Project (DEFRA – UK, Ref. No.16-001) provided financial support to our work in this region. Authors are grateful to Tainá Rodrigues by identifying the lizards and Guy Kirwan for reviewing the English and give great suggestions on the article.

REFERENCES

Crozariol, M. A. & Gomes, F. B. R. 2010. Insetívoro ou oportunista? A dieta do João-bobo, *Nystalus chacuru* (Galbuliformes: Bucconidae). *Atualidades Ornitológicas*, 154: 4–5.

Greeney, H. F. 2010. A nest of Brown Nunlet (*Nonnula brunnea*) and observations on the nesting of other Ecuadorian puffbirds. *Ornitología Colombiana*, 9: 31–37.

Greeney, H. F.; Kirwan, G. M. & Miller, E. T. 2012. Nesting biology of the Long-wattled Umbrellabird *Cephalopterus penduliger*. Part II: nestling provisioning. *Cotinga*, 34: 23–27.

Greeney, H. F.; Port, J. & Werner, F. 2004. First description of the nest of the Barred Puffbird (*Nystalus radiatus*) from northwestern Ecuador. *Ornitología Neotropical*, 15: 285–288.

Hilty, S. L. 2003. *Birds of Venezuela*. London & Princeton: Princeton University Press & Christopher Helm.

Piacentini, V. D. Q.; Aleixo, A.; Agne, C. E.; Maurício, G. N.; Pacheco, J. F.; Bravo, G. A.; Brito, G. R. R.; Naka, L. N.; Olmos, F.; Posso, S.; Silveira, L. F.; Betini, G. S.; Carrano, E.; Franz, I.; Lees, A. C.; Lima, L. M.; Pioli, D.; Schunck, F.; Amaral, F. R.; Bencke, G. A.; Cohn-Haft, M.; Figueiredo, L. F.; Straube, F. C. & Cesari, E. 2015. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia*, 23: 91–298.

Rasmussen, P. C. & Collar, N. 2016. Puffbirds (*Bucconidae*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & de Juana, E. (eds.). *Handbook of the birds of the world Alive*. Barcelona: Lynx Edicions. http://www.hbw.com/node/52282 (access on 5 January 2016).

Rasmussen, P. C.; Collar, N. & Kirwan, G. M. 2016a. Chestnut-capped Puffbird (*Cyphos macrodactylus*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & de Juana, E. (eds.). *Handbook of the birds of the world alive*. Barcelona: Lynx Edicions. http://www.hbw.com/node/55958 (access on 5 January 2016).

Rasmussen, P. C.; Collar, N. & Kirwan, G. M. 2016b. Collared Puffbird (*Bucco capensis*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & de Juana, E. (eds.). *Handbook of the birds of the world alive*. Barcelona: Lynx Edicions. http://www.hbw.com/node/55961 (access on 5 January 2016).

Schubart, O.; Aguirre A. C. & Sick H. 1965. Contribuição para o conhecimento da alimentação das aves brasileiras. *Arquivos de Zoologia*, 12: 95–249.

Sick, H. 1997. *Ornitologia brasileira*. Rio de Janeiro: Nova Fronteira.

Sigrist, T. 2006. *Aves do Brasil: uma visão artística*. São Paulo: Avis Brasilis.

Sombroek, W. 2001. Spatial and temporal patterns of Amazon rainfall – consequences for the planning of agricultural occupation and the protection of primary forests. *Ambio*, 30: 388–396.

Associate Editor: Marcos P. Dantas.

Revista Brasileira de Ornitologia, 24(2), 83-85
June 2016

SHORT-COMMUNICATION

Description of the nest of two Thamnophilidae species in Brazilian Amazon

Gabriel Augusto Leite[1,2,3,5], Marcelo Henrique Mello Barreiros[2], Izeni Pires Farias[3] and Carlos Augusto Peres[4]

[1] Instituto Nacional de Pesquisas da Amazônia, Programa de Pós-Graduação em Genética, Conservação e Biologia Evolutiva. Av. André Araújo, 2936, CEP 69067-375, Manaus, AM, Brazil.
[2] Clube de Observadores de Aves do Vale do Paraíba – COAVAP, Rua Pará de Minas, 47, CEP 12233-592, São José dos Campos, SP, Brazil.
[3] Laboratório de Evolucão e Genética Animal, Departamento de Genética, Universidade Federal do Amazonas, Av. Gen. Rodrigo Octávio Jordão Ramos, 3000, CEP 69077-000, Manaus, AM, Brazil.
[4] Centre for Ecology, Evolution and Conservation, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, UK.
[5] Corresponding author: gabrielzoobio@hotmail.com

Received on 12 February 2016. Accepted on 27 April 2016.

ABSTRACT: Many Thamnophilidae species have poorly known breeding. Here we describe the nests and eggs of two species, *Epinecrophylla ornata* from a *terra firme* forest, and *Myrmotherula assimilis* from a flooded forest in Brazil. Knowledge on the natural history of these species is important for future conservation strategies.

KEY-WORDS: *Epinecrophylla ornata*, floodplain forest, *Myrmotherula assimilis*, reproduction, *terra firme*.

Thamnophilidae is one of the most diverse bird families in the Neotropics, being restricted to this region. Recently, molecular techniques and differences in nest architectures provided insights on phylogenetic relationships and contributed to a better resolution on the organization of taxa within the family (Cadena *et al*. 2000, David & Londoño 2013, Greeney *et al*. 2013, Zimmer & Isler 2016). Despite a recent increase in information on the natural history of poorly known antbirds, breeding data are still scarce for many species (Londoño 2003, Flórez-V & Londoño 2014).

Nest site attributes (*e.g.* height above ground, proximity to water), as well as the shape of the nest (open cup, cavity) and materials (leaves, mosses or roots), are associated with differences in predation risk and may influence reproductive success (Robinson *et al*. 2005, Roper 2005, Ocampo & Londoño 2015). Because habitats are different, species developed many strategies to increase nesting success, such as nest building under leaves or inside cavities (Sick 1997, Roper 2000).

In this study we provide descriptions of the nest and eggs of the Ornate Antwren (*Epinecrophylla ornata*) from *terra firme* forest in Tapajós River region, and of the Leaden Antwren (*Myrmotherula assimilis*), in the Juruá River region, both in Brazilian Amazon.

On 3 November 2013, during the dry season, we observed a male *E. ornata* carrying small roots on its bill and finishing nest building (Figure 1), while a female was close to the nest. The individual was observed in the west bank of Jamanxin River (an affluent of the east bank of Tapajós River), municipality of Itaituba, Pará State, 69 m a.s.l. (4°49'29.82"S; 56°27'44.95"W). The nest is a deep open cup supported by a fork, inner diameter of 50 × 140 mm, and 65 mm depth. It was positioned 1.2 m above the ground, and was mainly constructed with fine roots, dry leaves and little sticks. The nest was 3 km from Jamanxim River, the upland forest had a canopy around 35 m high and closed. Some of the common tree species in the region are *Ocotea baturitensis*, *Manilkara huberi* and *Eschweilera obversa*. Next day the nest was inspected again, but the pair was not observed.

FIGURE 1. Nest of *Epynecrophylla ornata.* West bank of Jamanxin River, Itaituba, Pará, 03 November 2013. Photo: Gabriel A. Leite.

A nest of *M. assimilis* was found on 9 March 2015, during the rainy season in a floodplain forest, in the east bank of Juruá River, municipality of Carauari, Amazonas state, 93 m a.s.l. (5°46'18.19"S; 67°45'49.59"W). The open cup nest had internal diameter 60 × 55 mm and 30 mm depth. It was built with small roots and some dry leaves, and was placed 3.8 m above water, in a little fork from a small plant (Figure 2). The nest was 21 m from the nearest water body (Marari Igarapé); the floodplain forest had a closed canopy around 25 m high, and include tree species such as *Macrolobium acaciifolium*, *Calophyllum brasiliense* and *Hevea guianensis*. A female was observed incubating two eggs, which were pale brown with darker brown blotches. The nest was visited again three days later, without any alteration on nest or nest content.

FIGURE 2. Nest and eggs of *Myrmotherula assimilis*. RDS Uacari, Carauari – Amazonas, 09 March 2015. Photo: Gabriel A. Leite.

Breeding information on *E. ornata* and *M. assimilis* is scarce, and mostly limited to observations of fledglings fed by adults (Zimmer & Isler 2016). Regarding seasonality of breeding, the nest of *E. ornata* was found in the same season as three other *terra firme* forest antbird species, *Myrmoborus myiotherinus*, found in October (Londoño 2003), *Gymnopithys salvini*, found in November (Willson 2000) and *Neoctantes niger*, found in September (David & Londoño 2013) in the Peruvian Amazon. One *E. ornata* fledgling was also observed being fed by an adult in July in Peruvian Amazon (Zimmer & Isler 2016), suggesting the reproduction of the species could also occur during the dry season. While we found the nest of *M. assimilis* when water level was high on Juruá River floodplain forest (Sombroek 2001), adults were observed feeding fledglings on the dry season (October) in Anavilhanas, Rio Negro, Brazil (Zimmer & Isler 2016).

The nest of *M. assimilis* is similar in architecture to the nest of other *Myrmotherula* species, such as *M. multostriata, M. hauxwelli* and *M. axillaris* (Sick 1997, Chaparro-Herrera & Ruiz-Ovalle 2014, Zimmer & Isler 2016). Similarly, *M. surinamensis* and *M. cherriei* also build nests above water (Sick 1997, Chaparro-Herrera & Ruiz-Ovalle 2014). Regarding the *Epinecrophylla* genus, Isler *et al.* (2006) reported that species build domed or oven-shaped nests with side entrances, and the nest from *E. ornata* is an open cup nest. In the two species, both sexes were involved in parental care behavior and nest construction, which is apparently the case in most antbird species (Sick 1997, Willson 2000, Link & Ramirez 2003, Londoño 2003). Regarding environments where nests were found, it is noteworthy that *E. ornata* is a species inhabiting upland forest and transitional forests between *várzea* and *igapó*, while *M. assimilis* is a species restricted to the forests of *várzea/igapó* in Amazon (Zimmer & Isler 2016).

Detailed observations on breeding biology is important for many reasons, such as gathering information that enhance our understanding of phylogenetic relationships amongst species. Also, data on natural history is crucial for planning of conservation programs. Although *E. ornata* and *M. assimilis* are not considered threatened, all Amazonian forest species are affected by the increasing deforestation in the Amazon Basin.

ACKNOWLEDGEMENTS

We thank FAPEAM for the scholarship granted and the Darwin Initiative Project (DEFRA – UK, Ref. No.16-001) for financial support.

REFERENCES

Cadena, C. D.; Londoño, G. A. & Parra, J. L. 2000. Nesting records of five antbird species from the Colombian Amazon. *Wilson Bulletin*, 112: 313–317.

Chaparro-Herrera, S. & Ruiz-Ovalle, J. M. 2014. Anidación del Hormiguerito de Cherrie (*Myrmotherula cherriei*) en Colombia, con una revisión de los nidos y huevos en *Myrmotherula*. *Ornitología Colombiana*, 14: 136–144.

David, S. & Londoño, G. A. 2013. First nesting information on the enigmatic Black Bushbird (*Neoctantes niger*). *Wilson Journal of Ornithology*, 125: 840–844.

Flórez-V. C. & Londoño, G. A. 2014. Nesting biology of the Black Antbird (*Cercomacroides serva*). *Wilson Journal of Ornithology*, 126: 463–473.

Greeney, H. F.; Sánchez, C. E.; Sánchez, J. E. & Carman, E. 2013. A review of nest and egg descriptions for the genus *Myrmeciza*, with the first description of nests and eggs of Dull-mantled Antbird (*M. laemosticta*). *Journal of Ornithology*, 154: 1049–1056.

Isler, M. L.; Lacerda, D. R.; Isler, P. R.; Hackett, S. J.; Rosemberg, K. V. & Brumfield, R. T. 2006. *Epinecrophylla*, a new genus of antwrens (Aves: Passeriformes: Thamnophilidae). *Proceedings of the Biological Society of Washington*, 119: 522–527.

Link, A. & Ramirez, B. 2003. First description of the nest, eggs and nestlings of the White-shouldered Antbird (*Myrmeciza melanoceps*). *Ornitología Neotropical*, 14: 423–429.

Londoño, G. A. 2003. First description of the nest and eggs of the Plumbeous (*Myrmeciza hyperythra*) and the Black-faced (*Myrmoborus myotherinus*) Antbirds. *Ornitología Neotropical*, 14: 405–410.

Ocampo, D. & Londoño, G. A. 2015. Tropical montane birds have increased nesting success on small river islands. *Auk* 132: 1–10.

Robinson, W. D.; Styrsky, J. N. & Brawn, J. D. 2005. Are artificial bird nests effective surrogates for estimating predation on real bird nests? A test with tropical birds. *Auk*, 122: 843–852.

Roper, J. J. 2000. Experimental analysis of nest-sites and nest predation for a Neotropical bird: stuck between a rock and a hard place. *Ararajuba*, 8: 85–91.

Roper, J. J. 2005. Try and try again: nest predation favors persistence in a Neotropical bird. *Ornitología Neotropical*, 16: 253–262.

Sick, H. 1997. *Ornitologia brasileira.* Rio de Janeiro: Nova Fronteira.

Sombroek, W. 2001. Spatial and temporal patterns of Amazon rainfall - consequences for the planning of agricultural occupation and the protection of primary forests. *Ambio*, 30: 388–396.

Willson, S. K. 2000. First nest record of the White-throated Antbird (*Gymnopithys salvini*) and detailed nest records of the Hairy-crested Antbird (*Rhegmatorhina melanosticta*). *Ornitología Neotropical*, 11: 353–357.

Zimmer, K. & Isler, M. L. 2016. Typical antbirds (Thamnophilidae). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & de Juana, E. (eds.). *Handbook of the birds of the world alive*. Barcelona: Lynx Edicions. http://www.hbw.com/node/52291 (access on 16 February 2016).

Associate Editor: Marcos P. Dantas.

Revista Brasileira de Ornitologia, 24(2), 86-89
June 2016

SHORT-COMMUNICATION

Extreme use of feathers for nest construction by the Chilean Swallow (*Tachycineta leucopyga*) in the sub-Antarctic forests of southern Chile

Esteban Botero-Delgadillo[1,2] and Rodrigo A. Vásquez[1]

[1] Instituto de Ecología y Biodiversidad, Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Las Palmeras 3425, Santiago, Chile.
[2] Corresponding author: esteban.botero@ug.uchile.cl

Received on 17 March 2015. Accepted on 10 February 2016.

ABSTRACT: Nesting birds commonly incorporate feathers into nest linings given their insulation properties. Although use of feathers is common among swallows, here we provide the first recording of nests built almost completely with feathers (57–60% of total nests mass), by the Chilean Swallow (*Tachycineta leucopyga*) in southern Chile. Low temperatures or a high availability of feathers near the nesting sites could have elicited this response in the breeding birds, but further observations are needed to determine the frequency of the extreme use of feathers in this species, and the proximate causes promoting such behavior.

KEY-WORDS: breeding ecology, Isla Navarino, nest construction, nest insulation.

Nest construction is an essential process during the breeding cycle of most birds and it has important consequences for all stages of breeding attempts (Collias & Collias 1984). Given the role of nests in providing a stable environment for the development of eggs and nestlings and for the breeding adults themselves, careful construction and selection of building materials is considered vital for successful reproduction (Collias & Collias 1984, Hansell 2000). Typically, birds use plant materials to provide structural support for the nest and attach the nest firmly to a substrate (Hansell 2000). Non-plant materials may be used in nest lining. For example, feathers are often incorporated into nest linings, as they provide exceptional insulation properties (Barber 2013, Mainwaring *et al.* 2014). An increased use of feathers confers several thermal benefits, increasing the efficiency of egg incubation and nestling development (Winkler 1993, Lombardo 1994, Dawson *et al.* 2011), and enhancing reproductive output (Lombardo *et al.* 1995).

Despite the energetic benefits provided by the use of feathers, they are not an appropriate structural material and hence, they are limited to be used for nest lining. Hence, feather abundance compared to other materials in nests is usually low (Collias & Collias 1984, Hansell 2000). However, a few nest descriptions show that some species include more than 100 feathers in their internal linings (*e.g.* Tree Swallow, *Tachycineta bicolor*; Winkler 1993), and, in an exceptional case, more than 2600 feathers comprising *ca.* 40% of the nest mass, in the Long-Tailed Tit, *Aegithalos caudatus* (McGowan *et al.* 2004). Here we provide the first recording of nests built almost completely with feathers, by the Chilean Swallow (*Tachycineta leucopyga*) in the sub-Antarctic forests of southern Chile.

The Chilean Swallow is a secondary cavity nester that uses dry grasses for nest building, adding a variable amount of feathers for cup lining (Liljesthröm *et al.* 2009), similar to other *Tachycineta* swallows (see Dyrcz 1984, Brown *et al.* 1992, Allen 1996, Bulit & Massoni 2004, Townsend *et al.* 2008). This species has a large distributional range, reaching the southernmost portion of South America; some migratory populations breed between October and January in Isla Grande de Tierra del Fuego (Liljesthröm *et al.* 2009), and even further south in several islands of southern Chile (Jaramillo 2003). Given the low temperatures in these localities during the breeding season, Chilean Swallows add variable numbers of feathers before egg laying and during incubation, and it has been estimated that *ca.* 180 feathers can be incorporated to the structure of an average nest (Liljesthröm *et al.* 2009).

During a long-term breeding study focused on the furnariid Thorn-tailed Rayadito (*Aphrastura spinicauda*) at Isla Navarino (55°56'S; 67°39'W), located in the Magallanes and Chilean Antarctic Region, we observed Chilean Swallows occupying installed nest boxes (32 × 18 × 15 cm) since 2013 (see Botero-Delgadillo *et al.*

2015). We found five Chilean Swallow active nests during October–December 2013 and 2014. Clutch size ranged from three to five eggs (modal cutch size = 4 eggs), as has been reported for another population breeding in Tierra del Fuego (Liljesthröm *et al.* 2009). Three out of the five nests that we found were typical of this species, with a nest base made almost entirely of dry grasses and a nest cup lined with a variable number of feathers (see Liljesthröm *et al.* 2009). These three nests averaged 6.1 ± 1.1 cm in height and 78.2 ± 5.1 g total mass, similar to previous reports for the species and other members of *Tachycineta* breeding in nest boxes of similar size to our boxes (see Bulit & Massoni 2004, Liljesthröm *et al.* 2009). The remaining two nests had a small and thin base made of dry grass (mainly stems) and plant roots, and the nest cup was lined with several feathers; however, both had a feathered crown-like structure above the cup which concealed the eggs and accounted for most of the nests bulk (Figure 1). These "feather" nests heighted 16.2 and 18.9 cm, being up to three times higher than the nests described for *Tachycineta* swallows (see above). The nests base weighted 55.1 and 52.4 g, whereas the feathered structures weighted 73.5 and 78.1 g, respectively, comprising 57 and 60% of the nests total mass. We counted a total of 273 and 303 feathers in each nest, respectively. These feathers belonged to at least five species: Upland Goose, *Chloephaga picta* (71%); Ashy-headed Goose, *Chloephaga poliocephala* (18%); Great Horned Owl, *Bubo magellanicus* (3%); Chilean Swallow (2%); and feathers/down of unknown origin (6%). As observed in other populations of Chilean Swallows, feathers are commonly gathered from large aquatic birds, especially from Upland Goose (see Liljesthröm *et al.* 2009). This apparent preference for feathers from geese may reflect feather availability in the environment, since (i) geese tend to congregate in large flocks during the breeding season (Jaramillo 2003), (ii) large feathers may remain available longer than small feathers or may be more numerous, and/or (iii) carcasses of such large birds could be more easily located (see McCabe 1965).

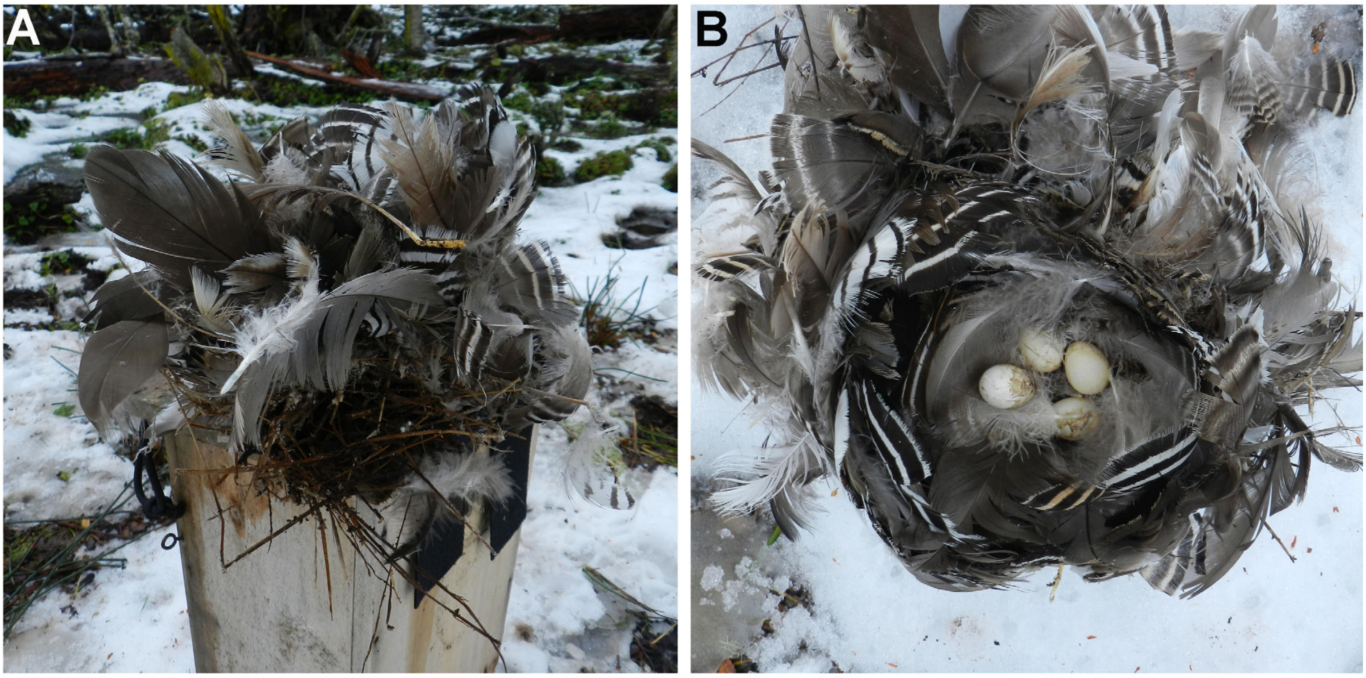

FIGURE 1. Details of the structure and content of a one of two "feather" nests of the Chilean Swallow *Tachycineta leucopyga* found during 2013 and 2014 at Isla Navarino, southern Chile. (**A**) the small base of plant materials is right below the feathered crown-like structure above the nest cup, with several feathers from *Chloephaga* geese; (**B**) four eggs were found in the nest center. Photos: Esteban Botero-Delgadillo.

Although *Tachycineta* swallows can use high amounts of feathers for nesting, the two nests that we described seem to be atypical, as feathers comprised almost the entire bulk of both nests and accounted for 57–60% of their total mass. Tree Swallows (*T. bicolor*) frequently include feathers (Lombardo *et al.* 1995, Dawson *et al.* 2011), averaging 40–50 per nest, sometimes exceeding 100 feathers (Sheppard 1977, Winkler 1993). White-rumped Swallows (*T. leucorrhoa*) can include up to 180 feathers (Bulit & Massoni 2004), similar to what have been described for Chilean Swallows breeding in Tierra del Fuego (Liljesthröm *et al.* 2009). This means that the "feather" nests had between two and three times the amount of feathers reported for species/populations of *Tachycineta* that use nest boxes in northern and southern latitudes.

Given the importance of feathers for nest insulation, especially in cold environments, it is conceivable that populations from any bird species breeding at higher latitudes will tend to include larger amounts of feathers in their nests compared to populations from more temperate environments (Mainwaring *et al.* 2014). Latitudinal comparisons of nest structure between populations have shown that such environmental adjustment indeed occurs in a number of species (Briskie 1995, Rohwer & Law 2010, Crossman *et al.* 2011, Mainwaring *et al.* 2012). Furthermore, recent studies revealed that this variation also takes place within populations (Mainwaring & Hartley 2008). For instance, evidence suggests that seasonal variation of nest morphology occurs in Chilean Swallows, for breeding birds make temporal adjustments of the amount of feathers in their nests as the breeding season progresses and environmental temperature increases (Liljesthröm *et al.* 2009). Following this reasoning, we would expect a higher use of feathers in those populations breeding in the southernmost localities of the species range (*i.e.* Isla Navarino), but also in the nests built by those breeding birds starting their nesting attempts early in the breeding season. Unfortunately, our reduced sample size limits our chances to infer if this could be the case. Three of the nests we described were structurally similar to Chilean Swallow nests from Tierra del Fuego (Liljesthröm *et al.* 2009) and also to nests described for the White-rumped Swallow (Bulit & Massoni 2004), but it is not clear if this is the most common nest structure in our study population. Further data is needed for describing nests from this locality in more depth, and for studying nest variation and its potential causes.

The extreme use of feathers for nest building could be a consequence of a relatively cold breeding season, but given that we found both "feather" and "typical" nests during 2013 and 2014, we cannot suggest how likely is this scenario. However, an opportunistic use of abundantly available feathers near the nesting sites could be an appealing and simpler explanation for the presence of "feather" nests in this population of Chilean Swallows. It is probable that the breeding adults could easily access a vast amount of feathers near the nesting site, making feathers the most energetically convenient item to collect, either by finding a corpse or a *Chloephaga* nest (see *e.g.* McCabe 1965), which are mainly made of self-plucked feathers. In any case (*i.e.* environmental adjustment or an opportunistic use of feathers, or both), the amount of feathers used in these nests seem an exaggerated response from the nesting birds involved, and thus, could reflect a rare behavior in this population. Further careful observations of nesting Chilean Swallows in both natural and artificial cavities will help determine the frequency of the extreme use of feathers at this study site or at ecologically similar localities, and the proximate causes promoting such behavior.

ACKNOWLEDGEMENTS

This work is part of research activities at the Omora Ethnobotanical Park, a member of the Chilean Network of Long-Term Socio-Ecological Study Sites, financed by the Institute of Ecology and Biodiversity (IEB). Funding was provided by grants from FONDECYT No. 1100359, and 1140548, grant ICM-P05-002, and PFB-23 CONICYT-Chile to RAV; graduate fellowships CONICYT-Chile 63130100 and ICM-P05-002, and a COLFUTURO' scholarship-loan PCB-2012 to EB-D. Research was conducted under permits 5193 and 6295 issued by the Servicio Agrícola y Ganadero de Chile (SAG), with the supervision of the Ethics Committee of the Sciences Faculty, Universidad de Chile. Comments from Benjamin Freeman helped to improve earlier versions of the manuscript.

REFERENCES

Allen, P. E. 1996. Breeding biology and natural history of the Bahama Swallow. *Wilson Bulletin*, 108: 380–495.

Barber, I. 2013. The evolutionary of nest construction: insight from recent fish studies. *Avian Biology Research*, 6: 83–98.

Botero-Delgadillo, E.; Poblete, Y. & Vásquez, R. A. 2015. Nestling mortality as a consequence of interspecific competition between secondary cavity nesters in the sub-Antarctic forests of Chile. *Wilson Journal of Ornithology*, 127: 131–134.

Briskie, J. V. 1995. Nesting biology of the Yellow Warbler at the northern limit of its range. *Journal of Field Ornithology*, 66: 531–543.

Brown, C. R.; Knott, A. M. & Damrose, E. J. 1992. Violet-green Swallow (*Tachycineta thalassina*). *In*: Poole, A. (ed.). *The birds of North America online*. Ithaca: Cornell Lab of Ornithology; Retrieved from http://bna.birds.cornell.edu/bna/species/014. doi: 10.2173/bna.14. (access on 03 February 2015).

Bulit, F. & Massoni, V. 2004. Arquitectura de los nidos de la Golondrina Ceja Blanca (*Tachycineta leucorrhoa*) construidos en cajas nido. *Hornero*, 19: 69–76.

Collias, N. E. & Collias, E. C. 1984. *Nest building and bird behaviour*. Princeton: Princeton University Press.

Crossman, C. A.; Rohwer, V. G. & Martin, P. R. 2011. Variation in the structure of bird nests between northern Manitoba and southeastern Ontario. *PLoS ONE*, 6: e19086.

Dawson, R. D.; O'Brien, E. L. & Mlynowski, T. J. 2011. The price of insulation: costs and benefits of feather delivery to nests for male Tree Swallows *Tachycineta bicolor*. *Journal of Avian Biology*, 42: 93–102.

Dyrcz, A. 1984. Breeding biology of the Mangrove Swallow *Tachycineta albilinea* and the Grey-breasted Martin *Progne chalybea* at Barro Colorado Island, Panama. *Ibis*, 126: 59–66.

Hansell, M. 2000. *Bird nests and construction behaviour*. New York: Cambridge University Press.

Jaramillo, A. 2003. *Birds of Chile*. New Jersey: Princeton University Press.

Liljesthröm, M.; Schiavini, A. & Reboreda, J. C. 2009. Chilean Swallows (*Tachycineta meyeni*) adjust the number of feathers added to the nest with time of breeding. *Wilson Journal of Ornithology*, 121: 783–788.

Lombardo, M. P. 1994. Nest architecture and reproductive performance in Tree Swallows (*Tachycineta bicolor*). *Auk*, 111: 814–824.

Lombardo, M. P.; Bosman, R. M.; Faro, C. A.; Houtteman, S. G. & Kluisza, T. S. 1995. Effect of feathers as nest insulation on incubation behavior and reproductive performance of Tree Swallows (*Tachycineta bicolor*). *Auk*, 112: 973–981.

Mainwaring, M. C. & Hartley, I. R. 2008. Seasonal adjustments in nest cup lining in Blue Tits *Cyanistes caeruleus*. *Ardea*, 96: 278–282.

Mainwaring, M. C.; Hartley, I. R.; Bearhop, S.; Brulez, K., du Feu; C. R., Murphy, G.; Plummer, K. E.; Webber, S. L.; Reynolds, S. J. & Deeming, D. C. 2012. Latitudinal variation in Blue Tit nest characteristics indicates environmental adjustment. *Journal of Biogeography*, 39: 1669–1677.

Mainwaring, M. C.; Hartley, I. R.; Lambrechts, M. M. & Deeming, D. C. 2014. The design and function of bird's nests. *Ecology and Evolution*, 20: 3909–3928.

McCabe, R. A. 1965. Nest construction by House Wrens. *Condor*, 67: 229–234.

McGowan, A.; Sharp, S. P. & Hatchwell, B. J. 2004. The structure and function of nests of Long-tailed Tits *Aegithalos caudatus*. *Functional Ecology*, 18: 578–583.

Rohwer, V. G. & Law, J. S. Y. 2010. Geographic variation in nests of Yellow Warblers breeding in Churchill, Manitoba, and Elgin, Ontario. *Condor*, 112: 596–604.

Sheppard, C. D. 1977. Breeding in the Tree Swallow, *Iridiprocne bicolor*, and its implications for the evolution of coloniality. Ph.D. Thesis. Ithaca, New York: Cornell University.

Townsend, J. M.; Garrido, E. & Mejia, D. A. 2008. Nests and nesting behavior of Golden Swallow (*Tachycineta euchrysea*) in abandoned bausite mines in the Dominican Republic. *Wilson Journal of Ornithology*, 120: 867–871.

Winkler, D. W. 1993. Use and importance of feathers s nest lining in Tree Swallows (*Tachycineta bicolor*). *Auk*, 110: 29–36.

Revista Brasileira de Ornitologia, 24(2), 90-93
June 2016

SHORT-COMMUNICATION

First record of the White-chinned Swift *Cypseloides cryptus* in the state of Acre, Brazil, with notes on its breeding biology

Renata Neves Biancalana[1,3] and Agimiro Magalhães[2]

[1] Laboratório de Evolução e Diversidade II, Programa de Pós-graduação em Evolução e Diversidade, Universidade Federal do ABC. Av. dos Estados, 5001, Bangu, CEP 09210-580, Santo André, SP, Brazil.
[2] Comunidade Pé da Serra, Parque Nacional Serra do Divisor, Mâncio Lima, AC, Brazil.
[3] Corresponding author: renata.biancalana@gmail.com

Received on 11 September 2015. Accepted on 25 April 2016.

ABSTRACT: We report the first photographic record of the White-chinned Swift *Cypseloides cryptus* breeding in the state of Acre in Brazil and include notes on breeding biology for this species. Four nests were found during the 2015 breeding season in waterfalls of the Serra do Divisor National Park. Egg laying started in early January, during the late rainy season, followed by an interval of one month between a second attempt, when three eggs were found in early April. Nests were cup shaped, made of mud, interwoven rootlets and bryophytes and constantly exposed to mist and dripping water. Nestlings were monitored from hatching in early May, to fledging in late June/early July. Our findings document the White-chinned Swift as a breeding resident in the region.

KEY-WORDS: Amazon, Apodidae, nestlings, waterfall.

Breeding season is the optimal period to observe and document Cypseloidine swifts behavior and biology due to their presence near nest sites. Many swifts in this subfamily are known to build nests in the same crevices and niches used in previous years in rock walls, near or behind waterfalls and in wet caves (Whitacre 1989, Marín & Stiles 1992, Chantler 1999). Although Amazonian lowlands are not generally considered to have the typical breeding sites for those swifts, the northern region of the Serra do Divisor mountain range on the border between Brazil and Peru has many waterfalls that could provide appropriate nest sites (Scarcello 1999).

Unidentified Cypseloidine swifts (*i.e.*, *Cypseloides*, *Streptoprocne*) and White-collared Swifts (*Streptoprocne zonaris*) were observed in flight during rapid assessments performed on the Peruvian side of the Sierra del Divisor and in the Juruá Valley, but with no detections of nests (Vriesendorp *et al.* 2007). In Brazil, observations of White-collared Swifts were made only in western Acre, on the west margin of the Purus River; recently the species was found breeding in Serra do Divisor National Park (SDNP) (Guilherme 2012, Biancalana 2015a).

Potential species to occur in the region would be the Chestnut-collared Swift (*Streptoprocne rutila*), the White-collared Swift, the White-chested Swift (*Cypseloides lemosi*), and the White-chinned Swift (*Cypseloides cryptus*), the closest recorded site for the latter would be in Abra Patricia region of Peru, more than 400 km away (Schulenberg *et al.* 2007, Vriesendorp *et al.* 2007, Roesler *et al.* 2009). Lane *et al.* (2003) suggested that White-chinned Swifts could also be present in the Yavarí Valley, somewhat closer to SDNP, where they were seen flying with other swift species.

Only two previous records for breeding White-chinned Swifts are recorded in Brazil, both in the region of Presidente Figueiredo and Rio Preto da Eva, state of Amazonas (Whittaker & Whittaker 2008, Brito *et al.* 2015).

An unidentified species of *Cypseloides* was observed by RNB flying over the Môa River on 17 July 2014. On the following day, an empty nest typical in locality and construction of a Cypseloidine swift was photographed behind Ar Condicionado Waterfall. Regular monitoring of this and other waterfalls started in the beginning of the rainy season (mid October) of 2014, in order to locate other possible nesting sites.

All observations took place in Serra do Divisor National Park, located in the state of Acre. The park borders the municipalities of Cruzeiro do Sul, Mâncio Lima, Rodrigues Alves, Porto Walter and Marechal Thaumaturgo. Several waterfalls can be found in the more montainous north part of the park (Scarcello 1999). Ar

Condicionado (7°26'46.26"S; 73°41'17.60"W) is a waterfall 4 m high that can be reached by foot on a short trail from the Môa River. Another trail leads to a small rock canyon at Igarapé do Amor where there are two waterfalls, Amor and Estátua Waterfalls (7°26'39.01"S; 73°40'2.07"W). The access from Amor to Estátua is made via a wooden ladder. Both waterfalls are more than 10 m high, but the water flow is low. Elevation at the three waterfalls is 286 m a.s.l.

On 23 February 2015, AM observed an unidentified adult swift adult sitting on a nest behind Estátua Waterfall. The nest, N1, was in a dark crevice 4 m above the ground, cup shaped, made with mud and interwoven rootlets and covered with fresh moss and liverworts. The exterior was damp. When approached, the adult flushed and a chick approximately two weeks old with dark grey semiplumes covering the body was observed. The identity of the bird as a White-chinned Swift was made by RNB. Age was estimated based on plumage described in other White-chinned Swift studies (Marín & Stiles 1992). One week later the nest was empty. No other nests or adults were observed at this location during the following month.

A second breeding attempt occurred in early April, when two more nests were found, one at Ar Condicionado Waterfall, N2, and one at Amor Waterfall, N3. Nest N2 was positioned on a horizontal ledge with constant dripping water less than 1.4 m above the ground. It was less than 1 m away from the nest observed in July 2014. One adult was observed incubating an egg and did not leave the nest until approached (Figure 1). N3 was located at Amor Waterfall, 3 m from the ground. Although it was some distance from the water, the area was in constant mist and very humid. The previously discovered N1 at Estátua Waterfall was reused in a second breeding attempt. Both N1 and N3 were positioned in dark crevices and were cup shaped and covered with bryophytes.

FIGURE 1. Adult White-chinned Swift in its nest on 15 April 2015, at Ar Condicionado Waterfall, Serra do Divisor National Park, Brazil. Photo: Agimiro Magalhães.

One dull white egg was observed in each of the three nests early April and incubating adults were seen during weekly visits. Between 4 and 6 May, all three eggs hatched. The naked hatchlings had pinkish skin and their eyes were closed. Adults were seen together with them until the nestlings were 2 to 3 weeks old. The nestlings were sluggish and silent, did not display any agonistic behavior when approached or picked up, but held firmly to the nest lining. Nestlings at two weeks of age were covered with semiplumes except on the head where semiplumes only covered the crown (Figure 2).

FIGURE 2. Two weeks-old White-chinned Swift on 18 May 2015, at Estátua Waterfall, Serra do Divisor National Park, Brazil. Photo: Agimiro Magalhães.

The plumage of the nestlings from 4 weeks onward was sooty dark gray with the head paler than the rest of the body. The feathers on the back, rump, crown and primaries had very thin white fringes (<0.2 cm), whereas the feathers in the lower abdomen and around the vent had broader white tips (around 0.5 cm). The feathers on the alula were also white-tipped. Two lines of pale feathers, one at each side of the nostrils, extended up to the forehead. Between 8 and 9 weeks, at the end of June to early July, the three nestlings successfully fledged.

This is the first photographic record of the White-chinned Swift breeding in the state of Acre and the first record of the species for western Amazon of Brazil. Apodidae species are extremely overlooked in Brazil and in other Latin American countries. Their cryptic habits and almost strict aerial life make them difficult to identify in the field. In addition, the absence of information regarding their breeding biology makes it difficult for most ornithologists to discover new nesting sites during the months of the breeding season. When the adults are not in their nests it is almost impossible for the untrained eye to find the nests, which are in most cases behind waterfalls or in dark crevices. Due to their fragile structure and constant exposure to water spray, they collapse after the nestlings fledge, and few nests remain to be found.

Small swifts of the genus *Cypseloides*, like the Sooty Swift and the White-chinned Swift, usually start their breeding period in Brazil after the beginning of the rainy season, not before, like other Cypseloidinae, such as the Great Dusky Swift (*Cypseloides senex*) or the White-collared Swift (*Streptoprocne zonaris*) (Marín & Stiles 1992, Biancalana 2015b). Looking at the proper places, such as small to medium sized waterfalls along the species range during the rainy season should reveal more breeding sites in the Brazilian Amazon. Just recently, in 2004, a new bird species was identified in Serra do Divisor, the Acre Antshrike (*Thamnophilus divisorius*), indicating that the region is still poorly explored despite its rich biodiversity (Whitney *et al.* 2004).

Nests were only identified when adults were incubating due to the cryptic nature of nest sites. The nest site, construction, and materials used were similar to reports of other populations of this species breeding in Brazil, Costa Rica and Venezuela (Ayarzaguena 1984, Marín & Stiles 1992, Whittaker & Whittaker 2008).

Considering that incubation period lasts 30 days on average, and the first nestling observed was two weeks old in late February, we suggest that egg laying started in early January, followed by incubation, and hatching in mid February. The second breeding attempt started with egg laying in early April, with hatching occurring between 4 and 6 May and fledging late June to early July. Thus, the suggested breeding period for the species in western Acre spans from early January up to late June/early July. This is similar to the population of Amazonas, where they started to breed later in the wet season (Whittaker &Whittaker 2008, Brito *et al*. 2015).

Nestling development was similar to that observed by Marín & Stiles (1992) in Costa Rica, except that the nestlings in the present study did not display agonistic behavior when picked up.

Careful searches of other waterfalls in Serra do Divisor should reveal the presence of more nests of the White-chinned Swift as well as new records of other Cypseloidine swifts.

ACKNOWLEDGEMENTS

We are thankful to Diogo Koga and ICMBIO for their support during field work and data on the Park. RNB is particularly grateful to Carolyn Gunn and Charles Collins for their critics and suggestions that improved the manuscript.

REFERENCES

Ayarzaguena, J. 1984. Sobre la nidificación del Vencejo Castano (*Cypseloides cryptus*) (Aves: Apodidae). *Memoria de la Fundación La Salle de Ciencias Naturales*, 122: 141–147.

Biancalana, R. N. 2015a. First documented record of the White-collared Swift *Streptoprocne zonaris* in the state of Acre with notes on its breeding biology. *Atualidades Ornitológicas*, 184: 21.

Biancalana, R. N. 2015b. Breeding biology of the Sooty Swift, *Cypseloides fumigatus*, in São Paulo, Brazil. *Wilson Journal of Ornithology*, 127: 402–410.

Brito, G. R. R.; Figueira, D. M.; Buianain, N.; Firme, D. H.; Biancalana, R. N.; Assis, C. P.; Araujo, G. G.; Crozariol, M. A.; Frickes, G. R.; Parrini, R.; Ruschi, P. A. & Raposo, M. A. 2015. Diet and breeding of the poorly know White-chinned Swift *Cypseloides cryptus* Zimmer, 1945 in Brazil. *Revista Brasileira de Ornitologia*, 23: 398–404.

Chantler, P. 1999. Family Apodidae (swifts). p. 388–457. *In*: del Hoyo, J.; Elliott, A. & Sargatal, J. (eds.). *Handbook of the birds of the world*, v. 5. Barcelona: Lynx Edicions.

Guilherme, E. 2012. Birds of the Brazilian state of Acre: diversity, zoogeography, and conservation. *Revista Brasileira de Ornitologia*, 20: 393–442.

Lane, D. F.; Pequeño, T. & Villar, J. F. 2003. Birds. p. 150–156. *In*: Pitman, N.; Vriesendorp, C. & Moskovits, D. (eds.). *Rapid biological inventories*, v. 11: *Perú: Yavarí.* Chicago: Chicago Field Museum of Natural History.

Marín, M. & Stiles, F. G. 1992. On the biology of five species of swifts (Apodidae, Cypseloidinae) in Costa Rica. *Proceedings of the Western Foundation of Vertebrate Zoology*, 4: 287–351.

Roesler, I.; Kirwan, G. M.; Agostini, G.; Beadle, D.; Shirihai, H. & Binford, L. C. 2009. First sight records of White-chested Swift *Cypseloides lemosi* in Bolivia, with documented records of *C. lemosi* and White-chinned Swift *C. cryptus* in Peru. *Bulletin of the British Ornithologists' Club*, 129: 222–228.

Scarcello, M. C. G. (ed.). 1999. *Plano de Manejo do Parque Nacional da Serra do Divisor (PNSD)*. Rio Branco: SOS Amazônia/IBAMA/The Nature Conservancy/USAID.

Schulenberg, T. S.; Stotz, D. F.; Lane, D. F. & O'Neill, J. P. 2007. *Birds of Peru.* Princeton: Princeton University Press.

Vriesendorp, C.; Schulenberg, T. S.; Alverson, W. S.; Moskovits, D. K. & Moscoso, J. I. R. (eds.). 2007. *Rapid biological inventories*, v. 17: Perú: Sierra del Divisor. Chicago: Chicago Field Museum of Natural History.

Whitacre, D. F. 1989. Conditional use of nest structures by White-naped and White-collared Swift. *Condor*, 91: 813–825.

Whitney, B. M.; Oren, D. C. & Brumfield, R. T. 2004. A new species of *Thamnophilus* Antshrike (Aves: Thamnophilidae) from the Serra do Divisor, Acre, Brazil. *Auk*, 121: 1031–1039.

Whittaker, A. & Whittaker, S. A. 2008. The White-chinned Swift *Cypseloides cryptus* (Apodiformes: Apodidae) breeding near Presidente Figueiredo, Amazonas: the first documented record for Brazil. *Revista Brasileira de Ornitologia*, 16: 398–401.

Associate Editor: Alexandre Aleixo.

Revista Brasileira de Ornitologia, 24(2), 94-115
June 2016

ARTICLE

Breeding seabird populations in Brazilian oceanic islands: historical review, update and a call for census standardization

Patrícia L. Mancini[1,3], Patrícia P. Serafini[2] and Leandro Bugoni[1]

[1] Laboratório de Aves Aquáticas e Tartarugas Marinhas, Instituto de Ciências Biológicas, Universidade Federal de Rio Grande - FURG, CP 474, CEP 96203-900, Rio Grande, RS, Brasil.

[2] Centro Nacional de Pesquisa e Conservação de Aves Silvestres - CEMAVE/ICMBio/MMA. Base Multifuncional CEMAVE/SC. Rodovia Maurício Sirotsky Sobrinho s/nº, km 02, SC 402, trevo Jurerê, CEP 88053-700, Florianópolis, SC, Brasil.

[3] Corresponding author/Current address: Seção de Aves, Museu de Zoologia da Universidade de São Paulo, Av. Nazaré, 481, Ipiranga, CEP 04263-000, São Paulo, SP, Brasil. email: patmancinibr@yahoo.com.br

Received on 12 October 2015. Accepted on 21 April 2016.

ABSTRACT: In recent decades, several seabird populations have declined globally due to anthropogenic activities. In Brazil, 14 seabird species breed at four oceanic islands and one atoll: the Abrolhos, Fernando de Noronha, and São Pedro and São Paulo (SPSPA) archipelagos; the Trindade/Martin Vaz Islands; and the Atol das Rocas. Seven species are listed as nationally threatened by extinction. This study aimed to present new information on breeding seabird populations in Brazilian oceanic islands, compile all available data previously published and, when possible, to provide updated information on population estimates from censuses carried out sporadically at different islands between 2006 and 2013. Based on new data and the thorough review provided here, of the 35 seabird breeding populations analysed, 14% were increasing (as Red-billed Tropicbird *Phaethon aethereus*, Magnificent Frigatebird *Fregata magnificens* and Brown Noddy *Anous stolidus* in Abrolhos), 11% were decreasing (as Brown Booby *Sula leucogaster* in Atol das Rocas and Great Frigatebird *Fregata minor* in Trindade Island), 23% were stable (as White-tailed Tropicbird *Phaethon lepturus* in Fernando de Noronha and Brown Noddy and Black Noddy *Anous minutus* in São Pedro and São Paulo Archipelago), and the remaining 49% were unknown or not possible to evaluate. The Red-footed Booby (*Sula sula*) is locally extinct in Trindade Island, however there are colonies of only a few individuals of other species, such as the Audubon's Shearwater *Puffinus lherminieri* and Red-billed Tropicbird in Noronha, Black Noddy in Martin Vaz, and Great (*Fregata ariel trinitatis*) and Lesser (*F. m. nicolli*) Frigatebirds in Trindade, that may become extinct soon. Censuses at distinct periods of the breeding cycles and protocols were highly variable, making temporal comparisons difficult. These results indicate an urgent need for long-term studies to improve the scenario to assess seabird population trends based on comparable methodologies, in order to determine trends in the future.

KEY-WORDS: booby, frigatebird, noddy, petrel, tern.

INTRODUCTION

Of the 346 seabird species in the world, 114 (33%) are globally threatened and 10% are listed as "near threatened" (Croxall *et al.* 2012). In addition, about 70% of world seabird populations declined among the 19% of seabird populations monitored regularly between 1950 and 2010 (Paleczny *et al.* 2015). Globally there are 1352 threatened breeding seabird populations of 98 species, from 986 islands (Spatz *et al.* 2014). The main threats for seabirds are commercial fisheries (bycatch and competition for prey), habitat degradation, introduction of alien species to their breeding grounds, pollution, and climate change (Croxall 2008, Grémillet & Boulinier 2009, Croxall *et al.* 2012, Lewison *et al.* 2012, Quillfeldt & Masello 2013, Wilcox *et al.* 2015). Consequently, there is an urgent need for data on population sizes and distribution to assess trends over time to properly infer the conservation status for species and populations not yet assessed. However, trends are hard to measure without prior data (Bibby *et al.* 1998), so regular standardized censuses are fundamental tools to investigate seabird population trends.

Several approaches to estimate the abundance of seabirds have been used, including at-sea counts (Woehler 1996) and counts on wintering roosting sites (Bugoni & Vooren 2005). However, counting nests at breeding sites is assumed to be the most reliable way to monitor population trends of seabirds over time (Hutchinson 1979, Bibby *et al.* 1998), although it is not always possible due to nest inaccessibility for some species, disturbance causing nest failure, lack of funds, or because it is time-consuming or inaccurate (Hutchinson 1979). Thus, other methodologies to estimate population sizes can be used when counting nests is not possible, but it is essential that standardization be considered to compare population numbers (Vooren & Chiaradia 1990, van Franeker 1994, Yorio *et al.* 1994, Bibby *et al.* 1998).

About 38% of the seabird species recognized globally occurs in Brazil as breeders, migrants or vagrants (Piacentini *et al.* 2015). Seabird colonies are generally located on islands, cliffs or headlands (Schreiber & Burger 2002, Nelson 2005). In Brazil, 14 seabird species breed at the four offshore islands and one atoll (from now on called oceanic islands): Fernando de Noronha, and São Pedro and São Paulo (SPSPA) archipelagos; Trindade Island together with Martin Vaz, the Abrolhos Archipelago over the continental shelf and Atol das Rocas (Antas 1991, Vooren & Brusque 1999). The most important breeding areas in terms of the number of species and abundance are the Fernando de Noronha Archipelago and Atol das Rocas (Antas 1991, Schulz-Neto 2004). Eleven species breed in Fernando de Noronha, eight in Abrolhos, eight in Trindade and the Martin Vaz Islands, five in Atol das Rocas, and three in SPSPA (Antas 1991, Schulz-Neto 1998, 2004, Both & Freitas 2004). Despite such variety, there is only one globally threatened seabird species breeding in Brazil, the Trindade Petrel (*Pterodroma arminjoniana*), listed as "Vulnerable" by the IUCN (2014) and nationally as "Critically Endangered" by Ministério do Meio Ambiente (MMA 2014). However, 7 out of 14 species breeding in Brazilian offshore islands are considered nationally threatened and three of them are "Critically Endangered" according to the recent Brazilian Red List (MMA 2014).

Most species breeding in Brazilian offshore islands are widely distributed in tropical and subtropical oceans, such as the Brown Noddy (*Anous stolidus*), Black Noddy (*Anous minutus*), Sooty Tern (*Onychoprion fuscatus*), White Tern (*Gygis alba*), Brown Booby (*Sula leucogaster*), Masked Booby (*Sula dactylatra*), Red-footed Booby (*Sula sula*), White-tailed Tropicbird (*Phaethon lepturus*), Red-billed Tropicbird (*Phaethon aethereus*), Magnificent Frigatebird (*Fregata magnificens*), Great Frigatebird (*Fregata minor*), and Lesser Frigatebird (*Fregata ariel*) (del Hoyo *et al.* 1992). However, comparatively, some species have smaller global distributions such as the Trindade Petrel and Audubon's Shearwater (*Puffinus lherminieri*). The Trindade Petrel breeds on Trindade Island offshore in Brazil (Espírito Santo state), and which during the last century colonized Round Island in the Indian Ocean (Brown *et al.* 2010, 2011). Audubon's Shearwater is distributed in tropical and subtropical areas of the West Atlantic Ocean (Carboneras *et al.* 2014), but in Brazil breeds regularly only in Fernando de Noronha Archipelago (Antas 1991). This species was reported breeding at Itatiaia Archipelago (in Espírito Santo state, in August 1993), but there is no further record since then (Efe & Musso 2001). The Red-footed Booby breeds only in Fernando de Noronha (Antas 1991, Schulz-Neto 2004), as now it seems extirpated from Trindade Island (Fonseca-Neto 2004, this study). The Red-billed Tropicbird breeds mainly in Abrolhos with a few individuals breeding in Fernando de Noronha, while the White-tailed Tropicbird breeds mainly in Fernando de Noronha, with a few individuals breeding in Abrolhos (Oren 1984, Antas 1991, Sick 1997). Furthermore, Trindade Island is the only known nesting area of the subspecies *Fregata ariel trinitatis* and *Fregata minor nicolli* (Orta *et al.* 2014a,b,c).

Despite a 25-year-old study on the status of Brazilian seabirds (Antas 1991), estimates of seabird populations in Brazilian offshore islands have never been determined. Antas (1991) provided the first whole national assessment of seabird populations, based on his experience and the scarce available data at that time. The limited data from random counting were used for the assessments, which lacked of standardized methods. Some counts for specific islands, colonies and species were available before or after this time, but lacking in regularity and standardized methodology (*e.g.* Fernando de Noronha - Oren 1984, Antas 1991, Schulz-Neto 2004; Atol das Rocas - Antas 1991, Schulz-Neto 1998; Abrolhos - Antas 1991, Alves *et al.* 2004, Fonseca-Neto 2004; and Trindade/Martin Vaz Islands - Olson 1981, Fonseca-Neto 2004, Luigi *et al.* 2009). The only exception is SPSPA (Mackinnon 1962, Masch 1966, Smith *et al.* 1974, Edwards *et al.* 1981, Antas 1991, Both & Freitas 2004, Barbosa-Filho & Vooren 2010), mainly for the Brown Booby population, for which whole island counts have been carried out regularly since early 2000s.

This study aims to evaluate population data for 14 seabird species breeding in Brazilian oceanic islands, based on a thorough literature review and counts carried out during 14 irregular expeditions, from 2006 to 2013, to assess if these studies used methods that could provide a national picture of population sizes and trends. The initial motivation for a detailed compilation had been the need to reassess conservation status of species at the national level for the Brazilian Red List (MMA 2014). Additionally, we suggest standardized methodologies for long-term monitoring of such populations, to improve the scenario of their trends in the future and thus better subsidize conservation actions.

METHODS

Seabird censuses were carried out in sporadic visits to the islands between 2006 and 2013, during 14 expeditions, including four in Fernando de Noronha (two in partnership with CEMAVE - *Centro Nacional de Pesquisa e Conservação de Aves Silvestres*), four in SPSPA, two in Abrolhos, two in Atol das Rocas, and two in Trindade Island (Figure 1, Tables 1 & 2). The censuses were conducted between 05:30 h and 08:30 h and between 16:30 h and 18:30 h, when the majority of seabirds were in the colony (Schulz-Neto 2004). For breeding species, a stick was used to disturb adults and verify the presence of eggs or chicks. In almost all colonies (Table 2), censuses were performed by direct counting of individuals and nests (Bibby *et al.* 1998). This study used the direct counting of nests, but in order to compare with prior data, it was necessary to convert nests to number of individuals (1 nest = 2 individuals). In colonies with high seabird densities (*e.g.* Sooty Tern in Atol das Rocas), birds were counted in random quadrats (100 m^2) with different densities, and the mean number of individuals was calculated and subsequently extrapolated for the total area occupied by the colony (Bibby *et al.* 1998). In Fernando de Noronha, censuses on-board a motorboat were performed in August (6 h observation), November 2010 (4 h), and April 2011 (4 h) with 10 × 50 mm binoculars to count seabirds flying or roosting on the northeast coast of the main island and islets. Furthermore, for some species, such as tropicbirds and petrels, nests were actively searched in Fernando de Noronha, Abrolhos, and Trindade. For those species with a limited number of individuals and nesting in inaccessible places, such as both frigatebird species from Trindade, the maximum counts of flying individuals and individual plumage characteristics (male/female, juveniles/adults) were used for a rough estimate of the minimum number of individuals.

An extensive literature review was performed to gather data of breeding seabird population abundance (individuals or nests) in Brazilian oceanic islands. Published articles, thesis, and conference abstracts in English and Portuguese from 1936 to 2014 were used (Appendix I).

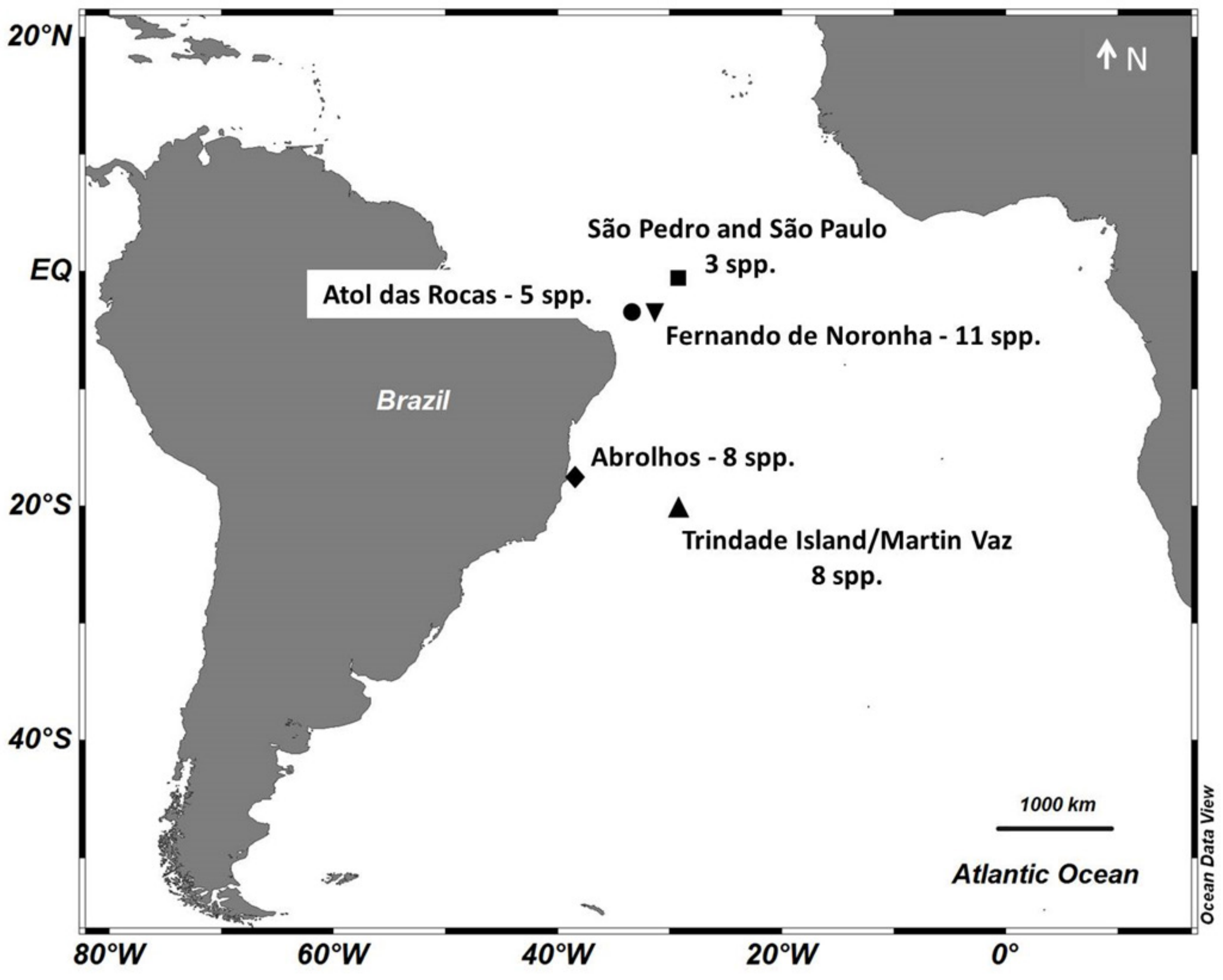

FIGURE 1. Location of the Brazilian offshore islands where the seabird population censuses were performed and the breeding seabird richness for each island/archipelago.

TABLE 1. Period of seabird censuses during expeditions carried out in each Brazilian offshore archipelago or island. - no census.

Island	Expedition I	Expedition II	Expedition III	Expedition IV
Abrolhos	20 February–06 March 2011	7–20 August 2011	-	-
Atol das Rocas	05 September–04 October 2010	13 February–06 March 2012	-	-
Fernando de Noronha	04–10 August 2010	23–28 November 2010	20 March–11 April 2011	08 July–02 August 2011
São Pedro and São Paulo (SPSPA)	14–27 August 2010	9–22 August 2011	06–17 January 2012	1–30 June 2013
Trindade Island	28–29 June 2006	16 December 2006–25 April 2007	-	-

TABLE 2. Seabird species recorded in their respective breeding sites in Brazilian offshore islands. X = presence, "-" = absence, E = extinct, SPSPA = São Pedro and São Paulo.

Breeding Species	SPSPA	Fernando de Noronha	Atol das Rocas	Abrolhos	Trindade and Martin Vaz Islands	No. of Islands
Pterodroma arminjoniana[1]	-	-	-	-	X	1
Puffinus lherminieri[2]	-	X	-	-	-	1
Phaethon aethereus[3]	-	X	-	X	-	2
Phaethon lepturus[3]	-	X	-	X	-	2
Sula dactylatra	-	X	X	X	X	4
Sula leucogaster	X	X	X	X	-	4
Sula sula[3]	-	X	-	-	E	1(1)
Fregata magnificens	-	X	-	X	-	2
Fregata ariel trinitatis[2]	-	-	-	-	X	1
Fregata minor nicolli[2]	-	-	-	-	X	1
Anous minutus	X	X	X	-	X	4
Anous stolidus	X	X	X	X	X	5
Gygis alba	-	X	-	-	X	2
Onychoprion fuscatus	-	X	X	X	X	4
Total spp. per island	**3**	**11**	**5**	**7**	**8(1)**	

[1] Listed as globally "Endangered" (IUCN 2014) and nationally "Critically Endangered" (MMA 2014); [2] Listed as nationally "Critically Endangered" (MMA 2014); [3] Listed as nationally "Endangered" (MMA 2014).

Results are presented as the number of individuals per species and archipelago. In order to make all censuses comparable, when the nest was the basis for counting, we considered each to indicate two individuals, in line with the predominantly monogamous breeding system of seabirds (Schreiber & Burger 2002). In the case of the direct counting of nests or individuals in the same area for the same species in the same expedition, we used the higher count as the estimated maximum number for the expedition. In Fernando de Noronha, for most seabird populations, censuses were possible only in some areas, which underestimated the actual seabird population sizes. Results of new censuses are presented together with data from previous studies, but a statistical evaluation of trends over time was not attempted, as census procedures differed markedly among studies, and frequently lack detailed information on protocols, census effort, seasonality and covered area. Reliable estimates for the current overview are those of Brown Boobies at SPSPA, a small place with a full-time presence of researchers at a scientific station. Other good estimates were those of both tropicbird species in Fernando de Noronha and Abrolhos. Estimates for these species were based on nest counts (through nest mapping), a laborious task undertaken with support from experienced cliff climbers, an intensive ringing scheme, and a year round research effort. In addition, estimates for these species benefited from their small populations. For SPSPA and Abrolhos, whole island nest/individual counts were adequate for a reliable and low disturbance estimation of population sizes. At the flat Atol das Rocas, due to the large number of nests, whole ground counts were unrealistic, and the delimitation of quadrats for counts and density estimation, followed by extrapolations, were a better option, except for species with limited numbers. More problematic were Fernando de Noronha and Trindade/Martin Vaz due to the size of these islands, their rough and steep terrain, and limited access, in addition to several surrounding islets. For these places, a species-by-species analysis should be undertaken before a standard protocol is established.

In the present study, for population trend estimations, only censuses using the same methodology (*e.g.* direct counts) for a species and site were evaluated. The criteria to classify population trends were: Increasing – when data showed an increasing number of individuals based in censuses carried out in similar periods (*e.g.* November 2001 and October 2010) and similar areas; Decreasing – when data showed a decreasing number of individuals based in census carried out in similar periods and similar areas; Stable – when data showed little variation (100–200 individuals) based in census carried out in similar periods and similar areas; Not Determined (ND) – when census were carried out using different methodology, periods, areas or lacking information, and Extinct (E) – when the species have been not recorded in the past 15 years in their breeding grounds.

Finally, based on the literature review and our experience in the field, at the five Brazilian oceanic islands, we summarized most suitable methods and breeding periods as a starting point for national standardization of seabird census on those islands.

RESULTS

All seabird population abundance for each species and islands are in Appendix I. Population trends are in Table 3 and further comments as follows.

Trindade Petrel *Pterodroma arminjoniana*

The Trindade Petrel breeds only at Trindade Island in the Atlantic Ocean and Round Island in the Indian Ocean (Brown *et al.* 2011). In Trindade, estimates ranged from 2000 individuals in August 1988 (Nacinovic *et al.* 1989) to 3000–5000 individuals in January–April 2006 (Luigi *et al.* 2009), but the lack of detailed information from previous censuses precludes trend estimation. The species did not breed on Martin Vaz as suggested in early studies.

Audubon's Shearwater *Puffinus lherminieri*

In Fernando do Noronha, a maximum of 30 Audubon's Shearwaters were counted in October 2005 (Silva-e-Silva & Olmos 2010). The population trend for this species was not determined because nests at Morro do Leão Island, where about half of reported nests are placed, have not been checked since 2006 due to weather and oceanographic conditions precluding landing.

TABLE 3. Summary of seabird population trends in their respective breeding sites in Brazilian offshore islands. ND = not determined, E = extinct, SPSPA = São Pedro and São Paulo Archipelago.

Breeding species	SPSPA	Fernando de Noronha	Atol das Rocas	Abrolhos	Trindade and Martin Vaz Islands
Pterodroma arminjoniana	-	-	-	-	ND
Puffinus lherminieri	-	ND	-	-	-
Phaethon aethereus	-	ND	-	Increasing	-
Phaethon lepturus	-	Stable	-	ND	-
Sula dactylatra	-	ND	ND	Stable	ND
Sula leucogaster	Increasing	ND	Decreasing	ND	-
Sula sula	-	Stable	Increasing*	-	E
Fregata magnificens	-	ND	Stable*	Increasing	-
Fregata ariel trinitatis	-	-	-	-	ND
Fregata minor nicolli	-	-	-	-	Decreasing
Anous minutus	Stable	ND	Decreasing	-	ND
Anous stolidus	Stable	ND	Decreasing	Increasing	Stable
Gygis alba	-	Stable	-	-	ND
Onychoprion fuscatus	-	ND	ND	Stable	Increasing

* Non-breeding population; - Non-breeding in this island.

Red-billed Tropicbird *Phaethon aethereus*

In Fernando de Noronha, a maximum of ten individuals were reported (Silva-e-Silva 2008). Despite oscillations, the small population persists in Fernando de Noronha, but trends were not possible to estimate. In Abrolhos, the population increased in the whole area (Figure 2).

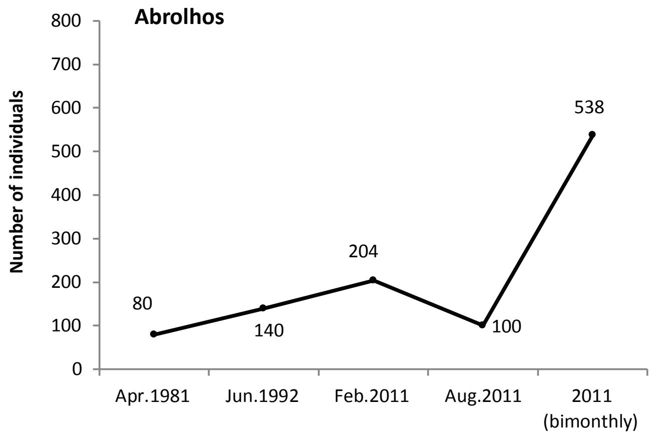

FIGURE 2. Population trend of the Red-billed Tropicbird *Phaethon aethereus* in Abrolhos from April 1981 (Antas 1991) to January 2012 (present study, M. A. Efe unpub. data in Nunes 2012), through direct counting.

White-tailed Tropicbird *Phaethon lepturus*

The population in Fernando de Noronha in December 1982 was estimated at 200 individuals (Oren 1984), which was similar to census results from August 2010 and August 2011 to January 2012 (Figure 3). Censuses from November 2010 to July 2011 covered only part of the archipelago, precluding whole population estimation. In Abrolhos, in February 2011, one individual was observed nesting at Santa Barbara Island, and other three nests were recorded over the years (G. R. Leal and M. A. Efe, pers. comm.).

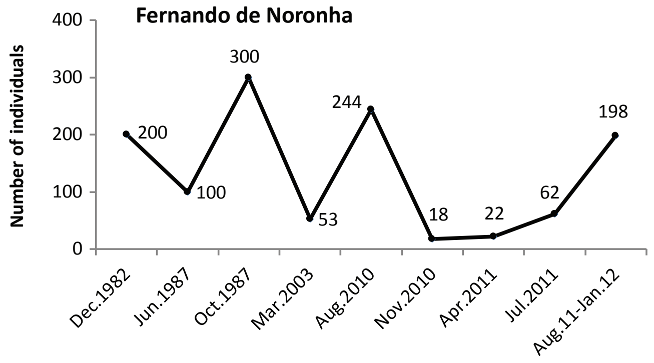

FIGURE 3. Population trend of the White-tailed Tropicbird *Phaethon lepturus* in Fernando de Noronha from December 1982 (Oren 1984) August 2011 to January 2012 (present study, M. A. Efe unpublished data, in Nunes 2012), through direct counting.

Masked Booby *Sula dactylatra*

The population in Fernando de Noronha, Atol das Rocas and Trindade Island showed no trends in abundance due to differences in the period of the year when census were carried out (Figure 4). The species also breeds on Martin Vaz, where 38 nests and 123 individuals were counted in early April 2007, with no previous estimate or previous breeding records for comparison. In Abrolhos, population estimates ranged from 1600 birds in July 1994 (Alves *et al.* 2000) to 1591 individuals in August 2011, thus the population trend was stable (Figure 4).

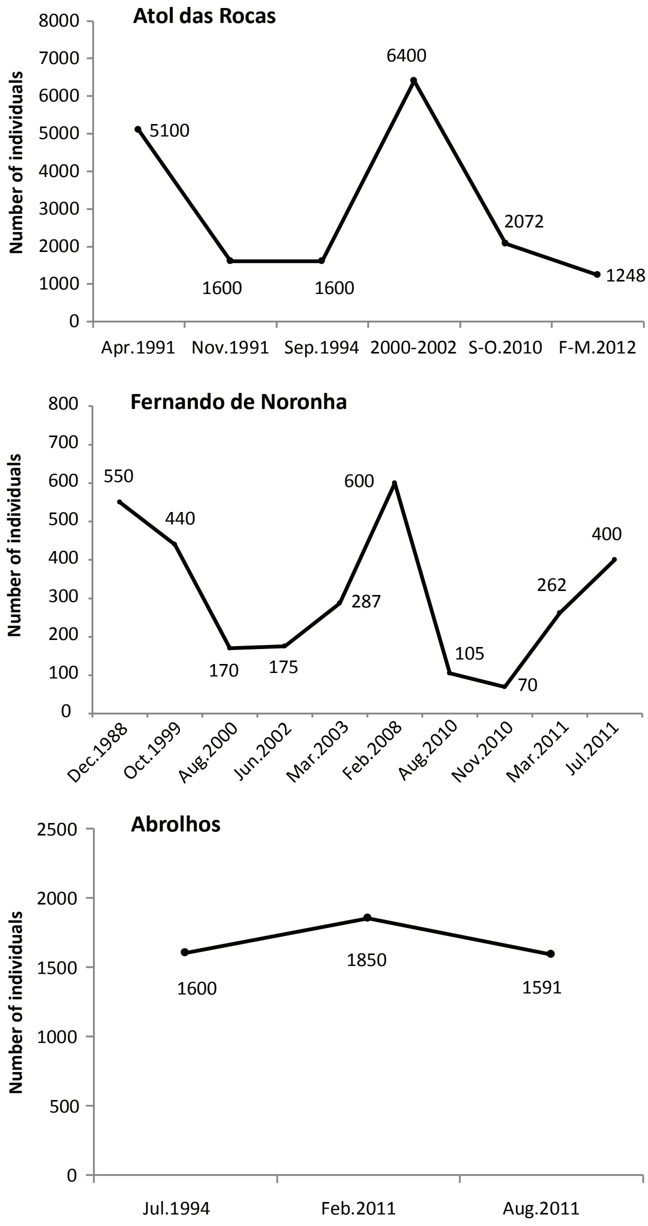

FIGURE 4. Population trends of the Masked Booby *Sula dactylatra* in Atol das Rocas from April 1991 (Schulz-Neto 1998) to February/ March 2012; in Fernando de Noronha Archipelago, from December 1988 (Antas 1991) to July 2011 and in Abrolhos Archipelago from July 1994 (Alves *et al.* 2000) to August 2011, through direct counting. S-O = September to October; F-M = February to March.

Brown Booby *Sula leucogaster*

In SPSPA, populations were increasing, particularly during the last decade when regular counts have been carried out (Figure 5). In Fernando de Noronha, the recent censuses did not cover the whole area in this archipelago, precluding trend estimation. In Atol das Rocas, the population halved between April 1991 and March 2012 (Figure 5). In Abrolhos, trends were not estimated due to differences in the period of the year among censuses data. Brown Booby breeds in other coastal islands along the Brazilian coasts (Efe *et al.* 2006).

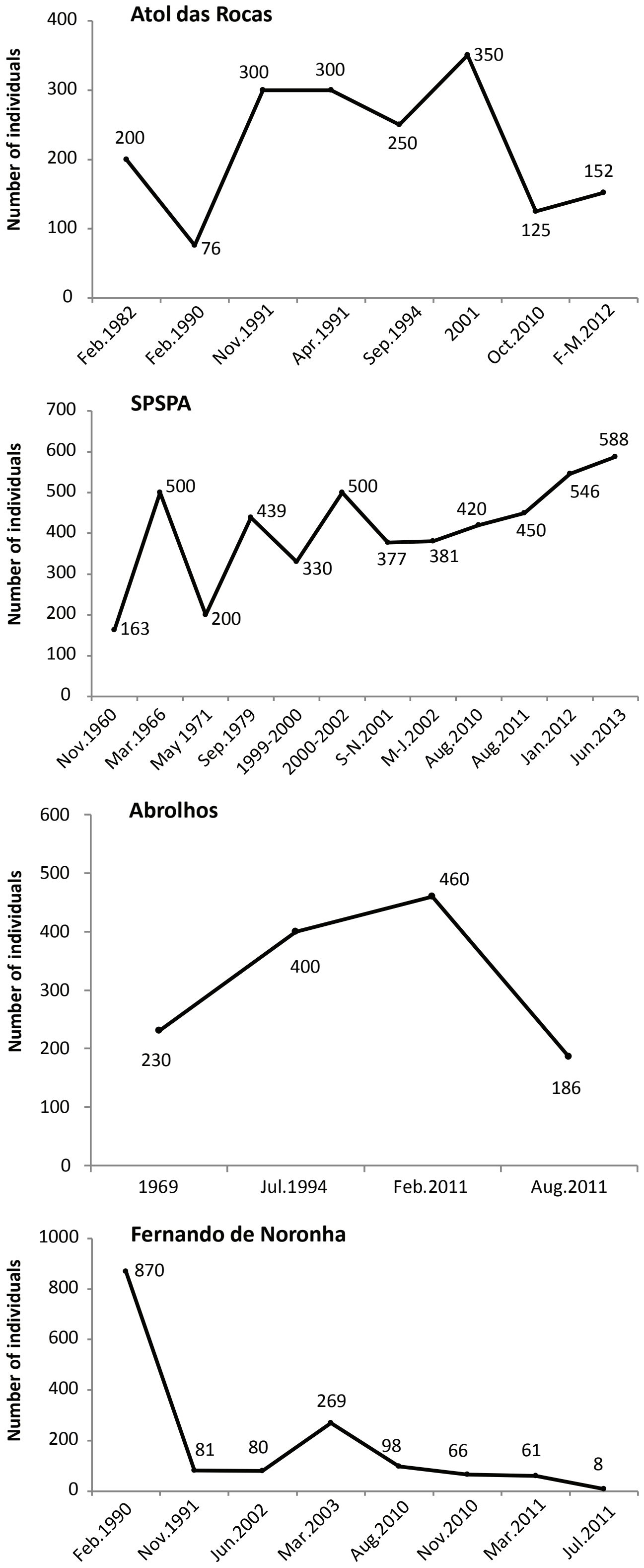

FIGURE 5. Population trends of the Brown Booby *Sula leucogaster* in Atol das Rocas from February 1982 (Antas 1991) to F-M = February to March 2012; in São Pedro and São Paulo Archipelago from November 1960 (Mackinnon 1962) to June 2013; in Abrolhos Archipelago from 1969 (Coelho 1981) to August 2011; and in Fernando de Noronha Archipelago from February 1990 (Antas 1991) to July 2011, through direct counting. F-M = February to March; S-N = September to November; M-J = March to July.

Red-footed Booby *Sula sula*

In Fernando de Noronha, the population trend was stable, when comparing census from October–November 1991 and November 2010 (1513 and 1511 birds, respectively), and March–April 2003 and 2011 (1658 and 1440 birds, respectively, Figure 6). Although this species does not breed in Atol das Rocas and SPSPA, part of the Fernando de Noronha population uses this area for foraging and resting. In Atol das Rocas, a maximum of 350 birds were recorded in September 2010, showing an increasing trend (Figure 6), while in SPSPA roosting birds varied from one to nine individuals from 2000 to 2013. Also, the Red-footed Booby used to breed on Trindade Island, but birds were not seen since 2000 (Fonseca-Neto 2004) and from December 2006 to April 2007 (this study) or thereafter, so the species is assumed to be extinct in the island.

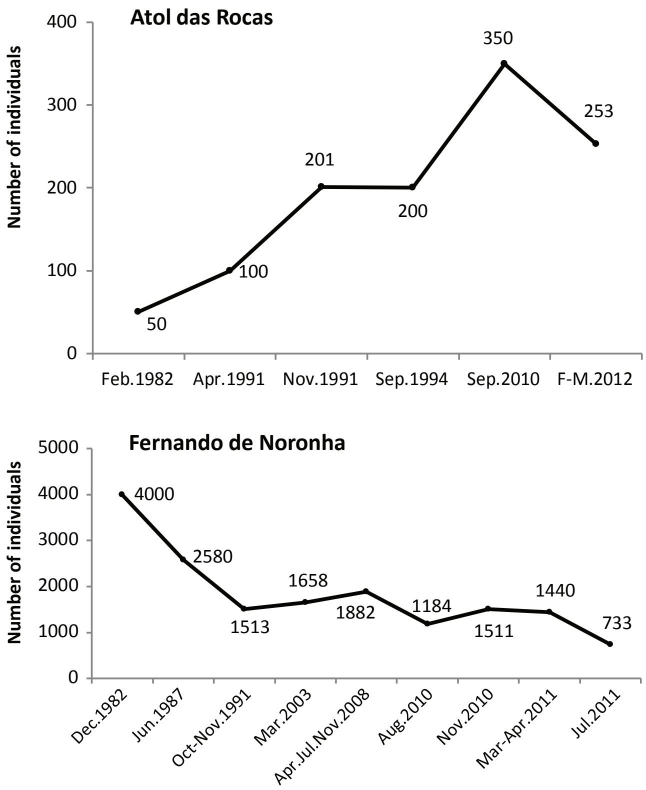

FIGURE 6. Population trends of the Red-footed Booby *Sula sula* in Atol das Rocas from December 1982 (Antas 1991) February and March 2012 and in Fernando de Noronha Archipelago from December 1982 (Oren 1984) to July 2011, through direct counting. F-M = February to March.

Magnificent Frigatebird *Fregata magnificens*

In Fernando de Noronha, recent censuses did not cover Sela Gineta Island (the only breeding colony) due to weather and oceanographic conditions, precluding trend estimation (Figure 7). In Atol das Rocas, the species also forages and rest, but does not breed, and the maximum number of individuals reported was 50 in February 1982 (Antas 1991). In Abrolhos, the population trend was increasing based on censuses carried out in March 1994 and February 2011 (230 and 660 birds, respectively) and

October 1994 and August 2011 (332 and 854 birds, respectively, Figure 7).

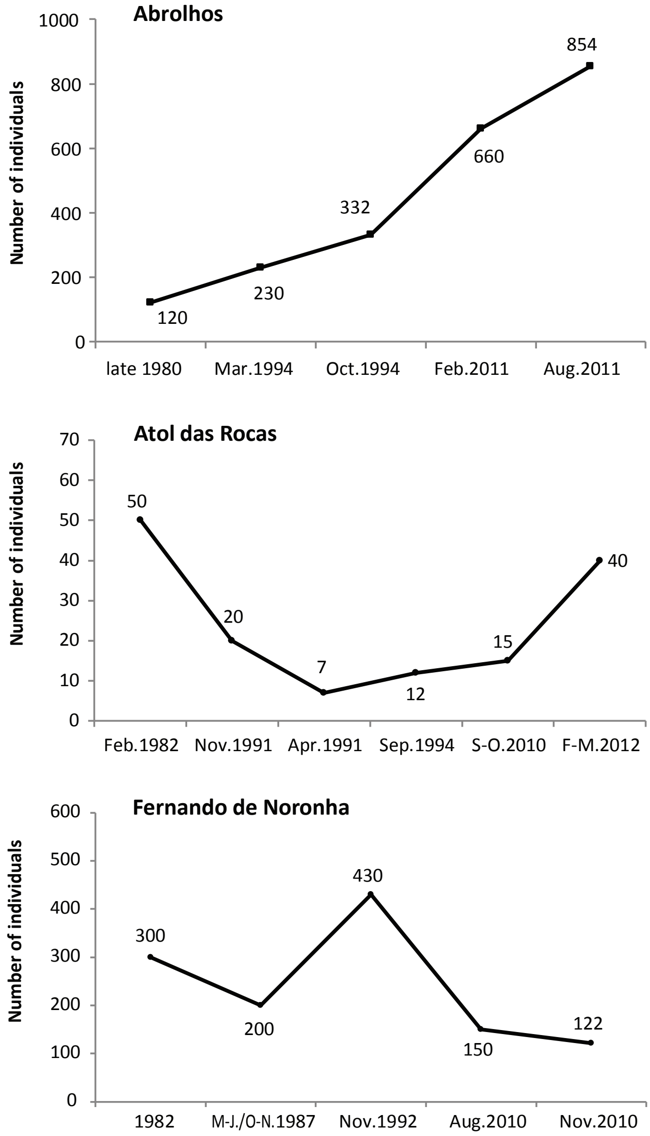

FIGURE 7. Population trends of the Magnificent Frigatebird *Fregata magnificens* in Abrolhos from late 1980 (Antas 1991) to August 2011; in Atol das Rocas from February 1982 (Schulz-Neto 1998) to March 2012; and in Fernando de Noronha Archipelago from 1982 (Oren 1984) to November 2010, through direct counting. S-O = September to October; F-M = February to March; M-J = May to June; O-N = October to November.

Lesser Frigatebird *Fregata ariel*

The subspecies *F. a. trinitatis* is restricted to the South Atlantic Ocean and only breeds at Trindade Island. The last breeding report was in 1975/76, when 15 pairs, about 50 individuals, were observed breeding in Trindade Island (Olson 1981). From December 2006 to April 2007 a maximum count of two non-breeding individuals was obtained.

Great Frigatebird *Fregata minor*

The subspecies *F. m. nicolli* is restricted to the South Atlantic Ocean. Great Frigatebirds once bred on Trindade Island; however, in 1975–1976 no bird colonies were recorded and only a small group of 15 Lesser Frigatebird nests (Olson 1981). Since then, there have been no further reports of either species nesting on the island, although there have been several reports of frigatebirds observed in flight (Orta *et al.* 2014b,c), including a record of 120 individuals attending a vessel for discards near Ponta Noroeste in August 1994 (Fonseca-Neto 2004). Only three individuals were recorded from December 2006 to April 2007, indicating a severe long-term decline (Appendix I).

Black Noddy *Anous minutus*

In SPSPA, the Black Noddy population trend was stable (Figure 8). In Fernando de Noronha, the recent censuses did not cover all the areas where this species occurs in the archipelago, precluding further analysis. In Atol das Rocas, population trend seem to be decreasing: 1,750 individuals in September 1994 (Schulz-Neto 1998) and 886 individuals in October 2010 (Figure 8). The species does not breed on Trindade Island, but a relict population persists on Ilha do Norte at Martin Vaz, where about 10 nests were photographed on an inaccessible cliff in April 2007. Based on nests and individuals flying nearby, a resident population of about 20 individuals is expected to persist at this place. No previous estimate for the island was available.

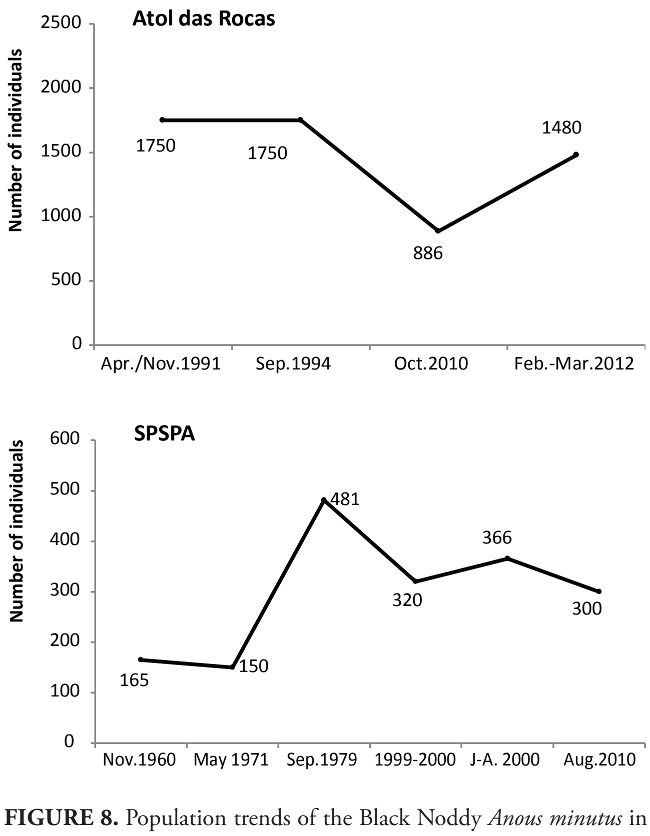

FIGURE 8. Population trends of the Black Noddy *Anous minutus* in Atol das Rocas from April to November 1991 (Schulz-Neto 1998) to February–March 2012 and in São Pedro and São Paulo Archipelago (SPSPA) from November 1960 (Mackinnon 1962) to August 2010, through direct counting. J-A = July to August.

Brown Noddy *Anous stolidus*

In SPSPA, the population trend was stable (Figure 9). In Fernando de Noronha, censuses in this study were restricted to Viuvinha Island and the port area, which precludes further analysis of the population trends. In Atol das Rocas, recent censuses indicated a decreasing trend (Figure 9) using the same methodology (random quadrats) in comparable seasons. In Abrolhos, the population increased from 2000 individuals in 1982 (Antas 1991) to 4725 in August 2011 (Figure 9). In Trindade, at least 250 nests could be found every year, based on direct counts or estimated based on adults attending colonies in inaccessible places, which converts to at least 500 individuals, in line with Fonseca-Neto (2004). Population trends were stable. The species potentially breeds on Martin Vaz, but the island was visited in early April 2007, a period out of the expected breeding season. Breeding at Martin Vaz remains to be confirmed. In Trindade Island important breeding locations include Pão de Açúcar, Pico do Vigia, Ilha do Sul, Farilhões, Pico do Monumento and the beach southward, Crista do Galo, and the nearby Ponta Norte.

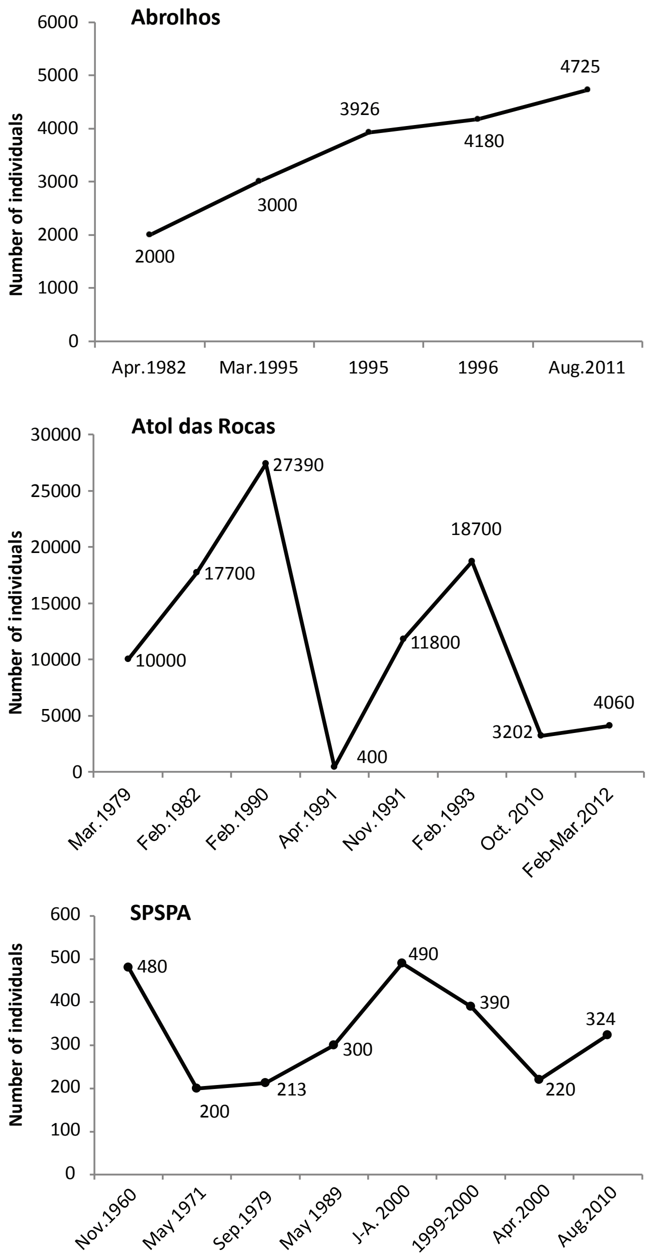

FIGURE 9. Population trends of the Brown Noddy *Anous stolidus* in Abrolhos Archipelago from April 1982 (Antas 1991) to August 2011; in Atol das Rocas from March 1979 (Antas 1991) to February–March 2012; and in São Pedro and São Paulo Archipelago (SPSPA) from November 1960 (Mackinnon 1962) to August 2010, through direct counting. J-A = July to August.

White Tern *Gygis alba*

In Fernando de Noronha, the population trend was stable comparing the first census of 250 individuals in December 1982 (Oren 1984), with recent counts in November 2010 (252 individuals). In 2011, both censuses covered only part of the species' distribution in the archipelago and the population size is underestimated. In Trindade Island nests are scattered on the cliffs and population trends were estimated due to differences in census seasonality. In Martin Vaz, eggs of at least 15 pairs and about 40 adults were found in early April 2007. No previous breeding record was available for this place.

Sooty Tern *Onychoprion fuscatus*

In Fernando de Noronha, the population size was underestimated, precluding trends estimation due to differences in areas and the period of the year when censuses were carried out. In Atol das Rocas, the population apparently decreased in the latest years (Figure 10). However, an oscillation of an order of magnitude is suspicious and may reflect methodological issues rather than real trends, thus no trends were estimated. In Abrolhos, population was stable indicating 20 Sooty Terns in early and latest census. The species also breeds in several colonies on Trindade Island, but the largest concentrations are on the top of Morro do Paredão, Morro das Tartarugas, Praia das Tartarugas, Pico do Monumento, and Parcel. Whole island count and colony size estimation was carried out from December 2006 to April 2007, which resulted in 2924 nests (roughly 6000

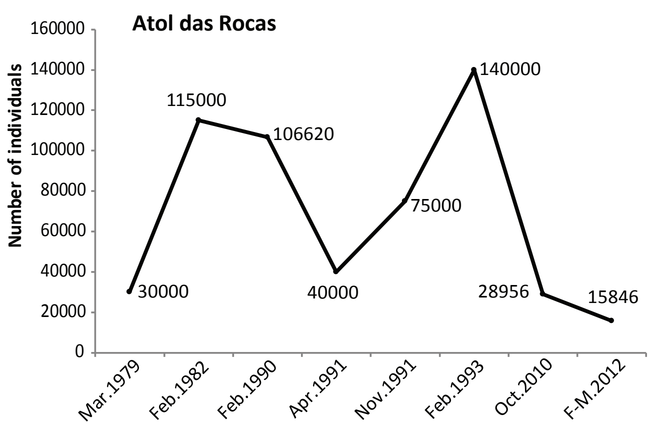

FIGURE 10. Population trend of the Sooty Tern *Onychoprion fuscatus* at Atol das Rocas from March 1979 (Antas 1991) to February–March 2012, through random quadrat censuses. F-M = February to March.

individuals). This is a conservative estimate, as the species breeds in small colonies in high places and areas facing the ocean. In Martin Vaz, several hundred individuals breed, and there is no previous estimate for the island.

Overall, considering every island and species as a population, of the 35 breeding populations, trends seems upward for 14%, decreasing for 11%, stable for 23%, unknown or not possible to evaluate for 49% (Table 3). The Red-footed Booby population from Trindade Island is now extinct, and six others, the Lesser and Great Frigatebirds, the Black Noddy from Martin Vaz, the Audubon's Shearwater and Red-billed Tropicbird from Fernando de Noronha, and the White-tailed Tropicbird from Abrolhos, are very tiny, with a real risk of extinction in the short-term.

Census standardization proposal

In order to obtain reliable data for long-term monitoring of seabird populations in the Brazilian islands, a range of methods in different periods of the year should be used. Nest mapping methodology is suggested as appropriate for Audubon's Shearwater, tropicbirds, Trindade Petrel, Red-footed Booby, Great Frigatebird and Lesser Frigatebird, while other species populations should be by counting nests. The only exceptions are high density colonies, such as for Sooty Tern in Trindade Island and Atol das Rocas, which the most appropriate census is random quadrats (100 × 100 m). A summary of methods and periods most suitable for censuses is presented in Table 4.

TABLE 4. Recommendation of the most suitable census methodology and breeding periods for seabird counting on Brazilian oceanic islands aiming the standardization and long-term monitoring. SPSPA = São Pedro and São Paulo Archipelago.

Breeding Species	SPSPA	Fernando de Noronha	Atol das Rocas	Abrolhos	Trindade and Martin Vaz Islands
Pterodroma arminjoniana	-	-	-	-	Nest mapping[1]/ Counting in flight for index locations
Puffinus lherminieri	-	Nest mapping[5]	-	-	-
Phaethon aethereus	-	Nest mapping[1]	-	Nest mapping[1]	-
Phaethon lepturus	-	Nest mapping[1]	-	Nest mapping[1]	-
Sula dactylatra	-	Counting nests[1]	Counting nests[1]	Counting nests[1]	Counting nests[7]
Sula leucogaster	Counting nests[1]	Counting nests[1]	Counting nests[1]	Counting nests[1]	-
Sula sula	-	Counting nests[1]	Counting individuals[1*]	-	
Fregata magnificens	-	Counting nests[5]	Counting individuals[1*]	Counting nests[1]	-
Fregata ariel trinitatis	-	-	-	-	Counting in flight[1]
Fregata minor nicolli	-	-	-	-	Counting in flight[1]
Anous minutus	Counting nests[2]	Counting nests[3]	Counting nests[1]	-	Counting nests[8]
Anous stolidus	Counting nests[2]	Counting nests[1]	Random quadrats[1]	Counting nests[6]	Counting nests[8]
Gygis alba	-	Counting nests[1]	-	-	Counting nests[9]
Onychoprion fuscatus	-	Counting nests[4]	Random quadrats[1]	Counting nests[6]	Random quadrats[7]

1= whole year, 2 = April to September, 3 = March to August, 4 = August to December, 5 = May to November, 6 = February to September, 7 = October to January, 8 = September to March, 9 = June to December. * Non-breeding at this site.

DISCUSSION

Seabird population trends

Population trends of seabirds in Brazil were previously unknown, despite the fundamental need for them to produce the Brazilian Red List of Threatened Fauna, in 2003 and 2014 (MMA 2014). However, population trends of about half of the seabird populations breeding in oceanic islands in Brazil, especially at Fernando de Noronha and Trindade/Martin Vaz Islands, remain unknown. In Fernando de Noronha, seabird populations are distributed in and around the main island, and in 21 adjacent islands and islets (Schulz-Neto 2004) difficult to reach. In the main island, species such as the Red-footed Booby, Black Noddy, tropicbirds, and the White Tern nest on trees, cliffs and in rocky crevices of limited access. Moreover, the adjacent islands may become inaccessible due to limited opportunity for landing. Similar access difficulties are also in Trindade/Martin Vaz Islands.

The Sooty Tern is the most abundant seabird in Brazil, mainly due to its huge colony at Atol das Rocas, although it is also the most abundant species in Trindade Island as well. On the other hand, Brown Noddy is the most widespread species in the offshore islands occurring in all five study places. However, considering the species breeding on coastal islands, Brown Boobies and Magnificent Frigatebirds are the most widespread species, breeding from Santa Catarina state (~27°S) north to SPSPA and Fernando de Noronha, respectively (Sick 1997).

Our results indicated that in recent decades there was a single local extinction, the Red-footed Booby in Trindade Island. However, there are colonies of only a few individuals of other species, such as the Audubon's Shearwater and Red-billed Tropicbird in Fernando de Noronha, White-tailed Tropicbird in Abrolhos, Black Noddy in Martin Vaz, and Great and Lesser Frigatebirds in Trindade. Thus, local extinctions in the near future would not be surprising. Trindade/Martin Vaz holds important breeding sites for the endemic subspecies of the Great and Lesser Frigatebirds, as well as the only breeding site in the Atlantic Ocean for the Trindade Petrel (Carboneras *et al.* 2014, Orta *et al.* 2014b,c). Both frigatebirds have global populations estimated from 100,000 to 1,000,000 individuals (BirdLife International 2015) over a broad range, and thus are considered not globally threatened, but the geographically isolated populations at Trindade Island are potentially full species under severe risk of extinction (Olson 1981). Information on the population size in these sites is scarce (Fonseca-Neto 2004) compared to the other oceanic islands, and more efforts are needed to improve it. Since 2007, a scientific research program at Trindade Island (PROTRINDADE) has been designed to manage the development of scientific research in the Trindade/Martin Vaz Islands and the adjacent marine area. Thus, it is expected that in the near future a dataset similar to those now available for SPSPA will appear.

Overall, a monitoring program of seabird populations based on standardized censuses must be established to generate a long-term database, enabling population trend analysis and the study of factors that may impact these populations, such as climate change and pollution. Essentially, for all Brazilian oceanic islands there is an urgent need for seabird population monitoring with methodologies that allow more comparable temporal sequences.

Methodological caveats

Seabird population trends can only be estimated based on prior counting data (Bibby *et al.* 1998), and caution must be taken with censuses that do not coincide with annual peaks in abundance, which affect population trend estimates, particularly for tropical species for which seasonality is sometimes limited. Furthermore, the lack of standardized methodology for censuses limits the strength of estimates of population size and trends.

Seasonal variations in population may occur due to differences in breeding time between species, as noddies in SPSPA and Abrolhos breed between March and September (Alves *et al.* 1997, Both & Freitas 2004), while Brown Boobies breed throughout the year at SPSPA (Both & Freitas 2004). Thus, knowing the breeding period or the breeding peak and conducting censuses in comparable periods is important in order to avoid misinterpretations. This is the reason why we suggested, when possible, the most suitable period to carry out census according to seabird species and breeding site, although such information is still lacking for some species and islands. Furthermore, the population size may oscillate between years and within years due to climatic or environmental factors affecting prey availability and seabird abundance near breeding areas (Furness & Camphuysen 1997, Quillfeldt & Masello 2013). The annual seasonal cycles of seabirds account for much of the total temporal variability of populations in all ecosystems (Furness & Camphuysen 1997). Although the general seasonal pattern repeats each year, climatic variability in the atmosphere and the ocean can generate detectable changes in intensity and onset timing among years and time scales. Consequently, long-term studies are desirable.

Censuses must be carried out following the same methodology wherever possible for future comparisons. For some species, such as the Brown Noddy, there were three different methodologies used for censuses (estimation, direct counting, and random quadrats) making some of the data not comparable. Whenever possible, counting the number of breeding pairs or active nests (with eggs or chicks) in a given breeding season for a given species is the most reliable way (Hutchinson 1979, see Table 4) to provide datasets for different years. This should be pursued by different teams and institutions in Brazil working within the same islands over several decades. However, this is not always possible for numerous reasons, including the inaccessibility of islands and cliffs, logistics, and the unpredictability of funds, which makes it impossible to monitor populations yearly. For these cases, other methodologies would be useful, as the use of unmanned aerial vehicles to take pictures of colonies (Vas *et al.* 2015) or predictive habitat modelling (Scott *et al.* 2009). Censuses can be undertaken on-board boats along the coast using sectors marked every kilometer along the perimeter of the island, as well as transects and distance sampling (Camphuysen *et al.* 2004). In Atol das Rocas, there are high population densities of the Sooty Tern and Brown Noddy, which make direct counting very laborious. Alternatively, prior studies used the random quadrat methodology (Antas 1991, Schulz-Neto 1998), which divided the study site with a grid (either on a map or actually on the ground with markers) and used random coordinates to position the sampling site within each grid square, with further extrapolation for the whole area (Bibby *et al.* 1998). However, the extrapolation should be "calibrated" in relation to population density, which makes this methodology rather subjective. Censuses also should be regularly carried out in the same areas as long as they cover all or most of the breeding colonies. For cryptic species, such as the burrowing nester Audubon's Shearwater, whose Brazilian population is small, one alternative is the use of independent acoustic recording devices, which can be deployed on remote islands to record the vocal activity of seabirds (Buxton & Jones 2012, Buxton *et al.* 2013, Oppel *et al.* 2014), or burrow-scopes (*e.g.* Hamilton 2000). Overall, agreement on the best way to monitor seabirds in Brazilian islands can only be achieved after a thorough discussion among different research teams, and would potentially be applicable case by case, *i.e.* defining methods specific to each species and colony/island, for which a first step is provide in the current study (Table 4).

Threats for Brazilian seabirds in breeding grounds

All Brazilian offshore islands are now protected areas under Brazilian legislation. This scenario would guarantee a safe ground for breeding seabirds. However, in the past, seabird species were threatened by the collection of eggs and nestlings, hunting, habitat degradation, and the introduction of alien invasive predators (Antas 1991, Alves *et al.* 2004, Fonseca-Neto, 2004, Schulz-Neto 2004), and some threats are still affecting their populations.

Seabird hunting and the collecting of eggs and nestlings are forbidden by law (Law of Environmental Crimes No. 9605/98), but in the past these activities might have been responsible for population declines for some species, such as tropicbirds in Fernando de Noronha, usually used as food and handcrafts (Nacinovic & Teixeira 1989). In 1870, when Fernando de Noronha was a penal colony, almost all vegetation was removed to avoid prisoner escape, which caused the tree-nesting Red-footed Booby to disappear from the island for a time (Oren 1984, Antas 1991, Schulz-Neto 2004). For centuries, egg collecting and the poaching of adults was a common practice, as well described at SPSPA and Abrolhos by Darwin during his voyage on the Beagle (Darwin 2008). In Trindade Island, the forests historically covered 85% of the island, but decreased to less than 5% due to devastation by feral pigs (*Sus scrofa*), goats (*Capra hircus*), House Mice (*Mus musculus*), and fire (Alves 1998). Habitat alteration critically reduced nesting opportunities for tree-nesting seabirds such as the Red-footed Booby and the two endemic frigatebirds, but in 2005 goat eradication was concluded by the Brazilian Navy (Luigi *et al.* 2009), while pigs were eliminated earlier, during the 1950s. The current threat is the introduced House Mouse. Currently, in Brazil the Red-footed Booby breeds only in Fernando de Noronha (Fonseca-Neto 2004) and the arboreal breeding habits protected the species of terrestrial predators such as rats (*Rattus rattus*, *R. norvegicus*), Tegu Lizard (*Salvator merianae*) and feral cats (*Felis catus*) (Barbosa-Filho *et al.* 2009). However, alien predators occur in most of the five sites studied. In Fernando de Noronha, potential egg and chick predators include the Tegu Lizard, rats, cats, pigs, and dogs (*Canis familiaris*), as well as others that destroy the vegetation, such as the Rock Cavy (*Kerodon rupestris*), House Mice, and goats (Schulz-Neto 2004).

Another growing threat to these birds is tourism. Seabird colonies are valuable tourist attractions, but species have different sensitivities to human disturbance and their presence in poorly managed sites may negatively affect breeding birds (Yorio *et al.* 2001, Croxall *et al.* 2012). Plastic ingestion and oil pollution are also potential threats (Croxall *et al.* 2012). Finally, considering recent pathogen transmission dynamics due to globalization and climate change (Morse 1995, Altizer *et al.* 2013), infectious diseases also have to be considered as important threats to birds breeding in colonies, since they have the potential to cause rapid declines and extinction of vulnerable populations (Heard *et al.* 2013). Furthermore, storms and pronounced maritime oscillations covering the marginal areas of an archipelago are natural causes of population decrease. In SPSPA, waves carried away eggs and nestlings in October 1999 (Both & Freitas 2004) and June 2014 (G. T. Nunes and F. P. Marques, pers. comm.).

All of the above threats, natural and anthropogenic, are ongoing in Brazilian seabird populations within offshore islands. Nevertheless, without knowing the real population sizes and monitoring them through standardized censuses, it will be difficult to take effective actions for conservation purposes. We reinforce the urgent need for additional studies focusing on rigorous and standardized methods for seabird population estimations, using comparable temporal methodologies.

ACKNOWLEDGEMENTS

We thank Fernanda P. Marques, Guilherme T. Nunes, Felipe M. Neves, Luciana R. Camillo, Vivian L. Ferreira, Isaac Simão Neto, Andrei L. Roos, Wolgrand M. Falcão, Márcio A. Efe and Gustavo R. Leal for assistance in fieldwork. Thanks also to ICMBio and Fernando de Noronha Administration for logistic support during Fernando de Noronha expeditions, and Zelinha Britto at REBIO Atol das Rocas. Brazilian Navy and *Comissão*

Interministerial para os Recursos do Mar (CIRM/SECIRM) for logistic support for the Trindade and SPSPA expeditions, and the Brazilian Research Council (CNPq - Grant No. 557152/2009-7) for funding the project. P.L.M. acknowledges CAPES Foundation for providing grant No. 9733/2011-6. PLM is a postdoctoral fellow of the *Fundação de Amparo à Pesquisa do Estado de São Paulo* (Proc. No. 2014-00194-2). L.B. is a research fellow from the Brazilian CNPq (Proc. No. 310550/2015-7). Authors are grateful to four reviewers which greatly improved earlier versions.

REFERENCES

Altizer, S.; Ostfeld, R. S.; Johnson, P. T. J.; Kutz, S. & Harvell, D. 2013. Climate change and infectious diseases: from evidence to a predictive framework. *Science*, 341: 514–519.

Alves, R. J. V. 1998. *Ilha da Trindade e Arquipélago Martin Vaz - um ensaio geobotânico*. Niterói: Serviço de Documentação, Diretoria de Hidrografia e Navegação, Marinha do Brasil.

Alves, V. S.; Soares, A. B. A.; Couto, G. S.; Efe, M. A. & Ribeiro, A. B. B. 2004. Aves marinhas de Abrolhos - Bahia, Brasil. p. 213–232. *In*: Branco, J. O. (ed.). *Aves marinhas e insulares brasileiras, bioecologia e conservação*. Itajaí: Univali Editora.

Alves, V. S.; Soares, A. B. A.; Couto, G. S.; Ribeiro, A. B. B. & Efe, M. A. 2000. *As aves do Arquipélago de Abrolhos (Bahia, Brasil)*. Brasília: IBAMA.

Alves, V. S.; Soares, A. B. A.; Couto, G. S.; Ribeiro, A. B. B. & Efe, M. A. 1997. Aves do Arquipélago dos Abrolhos, Bahia, Brasil. *Ararajuba,* 5: 209–218.

Antas, P. T. Z. 1991. Status and conservation of seabirds breeding in Brazilian waters. p. 141–158. *In*: Croxall, J. P. (ed.). *Seabird status and conservation: a supplement*. Cambridge: International Council for Bird Preservation.

Barbosa-Filho, R. & Vooren, C. M. 2010. Abundância, estrutura etária e razão sexual do Atobá-marrom *Sula leucogaster* (Pelecaniformes: Sulidae) no Arquipélago de São Pedro e São Paulo, Brasil. *Revista Brasileira de Ornitologia,* 18: 157–163.

Barbosa-Filho, R. C.; Sousa, A. E. B. A.; Freitas, G. L.; Nunes, M. F. C.; Souza, E. A. & Zeppelini-Filho, D. 2009. A Garça-vaqueira (*Bulbucus ibis* Linnaeus, 1758) e o Atobá-de-pé-vermelho (*Sula sula* Linnaeus, 1766) no Arquipélago de Fernando de Noronha: uma abordagem ecológica comparativa. *Ornithologia*, 3: 101–114.

Bibby, C.; Jones, M. & Marsden, S. 1998. *Expedition field techniques: bird surveys.* London: Royal Geographical Society.

BirdLife International. 2015. IUCN Red List for birds. http://www.birdlife.org (access on 09 February 2015).

Both, R. & Freitas, T. O. R. 2004. Aves marinhas no Arquipélago de São Pedro e São Paulo. p. 193–212. *In*: Branco, J. O. (ed.). *Aves marinhas e insulares brasileiras, bioecologia e conservação*. Itajaí: Univali Editora.

Brooke, M. L. 2004. *Albatrosses and petrels across the world. Bird families of the world.* New York: Oxford University Press.

Brown, R. M.; Nichols, R. A.; Faulkes, C. G.; Jones, C. G.; Bugoni, L.; Tatayah, V.; Gottelli, D. & Jordan, W. C. 2010. Range expansion and hybridization in Round Island petrels (*Pterodroma* spp.): evidence from microsatellite genotypes. *Molecular Ecology,* 19: 3157–3170.

Brown, R. M.; Jordan, W. C.; Faulkes, C. G.; Jones, C. G.; Bugoni, L.; Tatayah, V.; Palma, R. L. & Nichols, R. A. 2011. Phylogenetic relationships in *Pterodroma* petrels are obscured by recent secondary contact and hybridization. *PLoS ONE,* 6: e20350.

Bugoni, L. & Vooren, C. M. 2005. Distribution and abundance of six tern species in southern Brazil. *Waterbirds,* 28: 110–119.

Buxton, R. T. & Jones, I. L. 2012. Measuring nocturnal seabird activity and status using acoustic recording devices: applications for island restoration. *Journal of Field Ornithology,* 83: 47–60.

Buxton, R. T.; Major, H. L.; Jones, I. L. & Williams, J. C. 2013. Examining patterns in nocturnal seabird activity and recovery across the western Aleutian Islands, Alaska, using automated acoustic recording. *Auk,* 130: 331–341.

Camphuysen, K. C. J.; Fox, T. A. D.; Leopold, M. M. F. & Peterson, I. K. 2004. *Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K.* Amsterdam: Royal Netherlands Institute for Sea Research.

Carboneras, C.; Jutglar, F. & Kirwan, G. M. 2014. Audubon's Shearwater (*Puffinus lherminieri*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & Juana, E. (eds.). *Handbook of the birds of the world alive*. Barcelona: Lynx Edicions. http://www.hbw.com/node/52580 (access on 28 October 2014).

Coelho, A. G. M. 1981. Observações sobre a avifauna do Arquipélago dos Abrolhos, Bahia. *Publicações Avulsas UFPE,* 1: 1–7.

Croxall, J. P. 2008. Seabird mortality and trawl fisheries. *Animal Conservation,* 11: 255–256.

del Hoyo, J.; Elliott, A. & Sargatal, J. 1992. *Handbook of the birds of the world*. v. 1. Barcelona: Lynx Edicions.

Croxall, J. P.; Butchart, S. H. M.; Lascelles, B.; Stattersfield, A. J.; Sullivan, B.; Symes, A. & Taylor, P. 2012. Seabird conservation status, threats and priority actions: a global assessment. *Bird Conservation International,* 22: 1–34.

Darwin, C. R. 2008. *O diário do Beagle*. Curitiba: Editora da UFPR.

Edwards, A. J.; Wilson, K. & Hubbock, H. 1981. The seabird populations of St. Paul's Rocks. *Ibis,* 123: 233–238.

Efe, M. A.; Oliveira, A. C.; Kanegae, M. F.; Alves, V. S.; Rosário, L. A. & Scherer-Neto, P. 2006. Análise dos dados de recuperação de *Sula* spp. (Pelecaniformes, Sulidae) ocorridas no Brasil entre 1981 e 2000. *Ornithologia,* 1: 125–133.

Efe, M. A. & Musso, C. M. 2001. Primeiro registro de *Puffinus lherminieri* Lesson, 1839 no Brasil. *Nattereria*, 2: 21–23.

Fonseca-Neto, F. P. 2004. Aves marinhas da ilha Trindade. p. 119–146. *In*: Branco, J. O. (ed.). *Aves marinhas e insulares brasileiras, bioecologia e conservação*. Itajaí: Univali Editora.

Furness, R. W. & Camphuysen, K. C. J. 1997. Seabirds as monitors of the marine environment. *ICES Journal of Marine Science,* 54: 726–737.

Grémillet, D. & Boulinier, T. 2009. Spatial ecology and conservation of seabirds facing global climate change: a review. *Marine Ecology Progress Series*, 391: 121–137.

Hamilton, S. 2000. How precise and accurate are data obtained using an infra-red scope on burrow nesting Sooty Shearwaters *Puffinus griseus*? *Marine Ornithology,* 28: 1–6.

Heard, M. J.; Smith, K. F.; Ripp, K. J.; Berger, M.; Chen, J.; Dittmeier, J.; Goter, M.; McGarvey, S. T. & Ryan, E. 2013. The threat of disease increases as species move toward extinction. *Conservation Biology,* 27: 1378–1388.

Hutchinson, A. E. 1979. Estimating numbers of colonial nesting seabirds: a comparison of techniques. *Proceedings of the Colonial Waterbird Group,* 3: 235–244.

IUCN. 2014. Red list of threatened species, v. 2014.2. http://www.iucnredlist.org (access on 28 September 2014).

Kohlrausch, A. B. 2003. *Biologia reprodutiva, comportamento e ecologia de Atobás (Sulidae): implicações para a evolução do dimorfismo sexual no tamanho*. Ph.D. Thesis. São Paulo: Universidade de São Paulo.

Lewison, R.; Oro, D.; Godley, B. J.; Underhill, L.; Bearhop, S.; Wilson, R. P.; Ainley, D.; Arcos, J. M.; Boersma, P. D.; Borboroglu, P. G.; Boulinier, T.; Frederiksen, M.; Genovart, M.; González-Solís, J.; Green, J. A.; Grémillet, D.; Hamer,

K. C.; Hilton, G. M.; Hyrenbach, K. D.; Martínez-Abraín, A.; Montevecchi, W. A.; Phillips, R. A.; Ryan, P. G.; Sagar, P.; Sydeman, W. J.; Wanless, S.; Watanuki, Y.; Weimerskirch, H. & Yorio, P. 2012. Research priorities for seabirds: improving conservation and management in the 21st century. *Endangered Species Research,* 17: 93–121.

Luigi, G.; Bugoni, L.; Fonseca-Neto, F. P. & Teixeira, D. M. 2009. Biologia e conservação do Petrel-de-trindade, *Pterodroma arminjoniana*, na Ilha da Trindade, Atlântico sul. p. 223–263. *In*: Mohr, L. V.; Castro, J. W. A.; Costa, P. M. S. & Alves, R. J. V. (eds.). *Ilhas oceânicas brasileiras, da pesquisa ao manejo*, v. 2. Brasília: MMA/Secretaria de Biodiversidade e Florestas.

Luigi, G. 1992. Considerações sobre a avifauna da Ilha da Trindade, ES. p. 85, *In*: II Congresso Brasileiro de Ornitologia, Campo Grande: SOB/UFMS.

Mackinnon, R. S. 1962. Bird life on St Paul's Rocks. *Sea Swallow,* 15: 53–55.

Martins, F. C. 2004. Estimativas populacionais e considerações para a conservação da avifauna marinha e aquática em Fernando de Noronha. Pp. 40, *In*: XXV Congresso Brasileiro de Zoologia, Brasília: UnB.

Masch, D. 1966. Life on the rocks. *Oceanus,* 12: 5–7.

Mestre, L. A. M.; Ross, A. L. & Nascimento, J. L. X. 2009. Dados biológicos de *Puffinus lherminieri* anilhados em Fernando de Noronha em 2005 e 2006. *Revista Brasileira de Ornitologia*, 17: 65–69.

Murphy, R. C. 1936. *Oceanic birds of South America*. New York: Macmillam and America Museum of Natural History.

MMA (Ministério do Meio Ambiente). 2014. Portaria Nº. 444, 17/12/2014. Dispõe sobre as espécies da fauna brasileira ameaçadas de extinção. p. 121–126 *In*: Diário Oficial da União, Brasília, DF, N 245 publicado em 18/12/2014, Seção 1.

Morse, S. S. 1995. Factors in the emergence of infectious diseases. *Emerging Infectious Diseases,* 1: 7–15.

Nacinovic, J. B. & Teixeira, D. M. 1989. As aves de Fernando de Noronha: uma lista sistemática anotada. *Revista Brasileira de Biologia,* 49: 709–729.

Nacinovic, J. B.; Luigi, G.; Teixeira, D. M.; Kischlat, E. & Novelli, R. 1989. Observações sobre a avifauna da Ilha de Trindade e Martin Vaz. p. 135 *In*: Abstracts of the XVI Congresso Brasileiro de Zoologia, João Pessoa.

Nelson, B. J. 2005. *Pelicans, cormorants, and their relatives: the Pelecaniformes*. Oxford: Oxford University Press.

Nunes, G. T. 2012. *Dimorfismo sexual de tamanho, variabilidade genética e conectividade intraespecífica de* Phaethon aethereus *and* Phaethon lepturus *no Brasil.* MSc. Dissertation. Rio Grande: Universidade Federal de Rio Grande - FURG.

Olson, S. L. 1981. Natural history of vertebrates on the Brazilian islands of the mid South Atlantic. *National Geographic Society Research Report,* 13: 481–492.

Oppel, S.; Hervías, S.; Oliveira, N.; Pipa, T.; Silva, C.; Geraldes, P.; Goh, M.; Immler, E. & McKown, M. 2014. Estimating population size of a nocturnal burrow-nesting seabird using acoustic monitoring and habitat mapping. *Journal of Nature Conservation,* 7: 1–13.

Oren, D. C. 1982. Avifauna do Arquipélago de Fernando de Noronha. *Boletim do Museu Paraense Emílio Goeldi, Série Zoologia,* 118: 1–22.

Oren, D. C. 1984. Resultados de uma nova Expedição Zoológica a Fernando de Noronha. *Boletim do Museu Paraense Emílio Goeldi, Série Zoologia,* 1: 19–44.

Orta, J.; Christie, D. A.; Garcia, E. F. J. & Boesman, P. 2014a. Magnificent Frigatebird (*Fregata magnificens*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & Juana, E. (eds.). *Handbook of the birds of the world alive*. Barcelona: Lynx Edicions. http://www.hbw.com/node/52669 (access on 28 October 2014).

Orta, J.; Garcia, E. F. J.; Kirwan, G .M. & Boesman, P. 2014b. Lesser Frigatebird (*Fregata ariel*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & Juana, E. (eds.). *Handbook of the birds of the world alive*. Lynx Edicions, Barcelona. http://www.hbw.com/node/52671 (access on 28 October 2014).

Orta, J.; Kirwan, G. M.; Garcia, E. F. J. & Boesman, P. 2014c. Great Frigatebird (*Fregata minor*). *In*: del Hoyo, J.; Elliott, A.; Sargatal, J.; Christie, D. A. & Juana, E. (eds.). *Handbook of the birds of the world alive*. Lynx Edicions, Barcelona. http://www.hbw.com/node/52670 (access on 28 October 2014).

Paleczny, M.; Hammill, E.; Karpouzi, V. & Pauly, D. 2015. Population trend of the world's monitored seabirds, 1950–2010. *PLoS ONE,* 10: e0129342.2.

Piacentini, V. Q.; Aleixo, A.; Agne, C. E.; Maurício, G. N.; Pacheco, J. F.; Bravo, G. A.; Brito, G. R. R., Naka, L. N.; Olmos, F.; Posso, S.; Silveira, L. F.; Betini, G. S.; Carrano, E.; Franz, I.; Lees, A. C.; Lima, L. M.; Pioli, D.; Schunck, F.; Amaral, F. R.; Bencke, G. A.; Cohn-Haft, M.; Figueiredo, L. F. A.; Straube, F. C. & Cesari, E. 2015. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia,* 23: 91–298.

Quillfeldt, P. & Masello, J. F. 2013. Impacts of climate variation and potential effects of climate change on South American seabirds - a review. *Marine Biology Research*, 9: 337–357.

Sarmento, R.; Brito, D.; Ladle, R. J.; Leal, G. R. & Efe, M. A. 2014. Invasive House (*Rattus rattus*) and Brown Rats (*Rattus norvegicus*) threaten the viability of Red-billed Tropicbird (*Phaethon aethereus*) in Abrolhos National Park, Brazil. *Tropical Conservation Science,* 7: 614–627.

Schreiber, E. A. & Burger, J. 2002. *Biology of marine birds*. Boca Raton: CRC Press.

Schulz-Neto, A. 1995. Observando aves no Parque Nacional Marinho de Fernando de Noronha: guia de campo. Brasília: Instituto Brasileiro dos Recursos Naturais Renováveis.

Schulz-Neto, A. 1998. Aspectos biológicos da avifauna marinha na Reserva Biológica do Atol das Rocas, Rio Grande do Norte, Brasil. *Hornero,* 15: 17–28.

Schulz-Neto, A. 2004. Aves marinhas do Atol das Rocas. p. 169–192. *In*: Branco, J. O. (ed.). *Aves marinhas e insulares brasileiras: bioecologia e conservação*. Itajaí: Univali Editora.

Scott, D.; Moller, H.; Fletcher, D.; Newman, J.; Aryal, J.; Bragg, C. & Charleton, K. 2009. Predictive habitat modelling to estimate petrel breeding colony sizes: Sooty Shearwaters (*Puffinus griseus*) and Mottled Petrels (*Pterodroma inexpectata*) on Whenua Hou Island. *New Zealand Journal of Zoology,* 36: 291–306.

Sick, H. 1997. *Ornitologia brasileira*. Rio de Janeiro: Nova Fronteira.

Silva-e-Silva, R. 2008. *Aves de Fernando de Noronha*. São Paulo: Avis Brasilis.

Silva-e-Silva, R. & Olmos, F. 2010. Notes on the biology and morphology of Audubon's Shearwaters *Puffinus lherminieri* (Procellariiformes: Procellariidae) from Fernando de Noronha, northeast Brazil. *Revista Brasileira de Ornitologia,* 18: 139–145.

Smith, H. G.; Hardy, P.; Leith, I. M.; Spaull, V. W. & Twelves, E. L. 1974. A biological survey of St Paul's Rocks in the equatorial Atlantic Ocean. *Biological Journal of the Linnean Society,* 6: 794–800.

Soto, J. & Filippini, A. 2003. Ocorrência e reprodução da Pardela-de-Audubon, *P. lherminieri* Lesson, 1839 (Procellariiformes, Procellariidae), no Arquipélago Fernando de Noronha, com revisão dos registros de *P. lherminieri* e *P. assimilis* no Brasil. *Ararajuba*, 11: 112–115.

Spatz, D. R.; Newton, K. M.; Heinz, R.; Tershy, B.; Holmes, N. D.; Butchart, S. H. M. & Croll, D. A. 2014. The biogeography of globally threatened seabirds and island conservation opportunities. *Conservation Biology,* 28: 1282–1290.

van Franeker, J. A. 1994. A comparison of methods for counting seabirds at sea in the Southern Ocean. *Journal of Field Ornithology,* 65: 96–108.

Vas, E.; Lescroel, A.; Driez, O.; Boguszewski, G. & Grémillet, D. 2015. Approaching birds with drones: first experiments and ethical guidelines. *Biology Letters,* 11: 20140754.

Vooren, C. M. & Brusque, L. F. 1999. *As aves do ambiente costeiro do Brasil: biodiversidade e conservação*, v. 1. Rio de Janeiro: FUNBIO.

Vooren, C. M. & Chiaradia, A. 1990. Seasonal abundance and behaviour of coastal birds on Cassino Beach, Brazil. *Ornitología Neotropical,* 1: 9–14.

Wilcox, C.; van Sebille, E. & Hardesty, B. D. 2015. Threat of plastic pollution to seabirds is global, pervasive, and increasing. *Proceedings of the National Academy of Sciences of the United States of America,* 112: 11899–11904.

Woehler, E. J. 1996. Concurrent decreases in five species of Southern Ocean seabirds in Prydz Bay. *Polar Biology,* 16: 379–382.

Yorio, P.; Frere, E.; Gandini, P. & Schiavini, A. 2001. Tourism and recreation at seabird breeding sites in Patagonia, Argentina: current concerns and future prospects. *Bird Conservation International,* 11: 231–245.

Yorio, P.; Quintana, F.; Campagna, C. & Harris, G. 1994. Diversidad, abundancia y dinamica espacio-temporal de la colónia mixta de aves marinas em Punta Leon, Patagonia. *Ornitología Neotropical,* 5: 69–77.

Associate Editor: Alexander Lees.

APPENDIX I

Bibliographic revision and new data on population estimates of seabirds breeding on Brazilian offshore islands.

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
Pterodroma arminjoniana	Trindade Island	3000–5000	1130	January–April 2006	Direct counting, mapping nest+estimation	Luigi *et al.* (2009)	
		6500	-	1994–2000	Direct counting	Fonseca-Neto (2004)	
		2000	-	August 1988	Direct counting	Nacinovic *et al.* (1989)	
		15,000	-		Estimation (unexplained guess)	Brooke (2004)	
Puffinus lherminieri	Fernando de Noronha Arch.	8	4	November 2011	Direct counting	Present study	Morro da Viuvinha Island
		14	7	August 2010	Direct counting	Present study	Morro da Viuvinha Island
		26	13	October 2005 and September 2006	Direct counting	Mestre *et al.* (2009)	Morro da Viuvinha and Morro do Leão Islands
		30	10	October 2005	Direct counting	Silva-e-Silva & Olmos (2010)	Morro da Viuvinha Island
		4	2	November 2004	Direct counting	Silva-e-Silva & Olmos (2010)	Morro da Viuvinha Island
		12	6	September 2003	Direct counting	Silva-e-Silva & Olmos (2010)	Morro da Viuvinha Island
		30	11	1989–2000	Direct counting	Soto & Filipini (2001)	juveniles found at the beach
		2	1	November 1991	Direct counting	Soto & Filipini (2001)	juveniles found at the beach
		4	-	August 1990	Direct counting	Soto & Filipini (2001)	juveniles found at the beach
Phaethon aethereus	Fernando de Noronha Arch.	2	1	November 2010	Direct counting	CEMAVE data	
		7	3	August 2010	Direct counting	CEMAVE data	
		4	-	2003	Direct counting	Silva-e-Silva (2008)	
		6	-	2004	Direct counting	Silva-e-Silva (2008)	
		10	-	2005	Direct counting	Silva-e-Silva (2008)	
		5	-	2008	Direct counting	Silva-e-Silva (2008)	Ponta das Caracas
		1	-	September 1993	Direct counting	Schulz-Neto (2004)	
		5	-	March–April 2003	Direct counting	Martins (2004)	
		4	2	January 1987–1995	Direct counting	Antas (1991)	Morro da Viuvinha Island
		2	-		Direct counting	Oren (1982)	
		7	-	December 1982	Direct counting	Oren (1984)	Flying
	Abrolhos Arch.	709	-	2011–2012	Estimation	Sarmento *et al.* (2014)	-
		538	269	2011	Direct counting	M. A. Efe (unpublished data) in Nunes 2012	
		100	50	August 2011	Direct counting	Present study	Sta. Barbara, Sueste, Guarita,. Redonda, and Siriba Islands
		204	102	February 2011	Direct counting	Present study	
		140	70	June 1992	Direct counting	Alves *et al.* (1997)	
		80	40	April 1981	Direct counting	Antas (1991)	
Phaethon lepturus	Fernando de Noronha Arch.	198	99	August 2011–January 2012	Direct counting	Efe unpublished data (in Nunes 2012)	
		22	8	April 2011	Direct counting	Present study	Chapéu, Rasa Islands and Ponta da Sapata
		62	31	July 2011	Direct counting	Present study	Chapéu, Rasa Islands

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
		18	5	November 2010	Direct counting	Present study	flying or resting (onboard census)
		244	62	August 2010	Direct counting	Present study (CEMAVE)	120 flying or resting (onboard census) and 62 nests (active search) = 124 individuals
		53	-	March–April 2003	Direct counting	Martins (2004)	
		300	-	October 1987	Direct counting	Antas (1991)	
		100	-	June 1987	Direct counting	Antas (1991)	
		200	-	December 1982	Direct counting	Oren (1984)	
	Abrolhos Arch.	2	1	February 2011	Direct counting	Present study	Sta. Barbara Island
		7	2	January 1992	Direct counting	Alves *et al.* (2004)	
Sula dactylatra	Fernando de Noronha Arch.	400	200	July 2011	Direct counting	Present study	Rata, Rasa Meio Islands
		262	131	March 2011	Direct counting	Present study	Rata, Rasa Meio Islands
		70	-	November 2010	Direct counting	Present study (CEMAVE)	External Islands
		105	-	August 2010	Direct counting	Present study (CEMAVE)	External Islands
		600	-	February 2008	Direct counting	Silva-e-Silva (2008)	MeioIsland
		175	-	June 2002	Direct counting	Schulz-Neto (2004)	Rata, Meio Islands
		170	-	August 2000	Direct counting	Silva-e-Silva (2008)	Rata (50), Ovos (120) Islands
		440	-	October 1999	Direct counting	Silva-e-Silva (2008)	Rata (80), Meio (360) Islands
		5	-	November 1991	Direct counting	Schulz-Neto (2004)	Rasa Island
		287	-	March–April 2003	Direct counting	Martins (2004)	
		550	275	December 1988	Direct counting	Antas (1991)	Meio (180), Ovos (70), Rata and Macaxeira (25) Islands
	Atol das Rocas	1248	-	February–March 2012	Direct counting	Present study	Cemitério, Farol Islands
		2072	-	September–October 2010	Direct counting	Present study	Cemitério, Farol Islands
		6400	3175	2000 -2002	Direct counting	Kohlrausch (2003)	
		1600	-	September 1994	Direct counting	Schulz-Neto (1998)	
		160	-	April 1991	Randon quadrats	Schulz-Neto (1998)	
		5100	-	April 1991	Direct counting	Schulz-Neto (1998)	
		1600	-	November 1991	Direct counting	Schulz-Neto (1998)	
		4000	-	February 1990	Randon quadrats	Antas (1991)	
		5000	-	February 1982	Randon quadrats	Antas (1991)	
	Abrolhos Arch.	1591	486	August 2011	Direct counting	Present study	Redonda, Siriba, Sueste, Sta. Barbára Islands
		1850	825	February 2011	Direct counting	Present study	Redonda, Siriba, Sueste Islands
		1600	800	July 1994	Direct counting	Alves *et al.* (2000)	
	Trindade Island & Martin Vaz	150	72	December 2006–April 2007	Direct counting	Present study	Whole Island
		123	38	April 2007	Direct counting	Present study	Martin Vaz Island
		600	-	August 1994 to April 2000	Direct counting	Fonseca-Neto (2004)	
Sula leucogaster	São Pedro and São Paulo Arch.	588	120	June 2013	Direct counting	Present study	
		546	321	January 2012	Direct counting	Present study	
		450	281	August 2011	Direct counting	Present study	
		420	275	August 2010	Direct counting	Present study	

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
		381	-	March–July 2002	Direct counting	Barbosa-Filho & Vooren (2010)	
		377	-	September–November 2001	Direct counting	Barbosa-Filho & Vooren (2010)	
		500	160	2000–2002	Direct counting / Estimation	Kohlrausch (2003)	
		330	-	1999/2000	Direct counting	Both & Freitas (2004)	
		200	35	May 1989	Direct counting	Antas (1991)	
		439	-	September 1979	Direct counting	Edwards *et al.* (1981)	
		200	-	May 1971	Direct counting	Smith *et al.* (1974)	
		500	-	March 1966	Estimation	Masch (1966)	
		163	-	November 1960	Direct counting	Mackinnon (1962)	
	Fernando de Noronha Arch.	8	-	July 2011	Direct counting	Present study	Port, Meio, Viuvinha, Cabeluda Islands
		61	-	March 2011	Direct counting	Present study	Port, Meio, Viuvinha, Cabeluda Islands
		66	-	November 2010	Direct counting	Present study (CEMAVE)	External Islands
		98	-	August 2010	Direct counting	Present study (CEMAVE)	External Islands
		80	-	June 2002	Direct counting	Schulz-Neto (2004)	Port
		81	-	November 1991	Direct counting	Schulz-Neto (2004)	Sela Gineta, Meio Islands and Caieiras
		269	-	March–April 2003	Direct counting	Martins (2004)	
		870	-	February 1990	Direct counting	Antas (1991)	Breed in all islands, except Principal and Rasa
	Atol das Rocas	152	64	February / March 2012	Direct counting	Present study	Cemitério, Farol Islands
		125	29	October 2010	Direct counting	Present study	Cemitério, Farol Islands
		350	155	2001	Direct counting	Kohlrausch (2003)	Cemitério, Farol Islands
		250	-	September 1994	Direct counting	Schulz-Neto (1998)	Cemitério, Farol Islands
		34	-	September 1994	Linear quadrats	Schulz-Neto (1998)	Cemitério, Farol Islands
		300	-	April 1991	Direct counting	Schulz-Neto (1998)	Cemitério, Farol Islands
		300	-	April 1991	Randon quadrats	Schulz-Neto (1998)	Cemitério, Farol Islands
		80	-	November 1991	Randon quadrats	Schulz-Neto (1998)	Cemitério, Farol Islands
		300	-	November 1991	Direct counting	Schulz-Neto (1998)	Cemitério, Farol Islands
		76	-	February 1990	Direct counting	Schulz-Neto (1998)	Cemitério, Farol Islands
		200	100	February 1982	Direct counting	Antas (1991)	Cemitério, Farol Islands
	Abrolhos Arch.	186	93	August 2011	Direct counting	Present study	Redonda, Siriba, Sueste and Sta. Barbára Islands
		460	230	February 2011	Direct counting	Present study	Redonda, Siriba and Sueste Islands
		400	-	July 1994	Direct counting	Alves *et al.* (2000)	
		230	115	1969	Direct counting	Coelho (1981)	Sueste Island
Sula sula	São Pedro and São Paulo Arch.	1	-	May 2014	Direct counting	Present study	
		3	-	May–June 2013	Direct counting	Present study	
		7	-	January 2012	Direct counting	Present study	
		9	-	August 2011	Direct counting	Present study	
		1	-	April 2011	Direct counting	Present study	
		4	-	August 2010	Direct counting	Present study	
		3	-	1999–2000	Direct counting	Both & Freitas (2004)	

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
	Fernando de Noronha Arch.	733	-	July 2011	Direct counting	Present study	
		1440	-	March–April 2011	Direct counting	Present study	
		1511	-	November 2010	Direct counting	Present study (CEMAVE)	
		1184	-	August 2010	Direct counting	Present study (CEMAVE)	
		1882	-	April/July / November 2008	Direct counting	Barbosa-Filho & Vooren (2009)	
		1658	-	March–April 2003	Direct counting	Martins (2004)	Principal Island
		1513	-	October–November 1991	Direct counting	Schulz-Neto (2004)	
		2580	1290	June 1987	Direct counting	Antas (1991)	
		4000	-	December 1982	Direct counting	Oren (1984)	
	Atol das Rocas	253	-	February–March 2012	Direct counting	Present study	
		350	-	September 2010	Direct counting	Present study	
		200	-	September 1994	Direct counting	Schulz-Neto (1998)	
		201	-	November 1991	Direct counting	Schulz-Neto (1998)	
		100	-	April 1991	Direct counting	Schulz-Neto (1998)	
		50	-	February 1982	Direct counting	Antas (1991)	
	Abrolhos Arch.	1	-	February 2011	Direct counting	Present study	No breeding record.
	Trindade Island & Martin Vaz	0	0	December 2006–April 2007	Direct counting	Present study	After intensive search. Probably extinct.
		4	-	August 1994-April 2000	Direct counting	Fonseca-Neto (2004)	Individuals flying
		30	-	-	Direct counting	Luigi (1992)	
		87	-	December 1975–January 1976		Olson (1981)	
Fregata magnificens	Fernando de Noronha Arch.	122	-	November 2010	Direct counting	Present study (CEMAVE)	Onboard, external Islands
		150	-	August 2010	Direct counting	Present study (CEMAVE)	Onboard, external Islands
		430	215	November 1992	Direct counting	Schulz-Neto (1995, 2004)	Sela Gineta Island
		200	100	May–June and October–November 1987	Direct counting	Antas (1991)	Sela Gineta Island
		300	-	1982	Direct counting	Oren (1984)	Sela Gineta Island
	Atol das Rocas	40	-	February–March 2012	Direct counting	Present study	Farol Island (Coconut tree), 9 adults, 33 juveniles
		15	-	September–October 2010	Direct counting	Present study	Farol Island (Coconut tree)
		12	-	September 1994	Direct counting	Schulz-Neto (1998)	
		7	-	April 1991	Direct counting	Schulz-Neto (1998)	
		20	-	November 1991	Direct counting	Schulz-Neto (1998)	
		50	-	February 1982	Randon quadrats	Antas (1991)	
	Abrolhos Arch.	854	427	August 2011	Direct counting	Present study	Redonda Island
		660	330	February 2011	Direct counting	Present study	Redonda Island
		332	166	October 1994	Direct counting	Alves *et al.* (1997)	Redonda Island
		230	115	March 1994	Direct counting	Alves *et al.* (1997)	Redonda Island
		120	60	late 1980	Direct counting	Antas (1991)	Sta. Barbara Island
Fregata ariel trinitatis	Trindade Island & Martin Vaz	2	-	December 2006–April 2007	Photographs, estimated based on plumages	Present study	
		50	15	1975-1976	Direct counting	Olson (1981)	

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
Fregata minor nicoli	Trindade Island & Martin Vaz	3	-	December 2006–April 2007	Photographs, estimated based on plumages	Present study	No breeding record
		1	-	April 2007	Direct counting	Present study	No breeding record
		120	-	August 1994–April 2000	Direct counting	Fonseca-Neto (2004)	Following a fishing vessel near Ponta Noroeste
		30	15	1975–1976	Direct counting	Olson (1981)	
Anous minutus	São Pedro and São Paulo Arch.	300	-	August 2010	Estimation	Present study	
		366	-	July–August 2000	Direct counting	Both & Freitas (2004)	
		320	-	1999–2000	Direct counting	Both & Freitas (2004)	
		481	-	September 1979	Direct counting	Edward *et al.* (1981)	
		150	-	May 1971	Direct counting	Smith *et al.* (1974)	
		165	-	November 1960	Direct counting	Mackinnon (1962)	
	Fernando de Noronha Arch.	387	30	July 2011	Direct counting	Present study	Sancho Bay to Ponta da Sapata and Viuvinha Island
		498	-	March–April 2003	Direct counting	Martins (2004)	Principal Island
		21,260	10,630	June 1987	Direct counting	Antas (1991)	Sancho Bay to Ponta da Sapata
		5000	-	December 1982	Estimation	Oren (1984)	
	Atol das Rocas	1480	9	February–March 2012	Direct counting	Present study	Farol (1100), Cemitério (380) Islands
		886	-	October 2010	Direct counting	Present study	Farol Island (Coqueiros and Scientific station)
		1750	-	September 1994	Direct counting	Schulz-Neto (1998)	
		1750	-	April / November 1991	Direct counting	Schulz-Neto (1998)	
			6	February 1982		Antas (1991)	
	Trindade Island & Martin Vaz	~20	10	April 2007	Direct counting/estimation	Present study	Norte Island, Martin Vaz. Nest content not checked.
Anous stolidus	São Pedro and São Paulo Arch.	324	162	August 2010	Direct counting	Present study	Whole Archipelago
		220	110	April 2000	Direct counting	Both & Freitas (2004)	Whole Archipelago
		390	-	1999–2000	Direct counting	Both & Freitas (2004)	Whole Archipelago
		490	-	July–August 2000	Direct counting	Both & Freitas (2004)	Whole Archipelago
		300	-	May 1989	Direct counting	Antas (1991)	Whole Archipelago
		213	-	September 1979	Direct counting	Edward *et al.* (1981)	Whole Archipelago
		200	-	May 1971	Direct counting	Smith *et al.* (1974)	Whole Archipelago
		480	-	November 1960	Direct counting	Mackinnon (1962)	Whole Archipelago
	Fernando de Noronha Arch.	160	-	July 2011	Direct counting	Present study	Viuvinha Island
		90	-	April 2011	Direct counting	Present study	Viuvinha Island, Port,
		604	-	March 2011	Direct counting	Present study	Mirante dos Golfinhos and São José Islands
		220	-	March–April 2003	Direct counting	Martins (2004)	
		2000	-	October 1987	Estimation	Antas (1991)	
		2000	-	December 1982	Estimation	Oren (1984)	
	Atol das Rocas	3192	-	February–March 2012	Randon quadrats	Present study	
		4039	-	October 2010	Randon quadrats/direct counts	Present study	
		18,700	-	February 1993	Randon quadrats	Schulz-Neto (1998)	

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
		11,800	-	November 1991	Randon quadrats	Schulz-Neto (1998)	
		400	-	April 1991	Randon quadrats	Schulz-Neto (1998)	
		27,390	-	February 1990	Randon quadrats	Schulz-Neto (1998)	
		17,700	-	February 1982	Randon quadrats	Schulz-Neto (1998)	
		10,000	-	March 1979	Randon quadrats	Schulz-Neto (1998)	
		2400	1200	?	Direct counting	Murphy (1936)	
	Abrolhos Arch.	4725	1275	August 2011	Direct counting	Present study	Guarita Island
		4180	-	1996	Direct counting	Fonseca-Neto (2004)	Guarita Island
		3926	-	1995	Direct counting	Fonseca-Neto (2004)	Guarita Island
		3000	-	March 1995	Direct counting	Alves *et al.* (2000)	Guarita Island
		2000	1000	April 1982	Direct counting	Antas (1991)	Guarita Island
	Trindade Island & Martin Vaz		8	January–March 2007	Direct counting	Present study	Praia das Cabritas
			30	January–March 2007	Estimation	Present study	Pico Monumento
			20	January–March 2007	Estimation	Present study	Racha Island
			40	January–March 2007	Estimation	Present study	Farilhões
			10	January–March 2007	Direct counting	Present study	Praia do M
			3	January–March 2007	Direct counting	Present study	Pico Nossa Senhora de Lourdes
			3	January–March 2007	Direct counting	Present study	Paredão
		>500	~250	December 2006–April 2007	Direct counting+Estimation	Present study	Whole Trindade Island
			20	December 2006	Direct counting	Present study	Crista do Galo & Ponta Norte
			88	December 2006	Direct counting	Present study	Pão de Açúcar
			1	December 2006	Direct counting	Present study	Praia Noroeste
			5	December 2006	Direct counting	Present study	Pico do Vigia
		> 500	-	1994–2000	Direct counting	Fonseca-Neto (2004)	near Pico Pão de Açúcar
Gygis alba	Fernando de Noronha Arch.	82	-	July 2011	Direct counting	Present study	Baía dos Porcos to Mirante dos Golfinhos / Morro do Piquinho
		62	-	April 2011	Direct counting	Present study	Baía dos Porcos to Mirante dos Golfinhos / Morro do Piquinho
		252	-	November 2010 (CEMAVE)	Direct counting	Present study	On board around the Principal Island
		325	-	August 2010 (CEMAVE)	Direct counting	Present study	On board around the Principal Island
		133	-	March–April 2003	Direct counting	Martins (2004)	
		1000	-	June–November 1987	Estimation	Antas (1991)	Whole archipelago (mainly Principal Is.)
		250	-	December 1982	Counting	Oren (1984)	
	Trindade Island & Martin Vaz	40	15	April 2007	Counting	Present study	Martin Vaz (nests with eggs)
		120	42	December 2006–March 2007	Estimation	Present study	Whole Trindade Is.
		800	-	August 1994 to April 2000	Estimation	Fonseca-Neto (2004)	
Onychoprion fuscatus	Fernando de Noronha Arch.	50	-	July 2011	Direct counting	Present study	Viuvinha Island
		30	-	March 2011	Direct counting	Present study	Viuvinha, São José Islands
		310	-	August 2010	Direct counting	Present study (CEMAVE)	
		2240	1120	October 1987	Direct counting	Antas (1991)	Viuvinha, Cuzcuz, Morro do Leão, Morro da Viuvinha Islands

Species	Archipelago/ Island	No. Individuals	No. Nests	Month/Year	Methods	References	Remarks
	Atol das Rocas	15,846	-	February–March 2012	Randon quadrats	Present study	
		28,956	-	October 2010	Randon quadrats	Present study	
		140,000	-	February 1993	Randon quadrats	Present study	
		75,000	-	November 1991	Randon quadrats	Schulz-Neto (1998)	
		40,000	-	April 1991	Randon quadrats	Schulz-Neto (1998)	
		106,620	-	February 1990	Randon quadrats	Schulz-Neto (1998)	
		115,000	-	February 1982	Randon quadrats	Antas (1991)	
		30,000	-	March 1979	Randon quadrats	Antas (1991)	
	Abrolhos Arch.	10	-	August 2011	Direct counting	Present study	Guarita Island
		10	-		Direct counting	Alves *et al.* (2000)	Guarita Island
		40	20	?	Direct counting	Antas (1991)	Guarita Island
	Trindade Island & Martin Vaz	6000	2924	December 2006–March 2007	Direct counting+estimation	Present study	Whole Island
		several hundreds		April 2007	feathers and abandoned colonies	Present study	Martin Vaz
		4000	-	1994–2000	August 1994 to April 2000	Fonseca-Neto (2004)	Whole Island
		2900	1450	December 1975–February 1976	Partial counts+estimation	Olson (1981)	main concentration of 450 eastern end of the island, elsewhere <1000 pairs

Revista Brasileira de Ornitologia, 24(2), 116-121
June 2016

ARTICLE

Intra-tropical migration and wintering areas of Fork-tailed Flycatchers (*Tyrannus savana*) breeding in São Paulo, Brazil

Alex E. Jahn[1,4], Nathaniel E. Seavy[2], Vanesa Bejarano[1], Marcela Benavides Guzmán[1], Ivan Celso Carvalho Provinciato[1], Marco A. Pizo[1] and Maggie MacPherson[3]

[1] Departamento de Zoologia, Universidade Estadual Paulista, Av. 24A, 1515, CEP 13506-900, Rio Claro, SP, Brazil.
[2] Point Blue Conservation Science, 3820 Cypress Drive #11, Petaluma, CA, 94954, USA.
[3] Ecology and Evolutionary Biology, Tulane University, New Orleans, LA, 70118, USA.
[4] Corresponding author: ajahn@rc.unesp.br

Received on 31 December 2015. Accepted on 01 July 2016.

ABSTRACT: Fork-tailed Flycatchers (*Tyrannus s. savana*) breed from central to southern South America from September to January, migrating to northern South America to spend the non-breeding season. However, little is known of the migratory routes, rate, and timing of migration of those that breed in Brazil. In 2013, we attached light-level geolocators to breeding Fork-tailed Flycatchers breeding in São Paulo State. Data for six male flycatchers recaptured in 2014 indicates that they exhibited two fall migration strategies. Some individuals migrated northwest to the wintering grounds (primarily Colombia, Venezuela and northern Brazil), while others first spent several weeks in southwestern Brazil before going to the wintering grounds. Mean fall migration rate was 69 km/day (±13.7) during 59 (±13.2) days. Some flycatchers moved during winter, using more than one winter area. Flycatchers initiated spring migration in July and migrated southeast to the breeding grounds at a mean rate of 129 km/day (±19.0) during 27 (±2.8) days. A detailed understanding of the annual cycle of South America's migratory birds is essential to evaluating theoretical questions, such as the evolution of their life history strategies, in addition to applied questions, such as explanations for changes in population size, or their role as disease vectors.

KEY-WORDS: austral, Cerrado, Itirapina, molt, Neotropical.

INTRODUCTION

The Fork-tailed Flycatcher (*Tyrannus savana*) is a widespread Neotropical species, occurring from Mexico to Argentina and much of lowland South America east of the Andes Mountains, from the northern coast of the continent south to central Argentina (Fitzpatrick *et al.* 2004, Jahn & Tuero 2013). The nominate subspecies (*T. s. savana*) breeds from central Brazil to south-temperate latitudes in Argentina, and overwinters in northern South America (primarily in the Orinoco River Basin and the northern Amazon River Basin; Chesser 1995, Fitzpatrick *et al.* 2004, Jahn & Tuero 2013, Jahn *et al.* 2013a).

Although the Fork-tailed Flycatcher is a widespread and relatively common species in South America, decades of observations have provided few details on its migratory routes or wintering areas (Zimmer 1938, Antas 1987, Capllonch *et al.* 2009). This is also true of many other Neotropical austral migrants, which breed and migrate (typically wintering to the north of where they breed) within South America (Chesser 1995, Jahn *et al.* 2004, Cueto & Jahn 2008). Although Brazil has long been recognized as an important crossroads for migratory birds (Sick 1983, Alves 2007), bird migration in Brazil has been understudied (Antas 1987, Cavalcanti 1990, Alves 2007). Indeed, almost all research on Neotropical austral bird migration in Brazil is in a descriptive stage, focused on answering such questions as how many migratory species there are and where they migrate (Alves 2007).

Understanding bird migration in Brazil is important not only for local and national research, education and conservation planning, it is also important at a continental scale. Brazil accounts for almost half (43%) of South America's landmass, and 73% of Neotropical austral migrant bird species (233 total) occur in the country (Parker *et al.* 1996). Therefore, improving our understanding of how birds migrate within and between Brazil and other countries holds significant potential for improving our knowledge of and ability to develop conservation plans for migratory birds across South America.

Previous research on the movements of Fork-tailed

Flycatchers indicate that those breeding in Buenos Aires, Argentina migrate from late January to April after breeding (November–January) through the center of the continent (northern Argentina, Bolivia, Paraguay) to northwestern South America to overwinter (Jahn *et al.* 2013a). Fork-tailed Flycatcher has been recorded as a passage migrant in Bolivia from February to April (Davis 1993, Chesser 1997), and again on its return south, from September to November (Chesser 1997). Within Brazil, the nominate subspecies breeds in the Planalto Central (central highlands) from September to December (Pimentel 1985, Marini *et al.* 2009), thereafter migrating to the wintering grounds in January and February (Alves 2007). The lack of records of the species around Brasilia after early February suggests that the fall migration route of southern breeding populations of Fork-tailed Flycatcher does not pass through central Brazil (Antas 1987, Alves 2007).

Our objective was to describe the migratory timing (begin and end dates, rate and duration), routes and wintering areas of individual Fork-tailed Flycatchers (hereafter, "flycatchers") breeding in southeastern Brazil. This represents a first step towards understanding the full annual cycle of this common migratory species.

METHODS

We captured flycatchers at the Estação Ecológica de Itirapina, São Paulo State (22.3°S; 47.9°W) from 11 to 27 of November 2013. This site is primarily composed of campo and cerrado grassland and gallery forest along streams. Flycatchers breed there from October to January (A.E. Jahn, unpub. data) and are absent from March to July (Willis 2004).

Flycatchers were captured by placing a predator model (*e.g.*, Savanna Hawk, *Buteogallus meridionalis*), or a speaker emitting a flycatcher call next to one or two 3 × 12 or 3 × 18 m polyester or nylon mist nets (38 mm mesh size). Nets were placed within an active flycatcher territory, usually 1–3 m from an active nest. Captured flycatchers were held in cotton bags before being banded using techniques described in Ralph *et al.* (1993). Flycatchers were aged using the presence of juvenile plumage, and sexed using the shape of the notch of primaries 8–10, or the presence of a brood patch or cloacal protuberance (Pyle 1997). Before release, flycatchers were fitted with a model IntiGeo P64 light-level geolocator (MigrateTech, Inc., Cambridge, UK) using a backpack-style harness (Rappole & Tipton 1991) made of Filament Kevlar (500 tex; Saunders Thread, Gastonia, North Carolina, USA).

Data analysis

We used R-package GeoLight (Lisovski & Hahn 2012) to process light data, identifying sunrise and sunset times using a light threshold of 15, and eliminating outliers using the loessFilter function to delete twilight transitions exceeding the interquartile range of residuals from a smoothed line. We calibrated light data using the first 20 days after the bird was released and excluded latitude estimates for 20 days before and after the vernal and autumnal equinoxes. Finally, we used a distance filter to exclude locations that required movements between consecutive positions in excess of a continuous rate of 20 km/h.

We identified departure and arrival dates by combining information about periods of movement and residency generated from twilight times and from latitude and longitude data. Periods of movement and residency were calculated using the changeLight function, with a probability of change of 0.8 and a minimum stationary period of 3 days. Because this method is based on changes in sunset and sunrise times, it can be used to infer the beginning and end of migration even around the equinox when latitudinal estimates are unreliable. We identified wintering locations by averaging latitude and longitude between 15 May and 1 July due to little evidence of movement during these dates and because these dates were far enough from the equinox that we could calculate latitude and longitude.

Because we defined distance of migration as the straight-line distance between the breeding site and the wintering area, reported migration distances are minimum distances. Likewise, the migration rates we report represent minimum rates because we defined migration rate in spring or fall as the distance of migration divided by the duration of migration (including stopovers) during each period. Summary statistics represent means ± standard error (SE).

RESULTS

In 2013, we deployed geolocators on 29 adult flycatchers (12 females and 17 males). In the 2014 breeding season, we recovered six geolocators, all from males. However, in that season we also observed, but were not able to recapture, an additional 3 males and 5 females that had been outfitted with geolocators in 2013. Females were more difficult to capture and recapture than males because they did not attack the predator model or respond to playback as aggressively as did males. Thus, the return rate of flycatchers with geolocators (*i.e.*, which were recaptured or re-observed in 2014) was 48.3% (14 of 29 flycatchers), which is similar to that of some other songbird species deployed with geolocators (*e.g.*, 44.7% return rate for Scissor-tailed Flycatchers, *Tyranus forficatus*; Jahn *et al.* 2013b).

The six birds initiated fall migration between mid-January and mid-February of 2014 (Table 1), with most migrating northwest across central or western Amazonia (western Brazil and eastern Bolivia) to wintering grounds in northern South America (Figure 1). However, two flycatchers (H527 and H595) first moved southwest to the region of the border of Brazil (Mato Grosso do Sul, Paraná states), Paraguay and northeastern Argentina, thereafter migrating to the wintering grounds (Figure 1). Fall migration ended between early March and mid-May (Table 1) and lasted 59 (13.2) days, during which flycatchers migrated at a rate of 69 (13.7) km/day (Table 2).

Some flycatchers initially overwintered in the region of northern Peru, northwestern Brazil (Amazonas) and southern Colombia (*e.g.*, H565, H595, H607; Figure 1) or in the region of eastern Colombia, western Venezuela and northern Brazil in Amazonas (*e.g.*, H524, H527, H548; Figure 1). The mean distance between the breeding site and the wintering area for the six flycatchers was 3169 (45.4) km (Table 2).

One flycatcher (H548) remained sedentary throughout winter whereas others (H524, H565, H595, H607) used multiple overwintering areas, moving in a northeasterly direction between March and July (Figure 1). One bird (H527) moved eastwards before returning south in spring (Figure 1).

Spring migration began in late July and August (Table 1) and lasted 27 (2.8) days, during which flycatchers generally migrated over central Amazonia in a southeasterly direction at a rate of 129 (19.0) km/day (Table 2). Some birds appeared to use spring stopover sites before arriving at the breeding grounds (*e.g.*, H565, H595; Figure 1). Three birds (H548, H595, H607) were located to the southwest of the breeding site before arriving there (Figure 1), though this could be due to light measurement error. In particular, point locations over the Atlantic Ocean (H527, H607, Figure 1) are likely due to geolocator light measurement errors. Birds arrived at the breeding site between 30 August and 9 September (Table 1).

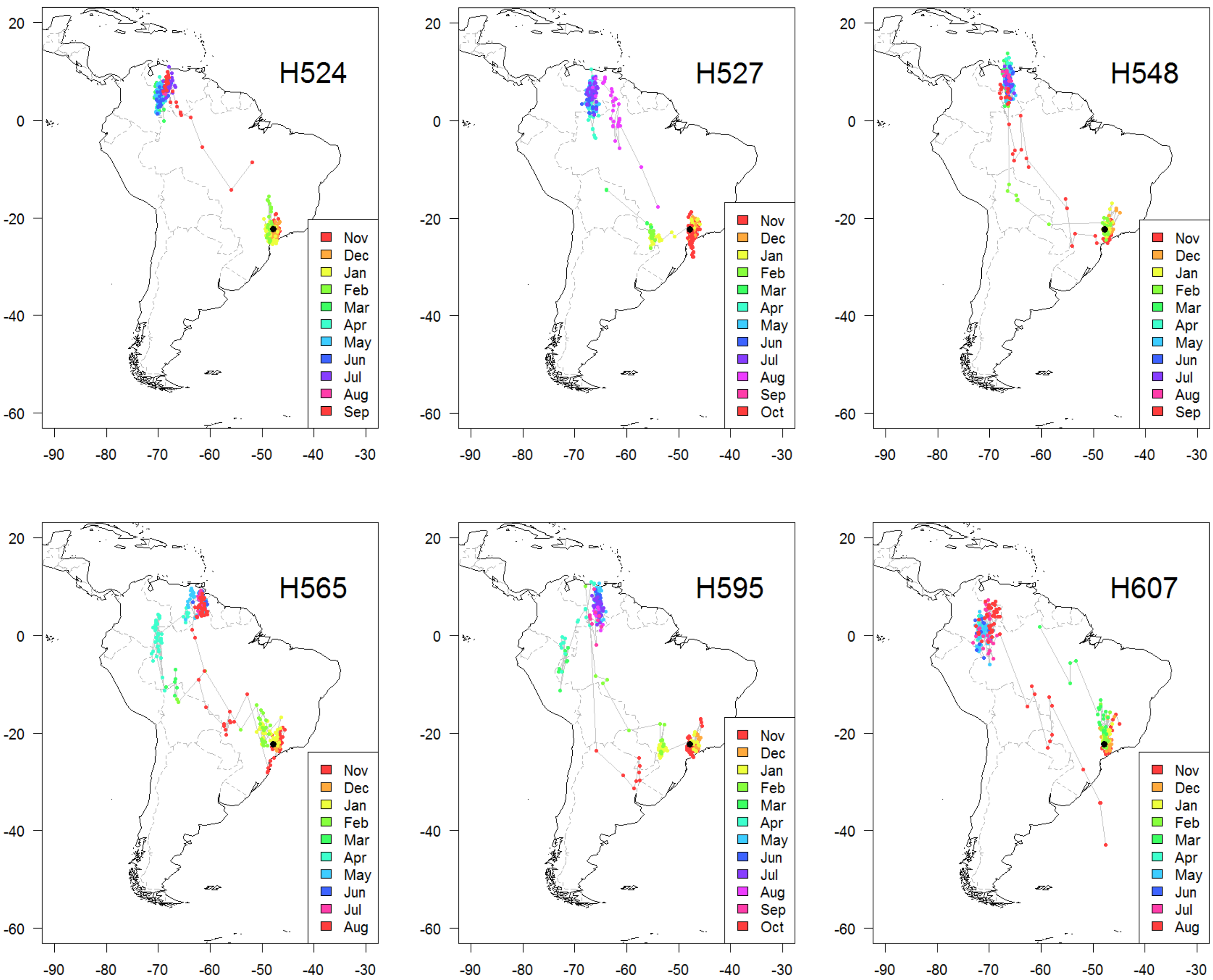

FIGURE 1. Wintering areas and migration routes of six male Fork-tailed Flycatchers captured at a breeding site in São Paulo, Brazil. Alphanumerical combinations in each map correspond to the individual ID for each bird in Tables 1 and 2. Point locations that occur over the Atlantic Ocean are likely due to geolocator light measurement errors.

TABLE 1. Fall and spring migration initiation and termination dates for six male Fork-tailed Flycatchers captured at a breeding site in São Paulo, Brazil, in 2013 and tracked in 2014. "ID" is the alphanumerical combination used to identify individuals in Figure 1.

ID	Fall migration		Spring migration	
	Begin date	End date	Begin date	End date
H524	19 Feb	8 Apr	21 Aug	5 Sep
H527	15 Jan	3 Mar	14 Aug	9 Sep
H548	12 Feb	16 Mar	7 Aug	2 Sep
H565	8 Feb	13 May	2 Aug	30 Aug
H595	16 Jan	30 Apr	11 Aug	8 Sep
H607	13 Feb	13 Mar	25 Jul	30 Aug
Mean	3 Feb	3 Apr	8 Aug	3 Sep

TABLE 2. Individual migration history (distance, duration and rate of migration in fall and spring) of six male Fork-tailed Flycatchers captured at a breeding site in São Paulo, Brazil. "ID" is the alphanumerical combination used to identify individuals in Figure 1. Migration distance represents the straight-line distance between the breeding site and the wintering area. Migration rate is calculated as the distance of migration divided by the duration of migration during each period. Summary statistics represent means ± standard error (SE).

ID	Distance (km)	Fall migration		Spring migration	
		Duration (days)	Rate (km/day)	Duration (days)	Rate (km/day)
H524	3293	48	69	15	220
H527	3166	47	67	26	122
H548	3255	32	102	26	125
H565	2990	94	32	28	107
H595	3214	104	31	28	115
H607	3098	28	111	36	86
Mean (SE)	3169 (45.4)	59 (13.2)	69 (13.7)	27 (2.8)	129 (19.0)

DISCUSSION

Overall, results indicate that male Fork-tailed Flycatchers breeding in southeastern Brazil initiate fall migration in January or February, with some migrating directly to wintering grounds, whereas others first spend time in the region of southern Brazil, Paraguay and northeastern Argentina before migrating to northern South America. All birds overwintered from March to July in either northern Amazonia or the Orinoco Basin (Colombia and Venezuela), with some remaining sedentary and others moving northeasterly or easterly during winter. Beginning in late July, flycatchers returned southeastwards in spring across the Amazon Basin to São Paulo.

That flycatchers migrated in fall through western Brazil and eastern Bolivia corroborates a historical lack of records of the species in Brasilia after the second week of February (Antas 1987). Flycatchers overwintered primarily in western and northern Amazonia and the Orinoco Basin, similar to results of previous research on the migration of Fork-tailed Flycatchers breeding in Buenos Aires, Argentina (Jahn *et al.* 2013a), suggesting that this is an important wintering area for various Fork-tailed Flycatcher populations. A large part of this winter range is composed of grasslands ("llanos") that are structurally similar to the cerrado grasslands that flycatchers occupy during the breeding season in central Brazil.

A notable and unexpected finding is that some flycatchers spend several weeks southwest of the breeding site prior to migrating to the wintering grounds. We do not yet know the reason for this, but it is similar to the movements of some species breeding in western North America, such as Western Kingbirds (*Tyrannus verticalis*; Barry *et al.* 2009, Jahn *et al.* 2013b) and Western Tanagers (*Piranga ludoviciana*; Butler *et al.* 2002), which go to northwestern Mexico to molt in late summer (Rohwer *et al.* 2005). Indeed, the use of miniaturized tracking devices and stable isotopes in feathers molted during winter has provided evidence showing that distinct movements that are separated by layovers is more common among passerine migrants during fall migration and winter than previously thought (McKinnon *et al.* 2013).

That spring migration was faster than fall migration is similar to that of congeneric Western Kingbirds and

Scissor-tailed Flycatchers that breed in North America (Jahn *et al.* 2013b), and has been found in other migratory taxa (McKinnon *et al.* 2013). Flycatchers are potentially under a time-selected schedule during spring migration due to positive selection to arrive, establish territories and find mates as early as possible on the breeding grounds, resulting in faster migration compared to fall. Because Fork-tailed Flycatchers undergo an annual molt primarily during winter (Pyle 1997), fall migration of flycatchers that breed in Brazil may be timed so that their arrival on the wintering grounds coincides with resource peaks at different parts of the continent, therefore acquiring the necessary food resources to molt, as has been suggested for populations that breed in Argentina (Jahn *et al.* 2013a).

Intriguing questions for future research include: 1) What obstacles to migration exist in South America and how are austral migrants adapted to face them? For example, since flycatchers in this study are primarily grassland species, does the Amazon Rainforest, which covers a large part of their migratory route, act as a barrier to their migration?; 2) How did different migratory strategies evolve among populations with different life history strategies (*e.g.*, clutch size)? Flycatchers breeding at tropical latitudes of South America lay on average one less egg than those at South-temperate latitudes in Argentina (Jahn *et al.* 2014). If tradeoffs exist between investment in migration *vs.* reproduction, such variation in investment in reproduction could potentially lead to different migration strategies among populations; and 3) What is the behavioral and physiological ecology of birds that migrate within South America, in comparison to those that breed on other continents? For example, some migratory songbirds in North America switch from consuming arthropods during the breeding season to consuming fruit during fall migration (Parrish 1997). Is this how post-breeding migration is fuelled in ecologically- and taxonomically-similar South American migrants?

South America, the epicenter of avian diversity on the planet, offers an exceptional opportunity to study bird migration. Given that at least 230 bird species migrate entirely within the continent, bird migration within South America represents – in terms of number of species – the largest bird migration system in the Southern Hemisphere (Chesser 1994, Stotz *et al.* 1996, Jahn *et al.* 2004). Furthermore, patterns of bird migration in South America are highly diverse and include (1) temperate-tropical migration (*i.e.*, breeding at temperate latitudes and wintering at tropical latitudes), (2) intra-tropical migration, and (3) longitudinal migration, in which birds breed at one longitude and overwinter at another (Areta & Bodrati 2010). As a result, future descriptive and theoretical research on these diverse types of migration offers novel insights into why and how birds migrate (Jahn & Cueto 2012). Research on the full annual cycle of migratory bird species within and between countries in South America should be prioritized, since such information is essential to develop effective management and conservation plans for these species in an era of rapid global change.

ACKNOWLEDGEMENTS

We dedicate this paper to the late E. O. Willis. We thank the Estação Ecológica de Itirapina for logistical support. This research was supported by the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP; 2012/17225–2) and conducted under SISBIO permit 40221-2, CEMAVE permit 3819/1, and COTEC permit 260108–008.399/2013.

REFERENCES

Alves, M. A. S. 2007. Sistemas de migrações de aves em ambientes terrestres no Brasil: exemplos, lacunas e propostas para o avanço do conhecimento. *Revista Brasileira de Ornitologia*, 15: 231–238.

Antas, P. T. Z. 1987. Migração de aves no Brasil, p. 153–187. *In*: *Anais do II Encontro Nacional de Anilhadores de Aves*. Rio de Janeiro: Editora UFRJ.

Areta, J. I. & Bodrati, A. 2010. Un sistema migratorio longitudinal dentro de la selva Atlántica: movimientos estacionales y taxonomía del Tangara Cabeza Celeste (*Euphonia cyanocephala*) en Misiones (Argentina) y Paraguay. *Ornitología Neotropical*, 21: 71–86.

Barry, J. H.; Butler, L. K.; Rohwer, S. & Rohwer, V. G. 2009. Documenting molt-migration in Western Kingbird (*Tyrannus verticalis*) using two measures of collecting effort. *Auk*, 126: 260–267.

Butler, L. K.; Donahue, M. G. & Rohwer, S. 2002. Molt-migration in Western Tanagers (*Piranga ludoviciana*): age effects, aerodynamics, and conservation implications. *Auk*, 119: 1010–1023.

Capllonch, P.; Ortiz, D. & Soria, K. 2009. Migraciones de especies de Tyrannidae de la Argentina: Parte 2. *Acta Zoológica Lilloana*, 53: 55–75.

Cavalcanti, R. B. 1990. Migrações de aves no Cerrado, p. 110–116. *Anais do IV Encontro Nacional de Anilhadores de Aves*. Pernambuco, Universidade Federal Rural de Pernambuco.

Chesser, R. T. 1994. Migration in South America, an overview of the Austral system. *Bird Conservation International*, 4: 91–107.

Chesser, R. T. 1995. *Biogeographic, ecological, and evolutionary aspects of South American austral migration, with special reference to the family Tyrannidae*. Ph.D. Thesis. Baton Rouge: Louisiana State University.

Chesser, R. T. 1997. Patterns of seasonal and geographical distribution of austral migrant flycatchers (Tyrannidae) in Bolivia. *In*: Remsen-Jr, J. V. (ed.) Studies in Neotropical Ornithology Honoring Ted Parker. *Ornithological Monographs*, 48: 171–204.

Cueto, V. R. & Jahn, A. E. 2008. Sobre la necesidad de tener un nombre estandarizado para las aves que migran dentro de América del Sur. *Hornero*, 23: 1–4.

Davis, S. E. 1993. Seasonal status, relative abundance, and behavior of the birds of Concepción, departamento Santa Cruz, Bolivia. *Fieldiana Zoology, New Series*, 71: 1–33.

**Fitzpatrick, J. W.; Bates, J. M.; Bostwick, K. S.; Caballero, I. C.; Clock, B. M.; Farnsworth, A.; Hosner, P. A.; Joseph, L.; Langham, G. M.; Lebbin, D. J.; Mobley, J. A.; Robbins, M.

B.; Scholes, E.; Tello, J. G.; Walther, B. A. & Zimmer, K. J. 2004. Family Tyrannidae (tyrant-flycatchers), p. 170–462. *In*: del Hoyo, J.; Elliot, A. & Sargatal, J. (eds.). *Handbook of the birds of the world v. 9*. Barcelona: Lynx Edicions.

Jahn, A. E. & Cueto, V. R. 2012. The potential for comparative research across New World bird migration systems. *Journal of Ornithology*, 153: S199–S205.

Jahn, A. E. & Tuero, D. T. 2013. Fork-tailed Flycatcher (*Tyrannus savana*), *In*: Schulenberg, T. S. (ed.). Ithaca: Cornell Lab of Ornithology; *Neotropical birds online*. http://neotropical.birds.cornell.edu/portal/species/overview?p_p_spp=482636 (access on 25 September 2015).

Jahn, A. E.; Levey, D. J. & Smith, K. G. 2004. Reflections across hemispheres: Austral migration is key to a system-wide approach to New World bird migration. *Auk*, 121: 1005–1013.

Jahn, A. E.; Cueto, V. R.; Fox, J. W.; Husak, M. S.; Kim, D. H.; Landoll, D. V.; Ledezma, J. P.; LePage, H. K.; Levey, D. J.; Murphy, M. T. & Renfrew, R. B. 2013b. Migration timing and wintering areas of three species of flycatchers (*Tyrannus*) breeding in the Great Plains of North America. *Auk*, 130: 247–257.

Jahn, A. E.; Levey, D. J.; Cueto, V. R.; Ledezma, J. P.; Tuero, D. T.; Fox, J. W. & Masson, D. 2013a. Long-distance bird migration within South America revealed by light-level geolocators. *Auk*, 130: 223–229.

Jahn, A. E.; Tuero, D. T.; Mamani, A. M.; Bejarano, V.; Masson, D. & Aguilar, E. 2014. Drivers of clutch size in Fork-tailed Flycatchers (*Tyrannus savana*) at temperate and tropical latitudes in South America. *Emu*, 114: 337–342.

Lisovski, S. & Hahn, S. 2012. GeoLight – processing and analysing light-based geolocator data in R. *Methods in Ecology and Evolution*, 3: 1055–1059.

Marini, M. Â.; Lobo, Y.; Lopes, L. E.; França, L. F. & Paiva, L. V. 2009. Biologia reprodutiva de *Tyrannus savana* (Aves, Tyrannidae) em Cerrado do Brasil Central. *Biota Neotropica*, 9: 55–63.

McKinnon, E. A.; Fraser, K. C. & Stutchbury, B. J. 2013. New discoveries in landbird migration using geolocators, and a flight plan for the future. *Auk*, 130: 211–222.

Parker-III, T. A.; Stotz, D. F. & Fitzpatrick, J. W. 1996. Ecological and distributional databases, p. 113–436, *In*: Stotz D. F.; Fitzpatrick J. W.; Parker-III, T. A. & Moskovits, K. D. (eds.) *Neotropical birds: ecology and conservation*. Chicago: University of Chicago Press.

Parrish, J. D. 1997. Patterns of frugivory and energetic condition in Nearctic landbirds during autumn migration. *Condor*, 99: 681–697.

Pimentel, T. M. 1985. *Biologia reprodutiva de* Tyrannus savana *(Aves: Tyrannidae), com uma comparação entre o forrageamento desta espécie e de* T. melancholicus *no Planalto Central*. MSc. Dissertation. Brasília: Universidade de Brasília.

Pyle, P. 1997. *Identification guide to North American birds*, part I. Bolinas: Slate Creek Press.

Ralph, C. J.; Guepel, G. R.; Pyle, P.; Martin, T. E. & DeSante, D. F. 1993. *Handbook of field methods for monitoring landbirds*. Technical Report PSW-GTR-144. Albany: U.S. Forest Service General.

Rappole, J. H. & Tipton, A. R. 1991. New harness design for attachment of radio transmitters to small passerines. *Journal of Field Ornithology*, 62: 335–337.

Rohwer, S.; Butler, L. K. & Froehlich, D. R. 2005. Ecology and demography of east-west differences in molt scheduling of Neotropical migrant passerines, p. 87–105. *In*: Greenberg, R. & Marra, P. P. (eds.) *Birds of two worlds: the ecology and evolution of migration*. Baltimore: Johns Hopkins University Press.

Sick, H. 1983. *Migrações de aves na América do Sul Continental*. Publicação Técnica No. 2. Brasília: CEMAVE/IBDF.

Stotz, D. F.; Fitzpatrick, J. W.; Parker-III, T. A. & Moskovits, D. K. 1996. *Neotropical birds: ecology and conservation*. Chicago: University of Chicago Press.

Willis, E. O. 2004. Birds of a habitat spectrum in the Itirapina Savanna, São Paulo, Brazil (1982–2003). *Brazilian Journal of Biology*, 64: 901–910.

Zimmer, J. T. 1938. Notes on migrations of South American birds. *Auk*, 55: 405–410.

Associate Editor: Gustavo Cabbane.

Revista Brasileira de Ornitologia, 24(2), 122-128
June 2016

ARTICLE

Diet of the Burrowing Owl *Athene cunicularia*, in two locations of the inter-Andean valley Ecuador

Héctor Cadena-Ortíz[1,2,4], César Garzón[1], Santiago Villamarín-Cortéz[1], Glenda M. Pozo-Zamora[1], Gabriela Echeverría-Vaca[1], Javier Yánez[1,3] and Jorge Brito-M.[1]

[1] Museo Ecuatoriano de Ciencias Naturales del Instituto Nacional de Biodiversidad. Calle Rumipamba 341 y Av. de los Shyris. Casilla 17-07-8976. Quito, Ecuador.
[2] Aves Quito (Club de observadores de aves), Ecuador.
[3] Escuela de Ciencias Biológicas y Ambientales, Facultad de Ciencias Médicas, Universidad Central del Ecuador, Yaguachi y Numa Pompillo Llona, Quito Ecuador.
[4] Corresponding author: fercho_cada@yahoo.es

Received on 04 May 2015. Accepted on 05 April 2016.

ABSTRACT: We provide the first detailed description of the diet of Burrowing Owls (*Athene cunicularia*) for Ecuador, based on an analysis of 408 pellets collected from one locality in the north and one in the south of the central dry Andean Valley. Our results are consistent with previous studies in the Neotropics that document the importance of insects in the diet. Rodents made up 78.8% of the biomass in our sample. Additionally, we highlight the first record of the Andean eared mouse *Phyllotis andium* in a xeric environment, which was identified in the pellets.

KEY-WORDS: pellets, *Phyllotis andium*, Strigidae, trophic ecology.

INTRODUCTION

The knowledge of the food type that a species consumes is important to establish inter and intraspecific interactions (Marti *et al*. 1993). Most of our knowledge on the feeding habits of owls has been based on the analysis of pellets, which are compact packages of hairs, bones and other indigestible material, regurgitated by these and other birds. Marks *et al*. (1999) mention that diet is the better-known ecological aspect of owls due to the presence of pellets, but this general statement does not necessarily reflects the reality for species in Ecuador (Freile *et al.* 2012, Cadena-Ortiz *et al*. 2013).

The Burrowing Owl (*Athene cunicularia*) usually lives in pairs or family groups, associated with burrows dug into soft ground. This owl has a wide distribution, from the North American plains to Tierra del Fuego in Argentina. In Ecuador, it is considered rare and two subspecies occur; *A. c. pichinchae* in open arid areas of the Andes, mainly between 1500–2000 m a.s.l., and *A. c. punensis*, smaller in size and found in coastal areas of the southwest, below 50 m a.s.l. (Ridgely & Greenfield 2001, König & Weick 2008).

The feeding ecology of *A. cunicularia* has received considerable attention, especially in North America (*e.g.*, Marks *et al.* 1999, Moulton *et al*. 2005) and in Argentina (see Pardiñas & Cirignoli 2002). Other studies from the Neotropics were carried out in Peru (Medina *et al.* 2013, 2014), Brazil (*e.g.*, Motta-Junior & Bueno 2004, Zilio 2006, Bueno & Motta-Junior 2008), Chile (*e.g.*, Schlatter *et al.* 1980, Silva *et al.* 1995, Carevic 2011, Carevic *et al.* 2013) and Paraguay (Andrade *et al.* 2004).

In Ecuador there is no detailed study on the ecology of this owl (Freile *et al*. 2012), only anecdotal references (Arteaga *et al.* 2012, Cadena-Ortiz *et al.* 2013). In the present study we detail the diet of *A. c. pichinchae*, based on pellets from populations of northern and southern Ecuador.

METHODS

Study area

Pellets samples were obtained from two sites in the central dry Andean Valley: 1) Piedra Labrada (03°22'25.4"S; 79°23'12.1"W, 1437 m a.s.l.), Saraguro Canton, Loja Province, southwestern Ecuador (Figure 1). This is an "Ecosistema arbustal desértico del sur de los valles" habitat (Figures 2A–B), with dominant plant species, *Croton* sp., *Acacia* sp. and *Carica parviflora.* This area has a desert bioclimate, with an average annual temperature of 22°C

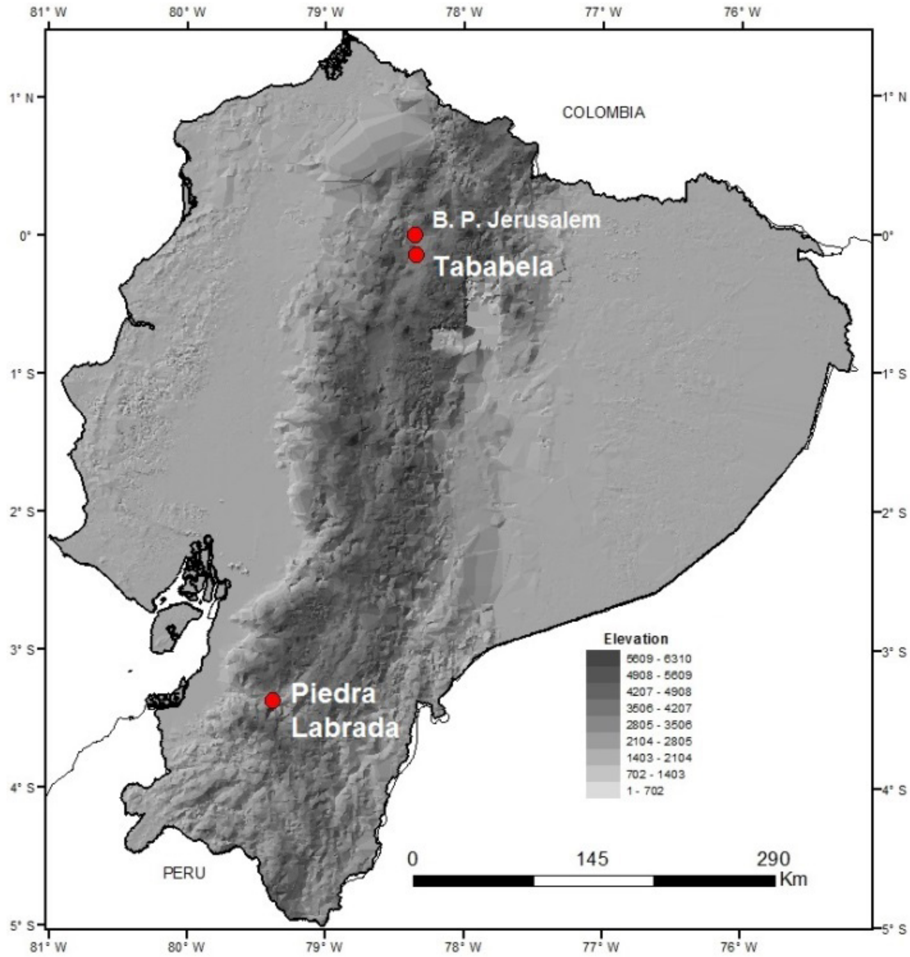

FIGURE 1. Sites in the inter-Andean valley of Ecuador, where the pellets of *Athene cunicularia* were collected.

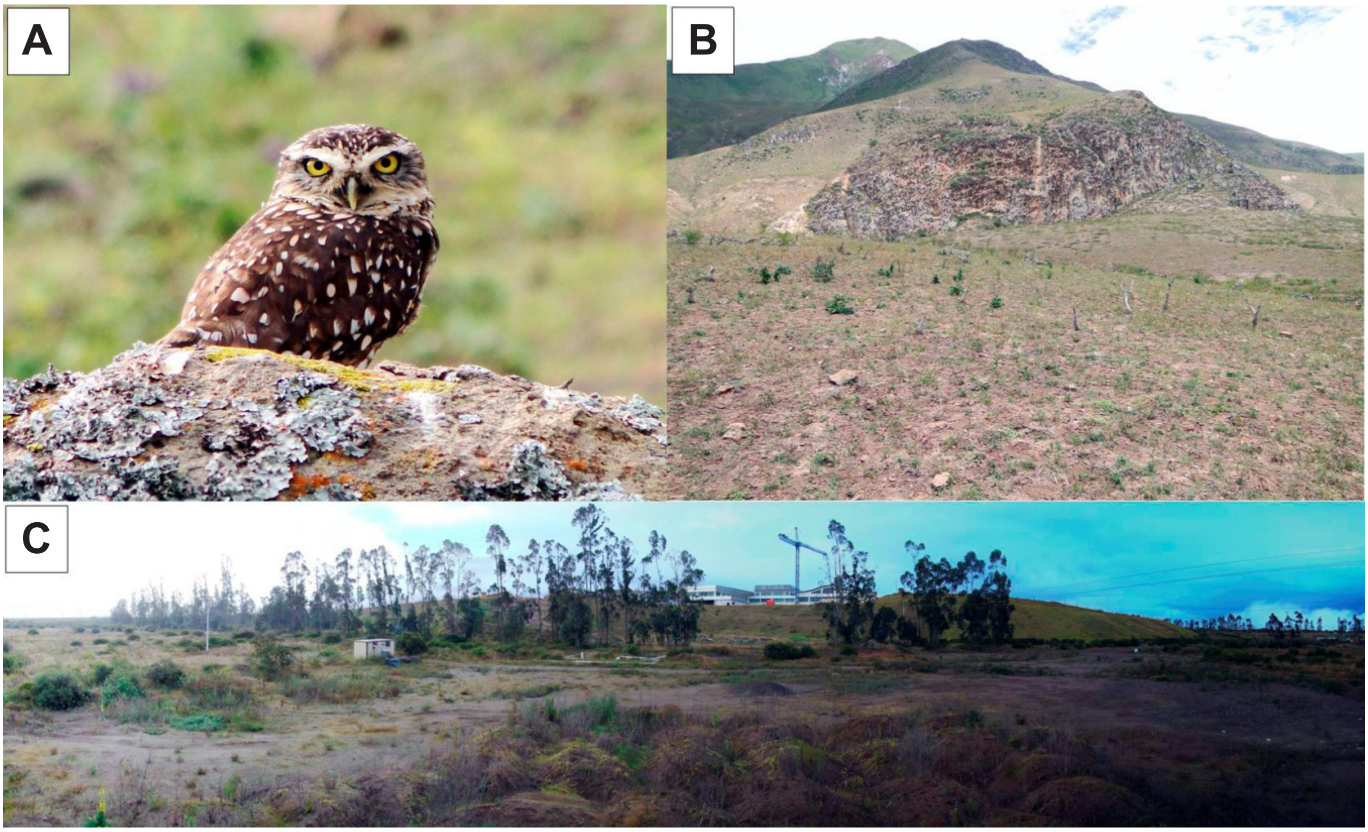

FIGURE 2. (**A**) Burrowing Owl, *Athene cunicularia*, at Piedra Labrada; (**B**) Habitat of Piedra Labrada; (**C**) Panoramic view of the Tababela habitat. Photos: Jorge Brito-M.

and 201 mm of precipitation per year (MAE 2013). 2) Tababela (00°8'42.15"S; 78°20'58.02"W, 2432 m a.s.l.), Quito Canton, Pichincha Province, Caraburo plateau, where the new Quito International Airport (AIMS) for northern Ecuador is located. This is a "Bosque y arbustal semideciduo del norte de los valles". The vegetation is up to 12 m in height and there is a dominance of *Acacia macracantha*, *Inga* sp. and *Eucalyptus globulus* trees and shrubs such as *Opuntia* sp., *Bryophyllum pinnatum* and *Dodonaea viscosa* (Figure 2C), characteristic of dry inter Andean valleys with hills and slopes of rocky soils (MAE 2013). The average annual temperature is 19°C with 360–600 mm of precipitation (Cañadas 1983). Additional qualitative data comes from Bosque Protector Jerusalem (00°00'08.8"N; 78°21'29.8"W, 2304 m a.s.l.) *c.* 12 km from Tababela and similar habitat.

Sampling

In both localities pellets were collected in individual bags with a numerical code. The Piedra Labrada collection came from two owl territories, *c.* 0.2 km apart. Both were visited in April 2012 and December 2013. In Tababela pellets were collected from nine territories, about 1.1 km from each other. All territories were visited nine times, between April 2013 and September 2014.

Data analysis

Pellets were measured with a caliper, ± 0.01 mm precision, the dry weight for each pellet was recorded with an analytical balance 120 ± 0.001 g. After measurement, pellets were manually disintegrated and the bone and arthropod remains were separated and stored in individual vials for later identification. Small mammals were identified through dental characters (Pearson 1958, Hershkovitz 1962, Weskler & Percequillo 2011). Identification of invertebrates was made using different characters (Endrödi 1966, Morón *et al.* 1997, Carvajal *et al.* 2011) and compared to invertebrate reference material in the Museo Ecuatoriano de Ciencias Naturales (MECN).

We determined the minimum number of individuals (MNI) in the sample by counting the homologous jaw or skull remnants for vertebrates, and elytra, heads and mandibles of arthropods. The dietary composition was expressed as relative frequency, MNI of each prey type divided by the total number of prey, multiplied by 100 (Grayson 1984, Formoso *et al.* 2012). Biomass consumed (BM) by *A. cunicularia* was calculated as the average weight of each prey type taxa by the MNI for each locality.

For weight data we used our own records, MECN records, Tirira (2007) and Ramírez-Jaramillo (2015). For invertebrates, the estimated weight of each taxa was only obtained for pellets from Tababela. There was no reference material at MECN to use for weight estimates of invertebrate prey in pellets from Piedra Labrada.

RESULTS

We found 37 taxa (10 vertebrates and 27 invertebrates) in the pellets of *A. cunicularia*, based on 408 pellets analysed from the two localities in Ecuador (Piedra Labrada and Tababela). Pellets were flattened ovals and flat, gray to black in color with average measurements (with standard deviations) of length 32.3 ± 6.1 mm; width 13.9 ± 2.5 mm; height 12.43 ± 2.53 mm and weight 1.55 ± 0.82 g (Piedra Blanca) and length 26.1 ± 6.6 mm; width 12.8 ± 1.4 mm; height 11.0 ± 1.4 mm and weight 1.0 ± 0.5 g (Tababela).

At Piedra Labrada, 40 pellets had remnants of 196 individual prey, grouped into 12 taxa, Coleoptera (5), Dermaptera (3), Scorpionida (1), Gastropoda (1) and small vertebrates (2). Vertebrates were the Andean Eared Mouse (*Phyllotis andium*) and the Guagsa (*Stenocercus rhodomelas*) (Table 1). In this area only two pellets contained exclusively vertebrate remains; the others contained only invertebrate remains or mixed content.

At Tababela, 368 pellets had remnants of 872 prey, grouped into 27 taxa, Coleoptera (14), four orders of other invertebrates (5) and small vertebrates (8). The rodent remains were from, *Akodon* cf. *mollis*, *Phyllotis haggardi*, *Reithrodontomys soderstromi*, *Mus musculus* and *Rattus rattus*; the reptile *Stenocercus guentheri* and anurans *Pristimantis unistrigatus* and *Gastrotheca riobambae* (Table 1). In the pellets from Tababela, 26 contained exclusively vertebrate remains; the others contained invertebrate remains or mixed content.

In both locations, the vertebrates in the diet of *A. cunicularia* were predominantly rodents, 60% of the individual vertebrate prey represented in the pellets; these were followed by reptiles and frogs, 20% each. Of the rodents, the most frequent prey in the diet of *A. cunicularia* was *Reithrodontomys soderstromi* (32 individuals) and *P. haggardi* (26), both species were in pellets from Tababela. *P. andium* (13) was the only rodent found in pellets from Piedra Labrada (Table 1).

In both locations, beetles (Coleoptera) were the predominant invertebrate prey of owls, representing 65.5% of invertebrates with remnants in the pellets, followed by spiders and scorpions with 7% each. Among Tababela samples, most prevalent beetles were Melolonthidae larvae (n = 218), followed by adult Tenebrionidae (n = 81) and *Barotheus andinus* (n = 80). In Piedra Labrada, Melolonthidae larvae (n = 49) were also the most abundant prey, followed by adult Scarabidae (n = 44). We did not find remains of birds in pellets, however, we

TABLE 1. Taxa found in *Athene cunicularia* pellets at two locations in Ecuador. Average weight = AW in g; Minimum number of individuals = MNI and biomass consumed = BM, *only for vertebrates.

ORDER/Family/*Species*	AW	Tababela		Piedra Labrada	
		MNI (%)	BM (%)	MNI (%)	BM (%)*
RODENTIA		84 (9.6)	1669 (74.9)	13 (6.6)	403 (94.8)
Cricetidae					
Akodon cf. *mollis*	15	9 (1.0)	135 (6.1)	0	0
Phyllotis haggardi	20	26 (3.0)	520 (23.3)	0	0
Phyllotis andium	31	0	0	13 (6.6)	403 (94.8)
Reithrodontomys soderstromi	15	32 (3.7)	480 (21.6)	0	0
Muridae					
Mus musculus	14	15 (1.7)	210 (9.4)	0	0
Rattus rattus	162	2 (0.2)	324 (14.5)	0	0
REPTILIA		1 (0.1)	11 (0.5)	2 (1.0)	22 (5.2)
Tropiduridae					
Stenocercus guentheri	11	1 (0.1)	11 (0.5)	0	0
Stenocercus rhodomelas	11	0	0	2 (1.0)	22 (5.2)
ANURA		7 (0.8)	87 (3.9)	0 (0)	0 (0)
Craugastoridae					
Pristimantis unistrigatus	3	1 (0.1)	3 (0.1)	0	0
Hemiphractidae					
Gastrotheca riobambae	14	6 (0.7)	84 (3.8)	0	0
COLEOPTERA		585 (67.2)	269.2 (12.2)	151 (77)	0
Carabidae					
Anchomenus aff. *quitensis*	0.15	46 (5.3)	6.9 (0.3)	0	0
Cerambicidae	0.19	1 (0.1)	0.19 (0.01)	0	0
Curculionidae	0.92	64 (7.3)	58.9 (2.6)	27 (13.8)	0
Chrysomelidae	0	0	0	9 (4.6)	0
Elateridae	0	0	0		0
Chalcolepidius sp1	0.13	30 (3.4)	3.9 (0.2)	0	0
Chalcolepidius sp2	0.14	1 (0.1)	0.14 (0.01)	0	0
Melolonthidae	0	0	0	49 (25.0)	0
Barotheus andinus	0.51	80 (9.2)	40.8 (1.8)	0	0
Clavipalpus whymperi	0.30	41 (4.7)	12.3 (0.6)	0	0
Heterogomphus bourcieri	1.0	4 (0.5)	4 (0.2)	0	0
Morphospecies 1	0.22	8 (0.9)	1.8 (0.1)	0	0
Morphospecies 2	0.20	6 (0.7)	1.2 (0.1)	0	0
Larvae	0.56	218 (25.0)	122.1 (5.5)	0	0
Platycoelia cf. *lutescens*	0.40	1 (0.1)	0.40 (0.02)	0	0
Scarabaeidae	0	0	0	44 (22.4)	0
Tenebrionidae	0	0	0	22 (11.2)	0
Tenebrio sp.	0.16	81 (9.3)	13 (0.6)	0	0
Trogidae					
Omorgus suberosus	0.89	4 (0.5)	3.6 (0.2)	0	0
DERMAPTERA		0	0	5 (2.6)	0
Anisolabiidae	0	0	0	2 (1.0)	0
Labiduridae	0	0	0	2 (1.0)	0
Forficulidae	0	0	0	1 (0.6)	0
HYMENOPTERA		1 (0.1)	0.31 (0.01)	0	0
Formicidae					
Linepithema sp.	0.31	1 (0.1)	0.31 (0.01)	0	0
ORTHOPTERA		7 (0.8)	1.1 (0.05)	0	0
Acrididae					
Paradichroplus sp.	0.16	7 (0.8)	1.1 (0.05)	0	0
ARANEA		174 (19.9)	182.1 (8.2)	0	0
Lycosidae					
Hogna sp.	1.05	171 (19.6)	179.6 (8.1)	0	0
Alopecosa sp.	0.82	3 (0.3)	2.5 (0.1)	0	0
SCORPIONIDA		13 (1.5)	7.4 (0.3)	24 (12.2)	0
Buthidae	0	0	0	24 (12.2)	0
Chactoidae					
Teuthraustes atramentarius	0.57	13 (1.5)	7.4 (0.3)	0	0
GASTROPODA	0	0	0	1 (0.5)	0
Bulimulidae	0	0	0	1 (0.5)	0
Total individuals		872 (100)	2227.14 (100)	196 (100)	425 (100)

observed remains of bird feathers or carcasses of *Zenaida auriculata*, *Columbina passerina*, *Turdus fuscater*, *Phrygilus plebejus* (Figure 3A) and *Sporagra magellanica*, in burrows at Tababela. We found similar results in Bosque Protector Jerusalem, where in a burrow inhabited by at least five individuals of *A. cunicularia*, we found only four pellets, one per visit to the burrow. These pellets only contained remains of invertebrates, mainly Scarabaeidae (adults) and several Dermaptera. Also in the entrance of the burrow we noted pellet remains with several fragments of snail shells (Bulimulidae). Finally, a dead individual of *A. cunicularia*, found on the road bordering Bosque Protector Jerusalem, had remains of lizards, probably *S. guentheri*, in the stomach (S. Varela, pers. comm.).

The weight of vertebrate prey consumed in Piedra Labrada and Tababela averaged 29.6 g (3–162 g; n = 10). Rodents represent 74.9% of the biomass in Tababela, 94.8% in Piedra Labrada and 78.8% for whole samples, excluding the invertebrates from Piedra Labrada (Figure 3B).

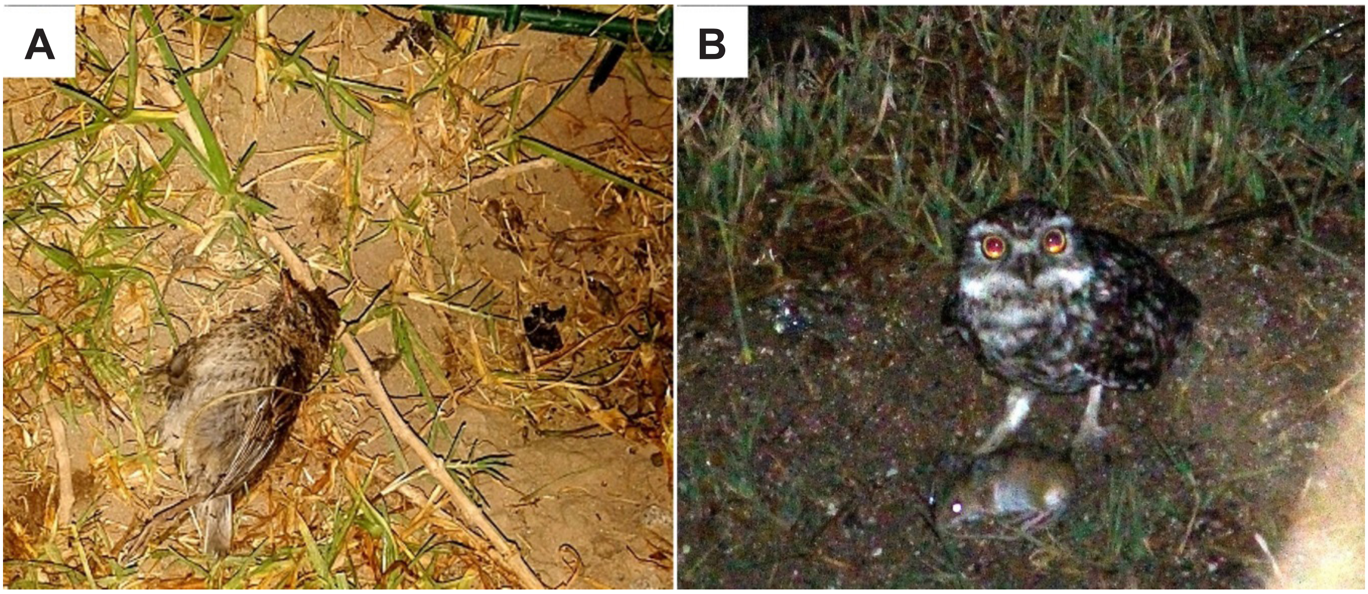

FIGURE 3. Prey of *Athene cunicularia* at Tababela: (**A**) *Phrygilus plebejus* dead at the entrance of the owl burrow; (**B**) *Athene cunicularia* with a *Phyllotis haggardi* recently captured. Photos: Glenda Pozo-Zamora and César Garzón.

DISCUSSION

Our results are in agreement with the descriptions of this owl as a generalist predator using a hunting strategy focused on the most abundant and accessible prey (Vieira & Teixeira 2008). In the *A. cunicularia* pellets from Piedra Labrada and Tababela we found a predominance in number, of invertebrates, mainly beetles, and predominance in biomass of vertebrates, mainly rodents. The diversity of prey found was consistent with the general descriptions of *A. cunicularia* diets in other studies, mainly arthropods (beetles and other insects, spiders and scorpions), small mammals (up to 200 g), but also amphibians, reptiles and occasionally small birds (up to 200 g) (see Marks *et al*. 1999, König & Weick 2008).

A numerical predominance of insects and predominance in biomass of rodents in the *A. cunicularia* diet is a general pattern along its distribution range. For example, in the United States, insects and other invertebrates dominate the diet in numbers of prey, whereas rodents such as *Microtus montanus* contribute the greatest biomass (Moulton *et al*. 2005). In Brazil, termites, orthopterans and beetles are numerically the main prey items, but small rodents such as *Calomys tener* form the bulk of biomass in the diet (Motta-Junior & Bueno 2004). In Argentina, the majority of prey is from three groups, Coleoptera, Scorpionida and eight species of Rodentia (de Tommaso *et al*. 2009). In Peru Tenebrionidae beetles are the most frequent and the rodent *Lagidium peruanum* contributes the largest amount of biomass (Medina *et al.* 2014). In Chile insects and scorpions are the most common prey and the rodent *Phyllotis darwini* is the most important prey in biomass (Carevic *et al.* 2013). In Ecuador, Arteaga *et al.* (2012) analysed 16 owl pellets from Tababela and found 86% of numerical frequency of Coleoptera and Orthoptera remnants, and 14% of small vertebrates remnants, such as mice and lizards, without additional taxonomic detail. Additionally, for Ecuador there are only two zoological specimens of *A. c. punensis* with insects in their stomach contents detailed on their labels (Cadena-Ortiz *et al.* 2013).

These results reported for other locations are consistent with ours in the rate of prey groups, but with different species diversity, even though our research was conducted at only two locations. However, it is important to extend the studies of the diet of owl to different time periods and seasons and more locations in Ecuador to make comparisons and look for patterns.

Birds may be underestimated from owl diet based on pellet analysis since we found vestiges of birds in burrows at Tababela, but did not find remains of birds in pellets. Other studies also show low frequency of birds in the diet of *A. cunicularia*. For example, from 91 pellets analysed in Peru, evidence of only one bird was found (Medina *et al.* 2014); in Argentina evidences of 15 birds were found in 235 pellets (Andrade *et al.* 2010).

Rodents are an important component in the *A. cunicularia* diet, as corroborated by ours and other studies (*e.g.*, Bueno & Motta-Junior 2008, Carevic 2011, Carevic *et al.* 2013). This further highlights the value of this owl as a biological control of peridomestic rat populations (Carevic 2011), and could counteract the bad reputation of *A. cunicularia*, which is usually considered a bad luck bird or a bad omen among local people (Restrepo & Enríquez 2014, authors' pers. obs.).

The analysis of pellets has been proven be an efficient complementary inventory method of biodiversity in unexplored areas (Andrade *et al.* 2010), in particular for small mammals (*e.g.*, Bonvicino & Bezerra 2003, Torre *et al.* 2004, Moreno 2010, Brito *et al.* 2015). Analyses of *A. cunicularia* pellets has been demonstrated to be effective as an inventory method for small mammals in Lomas de Lima, Peru (Mena *et al.* 2007) and the Atacama Desert, Chile (Carevic 2011). We found evidence of the Andean Eared Mouse, an endemic species to the Andes, from central and northern Peru to southern Ecuador (Hershkovitz 1962, Zeballos & Vivar 2008). In Ecuador, this rodent has been reported in subtropical and temperate forests and in highlands, with most records from wetlands with abundant shrub vegetation (Tirira 2007). Our record in the pellets is the first one of *P. andium* in the valleys of southern Ecuador, in Piedra Labrada at 1435 m in a xeric environment.

ACKNOWLEDGEMENTS

We would like to thank Cliff Keil, Daniela Bahamonde and Adam Batty for their comments on this manuscript. We also thank Daniela Bahamonde for designing the map; Santiago Varela for sharing his observations. Thanks to CHARLIEG, Engineering and Remediation Cia. Ltda, consultant for funds granted for the field phase at Piedra Labrada and help of local guides: Jaime Miranda and Vicente Arias. The Ministerio del Ambiente of Loja gave license research No. 04-2012-I-B-DPL / MAE, for Piedra labrada. Quiport Corporation funded the study in Tababela. The Ministerio del Ambiente of Pichincha gave license research No. 01-2014-RIC-FAU-FLO-DPAP-MA, for Tababela.

REFERENCES

Andrade, A.; Nabte, M. J. & Kun, M. E. 2010. Diet of the Burrowing Owl (*Athene cunicularia*) and its seasonal variation in Patagonian steppes: implications for biodiversity assessments in the Somuncurá Plateau Protected Area, Argentina. *Studies on Neotropical Fauna and Environment*, 45: 101–110.

Andrade, A.; Teta, P. & Contreras, J. 2004. Dieta de la Lechucita Vizcachera (*Athene cunicularia*) en el Parque Nacional Médanos del Chaco (Paraguay). *Ornitología Neotropical*, 15: 87–92.

Arteaga, J.; Toscano, G.; Sánchez, P. & de Vries, T. 2012. Dieta del Búho Terrestre *Athene cunicularia pichinchae* mediante análisis de egagrópilas. *In*: Resúmenes de las XXXVI Jornadas Nacionales de Biología. Guayaquil, Ecuador.

Bonvicino, C. R. & Bezerra, A. M. R. 2003. Use of regurgitated pellets of Barn Owl (*Tyto alba*) for inventorying small mammals in the Cerrado of central Brazil. *Studies on Neotropical Fauna and Environment*, 38: 1–5.

Brito, J.; Orellana-Vásquez, H.; Cadena-Ortiz, H.; Vargas, R.; Pozo-Zamora G. & Curay, J. 2015. Mamíferos pequeños en la dieta de la lechuza *Tyto alba* (Strigiformes: Tytonidae) en dos localidades del occidente de Ecuador, con ampliación distribucional de *Ichthyomys hydrobates* (Rodentia: Cricetidae). *Papéis Avulsos de Zoologia*, 55: 261–268.

Bueno, A. A. & Motta-Junior, J. C. 2008. Small mammal prey selection by two owl species in southeastern Brazil. *Journal of Raptor Research*, 42: 248–255.

Cadena-Ortiz, H.; Freile, J. F. & Bahamonde-Vinueza, D. 2013. Información sobre la dieta de algunos búhos (Strigidae) del Ecuador. *Ornitología Neotropical*, 24: 469–474.

Cañadas, L. 1983. *El mapa bioclimático y ecológico del Ecuador.* Quito: Ministerio de Agricultura y Ganaderia.

Carevic, F. S. 2011. Rol del Pequén (*Athene cunicularia*) como controlador biológico mediante el análisis de sus hábitos alimentarios en la Provincia de Iquique, norte de Chile. *Idesia*, 29: 15–21.

Carevic, F. S.; Carmona, E. R. & Muñoz-Pedreros, A. 2013. Seasonal diet of the Burrowing Owl *Athene cunicularia* Molina, 1782 (Strigidae) in a hyperarid ecosystem of the Atacama Desert in northern Chile. *Journal of Arid Environments*, 97: 237–241.

Carvajal, V.; Villamarin-Cortez, S. & Ortega, A. 2011. *Escarabajos del Ecuador. Principales g*éneros. Quito: Instituto de Ciencias Biológicas. Escuela Politécnica Nacional. Serie Entomología, No. 1.

Endrödi, S. 1966. Monographie der Dynastinae (Col. Lam.) I. Teil. *Entomologische Abhandlungen Museum Tierkunde, Dresden*, 33: 1–457.

Formoso, A. E.; Teta, P. & Cheli, G. 2012. Food habits of the Magellanic Horned Owl (*Bubo virginianus magellanicus*) at southernmost Patagonia, Argentina. *Journal of Raptor Research*, 46: 401–406.

Freile, J. F.; Castro, D. F. & Varela, S. 2012. Estado del conocimiento, distribución y conservación de aves rapaces nocturnas en Ecuador. *Ornitología Neotropical*, 23: 235–244.

Grayson, D. K. 1984. *Quantitative zooarchaeology: topics in the analysis of archaeological faunas.* Orlando: Academics Press.

Hershkovitz, P. 1962. Evolution of Neotropical cricetine rodents (Muridae) with special reference to the phyllotine group. *Fieldiana Zoology, Chicago Natural History Museum*, 46: 1–524.

König, C. & Weick, F. 2008. *Owls of the world.* London: Christopher Helm.

MAE (Ministerio del Ambiente del Ecuador). 2013. *Sistema de clasificación de los ecosistemas del Ecuador Continental.* Quito: Ministerio del Ambiente, Subsecretaría de Patrimonio Natural.

Marks, J. S.; Canning, R. J. & Mikkola, H. 1999. Family Strigidae (typical owls). p. 76–242 *In*: del Hoyo, J.; Elliott, A. & Sargatal,

J. (eds.). *Handbook of the birds of the world*, v. *5 (barn-owls to hummingbirds).* Barcelona: Lynx Edicions.

Marti, C. D.; Steenhof, K.; Kochert, M. N. & Marks, J. S. 1993. Community trophic structure: the roles of diet, body size, and activity time in vertebrate predators. *Oikos*, 67: 6–18.

Medina, C.; Zelada, W. & Pollack, L. 2014. Estructura alimenticia de la Lechuza de los Arenales, *Athene cunicularia*, en el Cerro Campana, La Libertad, Perú. 2011. *Revista Rebiol*, 34: 73–82.

Medina, C. A.; Zelada, W.; Pollack, L.; Huamán, E. & Gómez, A. 2013. Dieta de la Lechuza de los Arenales, *Athene cunicularia*, en Trujillo y en el Cerro Campana, La Libertad (Perú): 2013. *Revista Rebiol*, 33: 99–106.

Mena, J. L.; Williams, M.; Gazzolo, C. & Montero, F. 2007. Estado de conservación de *Melanomys zunigae* (Sanborn 1949) y de los mamíferos pequeños en las Lomas de Lima. *Revista Peruana de Biología*, 14: 201–208.

Moreno, P. 2010. Mamíferos presentes en la dieta de la Lechuza de Campanario (*Tyto alba*) en Valdivia, provincial de Guayas, Ecuador. *Avances en Ciencias e Ingenierías, Sección B*, 2: B87–B90.

Morón, M. A.; Ratcliffe, B. C. & Deloya, C. 1997. *Atlas de escarabajos de México. Coleoptera: Lamellicornia, v. I. Familia Melolonthidae.* Mexico: CONABIO, Sociedad Mexicana de Entomología.

Motta-Junior, J. C. & Bueno, A. A. 2004. Trophic ecology of the Burrowing Owl in southeast Brazil. *In*: Chancellor, R. D. & Meyburg, B. U. (eds.). *Raptors worldwide: proceedings of the VI world conference on birds of prey and owls*. World Working Group on birds of prey and owls, Budapest: MME BirdLife, 763–775.

Moulton, C.; Brady, R. & Belthoff, J. 2005. A comparison of breeding seasonal food habits of Burrowing Owls nesting in agricultural and non-agricultural habitat in Idaho. *Journal of Raptor Research*, 39: 429–438.

Pardiñas, U. & Cirignoli, S. 2002. Bibliografía comentada sobre los análisis de egagrópilas de aves rapaces en Argentina. *Ornitología Neotropical*, 13: 31–59.

Pearson, O. 1958. *A taxonomic revision of the rodent genus* Phyllotis. Berkeley: University of California Press.

Ramírez-Jaramillo, S. R. 2015. Observaciones sobre la historia natural de *Erythrolamprus epinephelus albiventris* en el valle de Quito, Ecuador. *Avances en Ciencias e Ingenierías*, *Sección B*, 7: B5–B7.

Restrepo, J. S. & Enríquez, P. L. 2014. Conocimiento popular sobre los búhos en poblaciones rurales del suroccidente de Manizales, Caldas, Colombia. *Etnobiología*, 12: 41–48.

Ridgely, R. S. & Greenfield, P. J. 2001. *The birds of Ecuador, v. 1: status, distribution and taxonomy.* Ithaca: Cornell University Press.

Schlatter, R. P.; Yáñez, J. L.; Núñez, H. & Jaksić, F. M. 1980. The diet of the Burrowing Owl in central Chile and its relation to prey size. *Auk*, 97: 616–619.

Silva, S. I.; Lazo, I; Silva-Aranguiz, E.; Jaksić, F. M.; Meserve, P. & Gutiérrez, J. R. 1995. Numerical and functional response of Burrowing Owls to long-term mammal fluctuations in Chile. *Journal of Raptor Research*, 29: 250–255.

Tirira, D. 2007. *Guía de campo de los mamíferos del Ecuador.* Publicación especial sobre los mamíferos del Ecuador. 6. Quito: Ediciones Murciélago Blanco.

de Tommaso, D. C.; Callicó, R. G.; Teta, P. & Pereira J. A. 2009. Dieta de la Lechucita Vizcachera (*Athene cunicularia*) en dos áreas con diferente uso de la tierra en el centro–sur de la provincia de La Pampa, Argentina. *Hornero*, 24: 87–93.

Torre, I.; Arrizabalaga, A. & Flaquer, C. 2004. Three methods for assessing richness and composition of small mammal communities. *Journal of Mammalogy*, 85: 524–530.

Vieira, L. A. & Teixeira, R. L. 2008. Diet of *Athene cunicularia* (Molina, 1782) from a sandy coastal plain in southeast Brazil. *Boletim do Museu de Biologia Mello Leitão*, 23: 5–14.

Weskler, M. & Percequillo, A. 2011. Key to the genera of the tribe Oryzomyini (Rodentia: Cricetidae: Sigmodontinae). *Mastozoología Neotropical*, 18: 281–292.

Zeballos, H. & Vivar, E. 2008. *Phyllotis andium*. The IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (access on 08 April 2015).

Zilio, F. 2006. Dieta de *Falco sparverius* (Aves: Falconidae) e *Athene cunicularia* (Aves: Strigidae) em uma região de dunas no sul do Brasil. *Revista Brasileira de Ornitologia*, 14: 379–392.

Associate Editor: Carla S. Fontana.

Revista Brasileira de Ornitologia, 24(2), 129-136
June 2016

SHORT-COMMUNICATION

Stomach contents of some poorly known Brazilian birds with focus on species from the Caatinga biome

Nelson Buainain[1,2] and Giovanna Forcato[1]

[1] Setor de Ornitologia, Museu Nacional / UFRJ. Horto Botânico, Quinta da Boa Vista s/n, Departamento de Vertebrados, São Cristóvão, Rio de Janeiro, RJ, Brasil.
[2] Corresponding author: nnbuainain@gmail.com

Received on 09 November 2015. Accepted on 18 July 2016.

ABSTRACT: Studies on feeding biology comprise one of the most basic knowledge about natural history of birds. Here, we report detailed descriptions of the stomach contents of 12 species (*Eupsittula cactorum*, *Neomorphus geoffroyi*, *Picumnus pygmaeus*, *Synallaxis hellmayri*, *Megaxenops parnaguae*, *Myrmorchilus strigilatus*, *Hylopezus ochroleucus*, *Herpsilochmus sellowi*, *Formicivora serrana*, *Scytalopus speluncae*, *Arremon franciscanus* and *Lanio pileatus*). Most species are from the Caatinga biome and many have none or vague information about their diet. We report consumption of soil from termite nest by *E. cactorum*, almost exclusively arachnids including large spiders for *N. g. dulcis*, a diverse composition of arthropods for *S. speluncae*, and the unrecorded importance of Isoptera for *F. serrana*. Finally, we briefly discuss the importance of some items such as Isoptera, Formicidae, Coleoptera and Lepidoptera larvae in the diet of most birds from the Caatinga biome.

KEY-WORDS: arthropod, aves, diet, endemic species, feeding biology, semi-arid environments.

"It is still little the number of works that report stomach contents of Brazilian birds" (Schubart *et al.* 1965). Fifty years later and this quote is still current. It is true that significant progress has been done. Durães & Marini (2005), Lopes *et al.* (2005) and Manhães *et al.* (2010) described the stomach contents of several Atlantic forest birds, including some endemic species. Kupriyanov *et al.* (2012) investigated the diets of Amazonian woodcreepers, Aguiar & Coltro-Júnior (2008) focused on Thamnophilidae, Grallariidae and Formicariidae, while other authors approached one or few species and their ecology (*e.g.* Gomes *et al.* 2001, Vasconcelos *et al.* 2007, Buainain *et al.* 2015). However, most of those studies focused on Atlantic Forest species and/or were based on regurgitation or fecal samples collected in the field.

In the meantime, even though the Brazilian spirits collections have grown significantly and are now more complete than they were 50 years ago, studies on detailed descriptions of stomach contents of birds using anatomical collections are scarce. Besides the traditional papers of Moojen *et al.* (1941) and Hempel (1949), and more recently of Ballarini *et al.* (2013), not much was published on this subject. Whereas many specimens are housed in Brazilian anatomical collections, there is still several bird species whose diets are completely or poorly known, especially the ones from Caatinga and Cerrado biomes.

Studies on feeding biology comprise one of the most basic knowledge about the natural history of birds, which in turn is essential information for conservation of species. Even though new methods and technologies allow us to explore new aspects of the biology of birds, such basic knowledge of many species still remains unknown. In order to expand and provide new information on the diet of Brazilian birds we give detailed descriptions of the stomach contents of species based entirely on material housed in Brazilian scientific collections. Most of these species are from the Caatinga biome, one of the least studied biome in Brazil, and many so far have their diet currently unknown.

We examined the stomach contents of 113 specimens of 12 species housed at the Museu Nacional, Universidade Federal do Rio de Janeiro (MN) and Museu Paraense Emilio Goeldi (MPEG). Most material was collected in a fragment of shrubby Caatinga Forest at the municipality of São Félix do Coribe, Bahia state (13°20'3.19"S; 43°48'24.12"W), near Corrente River, a tributary of São Francisco River (middle region of São Francisco). Other localities and detailed description of the stomach contents examined are listed on Appendix I.

Stomachs were extracted from the abdominal cavity, dissected and stored in 70% ethanol. Contents were placed on a Petri dish, examined with a *Leica ES2* stereo microscope and stored under the same collection number as carcasses. Fragments of arthropods were identified by N.B., with assistance of specialized bibliography (Borror *et al.* 1989, Costa *et al.* 2006, Rafael *et al.* 2012), comparison with material from entomological and arachnids collections of the Universidade Federal do Rio de Janeiro, consultations with experts and comparisons with illustrations of fragments presented in other studies (Ralph *et al.* 1985, Chapman & Rosenberg 1991, Gomes *et al.* 2001, Manhães *et al.* 2010). Fragments were grouped and counted by morphological similarity estimating the minimum number of individuals (items) belonging to the same prey type in a sample. Seeds were counted individually and measured with a *BTS Digital Caliper* (150 x 0.01 mm) when not damaged. For each prey type, relative abundance (number of items of a prey type divided by the total number of items, in percentage), relative occurrence (number of samples in which a prey type occur divided by the total number of samples, in percentage) and average prey type/sample (total items of a prey type divided by the total number of samples), were calculated for each taxon and are shown in Table 1 and 2.

TABLE 1. Diet indexes calculated for the taxa examined. Items per sample/(relative abundance/relative occurrence) of each prey type. Less representative categories were grouped as "others" and are shown in Appendix I.

	***N. geoffroyi* (n = 2)**	***P. pygmaeus* (n = 11)**	***S. hellmayri* (n = 13)**	***M. parnaguae* (n = 23)**	***M. strigilatus* (n = 9)**	***H. sellowi* (n = 18)**
Lepidoptera (larvae)	0.5 (1.6%/50%)	1.5 (1.8%/18.1%)	2.7 (2.7%/46.1%)	1.9 (3.8%/47.8%)	0.1 (0.1%/11.1%)	2.3 (15.7%/50%)
Coleoptera	4 (12.7%/100%)	1 (1.2%/63.7%)	1.9 (1.9%/64.6%)	2 (4%/87%)	2.4 (2.5%/88.9%)	4.2 (28.1%/100%)
Formicidae	3 (9.5%/50%)	3.6 (4.5%/90.9%)	5.8 (5.9%/76.9%)	5.2 (10.1%/82.6%)	36.9 (38.2%/100%)	4.7 (31.8%/61.1%)
Isoptera	1 (3.2%/50%)	72.1 (88.4%/100%)	81.9 (82.4%/84.6%)	38.9 (76.1%/91.3%)	55.8 (57.8%/100%)	0.4 (3%/11.1%)
Orthoptera	6 (19%/100%)	0	0.3 (0.3%/30.8%)	1.7 (3.2%/65.2%)	0.1 (0.1%/11.1%)	0.6 (4.1%/50%)
Vegetal material	0	0	6 (6%/100%)	0.9 (1.7%/4.4%)	0	0.8 (5.2%/5.6%)
Hemiptera	0.5 (1.6%/50%)	0.2 (0.2%/18.1%)	0.1 (0.1%/7.7%)	0.1 (0.1%/4.4%)	0	1.3 (9%/61.1%)
Araneae	14 (44.4%/50%)	0	0.4 (0.4%/23.1%)	0.1 (0.2%/8.7%)	0	0.2 (1.1%/11.1%)
Coleoptera (larvae)	0	3.1 (3.8%/72.7%)	0.2 (0.2%/23.1%)	0.2 (0.3%/17.4%)	0.1 (0.1%/11.1%)	0
Chilopoda	1.5 (4.8%/100%)	0	0	0.1 (0.1%/4.4%)	0	0
Opiliones	1 (3.2%/50%)	0	0	0	0	0
Others	0	0.1 (0.1%/9.1%)	0.2 (0.2%/15.3%)	0.2 (0.3%/13%)	0.3 0.3%/33.3%)	0.3 (1.9%/27.8%)

Eupsittula cactorum (Kuhl, 1820) (n = 2): stomachs contained only crushed seeds and stones. Information agrees with Barros & Marcondes-Machado (2000) and Ballarini *et al.* (2013) on the predominance of seeds. Unlike previous studies, no latex, fruit pulp or flowers were detected in our samples. Some dark brownish hard fragments, which looked like pieces of termite nests (Isoptera), were recorded. Barros & Marcondes-Machado (2000) observed the species carving termite nests, where they looked for food and built their nest. However, no termite was found inside the stomachs analyzed. A recent study showed that geophagic behavior by Yellow-chevroned Parakeet *Brotogeris chiriri* (Vieillot, 1818), particularly the ingestion of soil from termites nest, is related to supplementation of minerals and organic matter (essential for physiological functions), and also to bind toxins present on fruits consumed by the species (Costa-Pereira *et al.* 2015). Further observations are needed to clarify if consumption of soil from termites nest by *E. cactorum* is accidental (during nest carving) or if the species present geophagic behavior similar to other Psittacidae.

Neomorphus geoffroyi (Temminck, 1820) (n = 2): one individual corresponds to the subspecies *N. g. dulcis* and the other to *N. g. amazonicus.* The stomach of the former contained almost exclusively arachnids. Items recorded were Araneae (spiders), mostly Ctenidae (*Ctenus medius* Keyserling, 1891, *C. ornatus* (Keyserling, 1877), *C.*

TABLE 2. Diet indexes calculated for the taxa examined. Items per sample/(relative abundance/relative occurrence) of each prey type. Less representative categories were grouped as "others" and are shown in Appendix I.

	H. ochroleucus **(n = 3)**	***F. serrana*** **(n = 17)**	***S. speluncae*** **(n = 5)**	***A. franciscanus*** **(n = 1)**	***C. pileatus*** **(n = 7)**
Lepidoptera (larvae)	1 (0.4%/33.3%)	0.8 (4.8%/58.8%)	0.4 (1.9%/40%)	2 (4.2%/100%)	1.3 (3.7%/57%)
Coleoptera	5 (5.3%/100%)	4.5 (27.8%/76.5%)	2.8 (13.2%/100%)	3 (6.3%/100%)	1.7 (4.9%/86%)
Formicidae	10 (10.5%/100%)	2.6 (16.1%/76.5%)	9.8 (46.2%/100%)	3 (6.3%/100%)	18.9 (53.9%/86%)
Isoptera	75 (78.9%/100%)	4.4 (27.1%/47.1%)	2 (9.4%/60%)	6 (12.5%/100%)	10 (28.6%/57%)
Orthoptera	0.7 (0.7%/33.3%)	1.2 (7.7%/88.2%)	0.6 (2.8%/60%)	0	0.1 (0.4%/14%)
Vegetal material	0.3 (0.4%/33.3%)	0.7 (4.4%/17.7%)	0.2 (0.9%/20%)	34 (70.8%/100%)	3 (8.6%/57%)
Hemiptera	0.3 (0.4%/33.3%)	0.4 (2.2%/29.4%)	2.2 (10.3%/80%)	0	0
Araneae	0.7 (0.7%/66.6%)	0.8 (5.1%/52.9%)	0.4 (1.9%/40%)	0	0
Coleoptera (larvae)	0.7 (0.7%/33.3%)	4.5 (1.1%/11.8%)	0.4 (1.9%/40%)	0	0
Chilopoda	0.3 (0.4%/33.3%)	0.1 (0.4%/5.9%)	0	0	0
Opiliones	0	0	1.4 (6.6%/20%)	0	0
Others	1.7 (1.8%/33.3%)	0.5 (3.3%/23.5%)	1 (4.7%/40%)	0	0

vehemens Keyserling, 1891, *Isoctenus foliiferus* (Bertkau, 1880), but also Coriinidae (*Corinna* sp.), Salticidae and Theraphosidae; Opiliones (Gonyleptidae: *Metagonyleptes calcar* Roewer, 1913); Chilopoda (centipede), including a 140 mm piece; Orthoptera, mostly Gryllidae (crickets), but also Acrididae (grasshoppers); and Coleoptera (beetles). Three hard and membranous egg-shaped items, which are possibly seeds, were registered. Sick (1953) and Schubart *et al.* (1965) examined five specimens of *N. g. dulcis* from Linhares, Espírito Santo state (locality close to our specimen) and reported similar results, except for the absence of Araneae, which was the main item found in our study. Food items identified by those authors include Orthoptera (Acrididae and Gryllidae), Blattaria (cockroaches), Opiliones (Gonyleptidae), Formicidae (ants), Coleoptera and Chilopoda (110 mm long).

Stomach contents of *N. g. amazonicus* differed from the ones of *N. g. dulcis* especially by the absence of Araneae and Opiliones. It consists mostly of Formicidae (not army ants, *Ecyton* sp.), Coleoptera, Orthoptera (Acrididae), but also Isoptera, Lepidoptera larvae (caterpillars), Hemiptera (Heteroptera, true bugs), and Chilopoda. Pelzeln (1871) examined two specimens from Pará state (*N. g. amazonicus*) and reported a big spider (Araneae), rests of Coleoptera and Orthoptera (Acrididae), and a hard membranous egg-shaped item, which he supposed to be a lizard egg. Schubart *et al.* (1965) reported Orthoptera, Blattaria, Hemiptera and Coleoptera in one specimen from Maranhão state (*N. g. amazonicus*).

Picumnus pygmaeus (Lichtenstein, 1823) (n = 11): stomachs had absolute predominance of Isoptera, followed by Coleoptera larvae (mostly Buprestidae), Formicidae and Coleoptera. Other less representative items recorded were Hemiptera and Pseudoscorpiones. Stomachs collected during the rainy season contained Lepidoptera larvae. Schubart *et al.* (1965) reported six Coleoptera larvae ("probably Elateridae") in one specimen from Rio Mearim (Maranhão state).

Synallaxis hellmayri Reiser, 1905 (n = 13): stomachs contained predominantly Isoptera, followed by Formicidae (mostly apterous, but also winged forms), seeds and Coleoptera (Curculionidae and others unidentified). Some of the less representative items were Orthoptera (mostly Gryllidae, but also Acrididae); Araneae (*Ctenus* sp.); Coleoptera larvae; Hemiptera and adult Lepidoptera. Samples collected during the rainy season in November (n = 2) had, among other insects, many Lepidoptera larvae. The majority of the Isoptera identified were apterous (worker and soldier castes), but some winged forms were also detected. Seeds were found in all samples, usually with some pulp/vegetable flesh. Three different morphotypes were identified (5.96 x 3.65 mm; 4.25 x 2.67 mm; 3.29 x 1.25 mm). Succulent plant parts with smooth surface and stomata, which are possibly epidermis of cactuses or bromeliads, were occasionally recorded. Whitney & Pacheco (1994) described an individual of *S. hellmayri* foraging in a bromeliad, sometimes tapping directly on the leaves of the plant, while Teixeira (1992) reported the use of branches and spines of the Xique-xique cactus (*Pilocereus gounellei* (A. Weber ex K. Schum.) Bly. ex Rowl)) in the nest of the species. It is likely that plant parts found in our samples were accidentally ingested during foraging or nest construction. A large amount of soil/sand was found in all stomachs. This finding agrees with descriptions of Whitney & Pacheco (1994), who observed individuals ingesting small spiders and orthopterans, while foraging directly on the ground. Teixeira (1992) reported: *"captures small spiders and insects (Coleoptera, Orthoptera, etc.), sometimes ingesting non-identified seeds, according to examined stomach contents"*.

Megaxenops parnaguae Reiser, 1905 (n = 23): stomachs contained predominantly Isoptera (mostly apterous, but also a few winged individuals), followed by Formicidae, Orthoptera (mostly Gryllidae, but also Acrididae) and Coleoptera (Nitidulidae, Carabidae and others unidentified). One stomach collected during the dry season contained 20 seeds of the same morphotype (5.65 x 1.26 mm), and another one contained 21 ant pupae (Formicidae). Less representative items recorded were Araneae, Chilopoda, Hymenoptera (non Formicidae), Hemiptera, Coleoptera larvae (Buprestidae and others unidentified), Neuroptera larvae and Odonata. Specimens collected during the rainy season (n = 7) had lower proportion of Isoptera and Orthoptera and higher proportion of Lepidoptera larvae, when compared to specimens collected during the dry season. Several pieces of bark were found inside stomachs. This information is in agreement with observation by Teixeira *et al.* (1989) and Whitney & Pacheco (1994), who described individuals tapping on bark, while looking for wood miner or borer arthropods. Teixeira *et al.* (1989) reported the stomach contents of one specimen containing Formicidae, Coleoptera (Scarabaeidae), Lepidoptera larvae and many Araneae (*Ctenus* sp. *Micrathena* sp. and *Phoneutria* sp.), "*but no typical endophytic arthropod*". Our samples differ from this study by the clear predominance of Isoptera and presence of Orthoptera and wood miner/borer arthropods (*e. g.* some Coleoptera larvae). Although Kirwan *et al.* (2001) observed individuals investigating a termite nest, the consumption of those insects, which are the predominant food resource of the species found according to our study, is a novelty.

Myrmorchilus strigilatus (Wied, 1831) (n = 9): stomachs contained predominantly Isoptera and Formicidae, followed by Coleoptera. Other items found were Lepidoptera, adults and larvae, Chilopoda, Orthoptera, Hymenoptera and Pseudoscorpiones. One specimen collected during the rainy season had six Lepidoptera larvae, but also a large amount of the other three main items in its stomach. Remsen *et al.* (1988) mentioned that "all stomachs contents contained insects", but did not mention specific taxa or life stages, while Bodrati (2012) recorded male adults feeding "larvae" to their nestlings.

Hylopezus ochroleucus (Wied, 1831) (n = 3): stomachs contained predominantly Isoptera (apterous form), followed by Formicidae and Coleoptera (Scarabaeidae and others unidentified). Less representative items registered were Hemiptera, Araneae, Scorpiones, Orthoptera, Diplopoda, Coleoptera, Lepidoptera larvae and Neuroptera larvae.

Herpsilochmus sellowi Whitney & Pacheco, 2000 (n = 18): stomachs contained mainly Coleoptera and Formicidae, followed by Hemiptera (Auchenorrhyncha), Orthoptera and seeds. Less representative items were Isoptera, Pseudoscorpiones, Gastropoda, Araneae and adult Lepidoptera. Specimens collected during the rainy season had a large amount of Lepidoptera larvae. Schubart *et al.* (1965) reported Orthoptera, Hemiptera and Coleoptera (small Curculionidae) in two specimens from the isolated populations of Serra do Cachimbo, Pará State.

Formicivora serrana Hellmayr, 1929 (n =17): stomach contents were fairly diverse. Most stomachs contained Coleoptera (Curculionidae, Cerambycidae and others unidentified), Isoptera, Formicidae, Orthoptera (Gryllidae), Araneae, Lepidoptera larvae and seeds. Other items recorded were Hemiptera, Hymenoptera, Coleoptera larvae, Blattaria, Pseudoscorpiones and Chilopoda. Specimens from the mountainous and Restinga populations had similar diet. The former consumed less Coleoptera and Isoptera, and more Orthoptera. Chaves & Alves (2013) analyzed fecal samples from Restinga populations and obtained similar results, except for Isoptera, one of the most consumed items recorded in our study, which was not registered by those authors.

Scytalopus speluncae (Ménétriès, 1835) (n = 5): Formicidae and Coleoptera were predominant and present in all samples. However, several other arthropods, mostly ground insects from the leaf litter substrate, were registered: Hemiptera, Isoptera, Opiliones, Diptera, Lepidoptera larvae, Coleoptera larvae, Araneae, Dermaptera, Acari and Hymenoptera.

Arremon franciscanus Raposo, 1997 (n = 2): one stomach was empty, while the other one contained mainly seeds, but also Isoptera, Formicidae (apterous), Lepidoptera larvae and Coleoptera. Stomach contents were similar to the ones of other closely related *Arremon* species, such as *A. taciturnus*, *A. semitorquatus*, and *A. flavirostris* (Schubart *et al.* 1965).

Lanio pileatus (Wied, 1821) (n = 7): stomach contents consisted mainly of Formicidae, Isoptera and seeds. Other items registered were Coleoptera, Orthoptera and Lepidoptera larvae. Stomachs contained several small stones, supposedly to crush seeds, sediment (sand) and also small leaf fragments. Schubart *et al.* (1965) reported fragments of insects and small Gramineae seeds.

Remarks on the diet of Caatinga bird species

Almost all of the Caatinga species examined had a major predominance of Isoptera, Formicidae and Coleoptera in their stomachs. This same pattern was recorded for the Silvery-Cheeked Antshrike *Sakesphorus cristatus* (Wied, 1831), which is an endemic species of the Caatinga biome (Buainain *et al.* 2015). While Formicidae and Coleoptera are frequently abundant prey types in diet studies of Neotropical birds (Gomes *et al.* 2001, Lopes *et al.* 2005, Aguiar & Coltro-Júnior 2008), Isoptera is not commonly reported in such large quantities and frequency. Nevertheless, previous studies show that these insects are important resources for vertebrates in other arid/semi-arid environments (Advani 1982, Poulin *et al.* 1994, Griffiths & Christian 1996, Gibson 2001, Cabral *et al.* 2006, Hardy & Crnkovic 2006). On the other hand, Formicidae, which is commonly reported as an important food item for birds, are crucial resources for Caatinga birds. In this biome, ants are able to maintain or increase their populations and activity during the dry season, while other insects tend to decrease them (Vasconcellos *et al.* 2010, Nunes *et al.* 2011, Medeiros *et al.* 2012). The large consumption of Lepidoptera larvae, in opposition to the lower importance of other items in several of the species examined in this study possibly follows the same pattern observed in *S. cristatus* (Buainain *et al.* 2015).

Overall, results presented here extend the importance of the main prey type discussed by Buainain *et al.* (2015) to other bird species from a variety of taxonomic group. However, further studies in other localities are needed to verify if the same pattern is observed in birds from other Caatinga areas or, alternatively, the same important prey are important only in the study area.

ACKNOWLEDGEMENTS

We thank Renner Baptista, José R. M. Mermudes and Michele Leocádio (IB, UFRJ) for helping with arthropod identification; José Simon and Alexandre Aleixo for providing the stomach contents of specimens of *Neomorphus geoffroyi*. Coordenação de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES) financially supported both authors.

REFERENCES

Advani, R. 1982. Seasonal fluctuations in the diet composition of *Rhinopoma hardwickei* in the Rashastan Desert. *Proceedings of the Indian Academy of Science*, 91: 563–568.

Aguiar, K. M. O. & Coltro-Júnior, L. A. 2008. Dietas de algumas espécies de aves das Famílias Thamnophilidae, Grallariidae e Formicariidae do Amapá. *Revista Brasileira de Ornitologia*, 16: 376–279.

Ballarini, Y.; Frizzas, M. R. & Marini, M. Â. 2013. Stomach contents of Brazilian non-passerine birds. *Revista Brasileira de Ornitologia*, 21: 235–242.

Barros, Y. M. & Marcondes-Machado, L. O. 2000. Comportamento alimentar do Periquito-da-caatinga *Aratinga cactorum* em Curaçá, Bahia. *Ararajuba*, 8: 55–59.

Bodrati, A. N. 2012. Huevos y aspectos reproductivos del Caraguatero (*Myrmorchilus strigilatus*) en el chaco argentino. *Nuestras Aves*, 57: 23–24.

Borror, D. J.; Triplehorn, C. A. & Johnson, N. F. 1989. *An introduction to the study of insects*. New York: Saunders College Publishing.

Buainain, N.; Gaspar, M. L. & Assis, C. P. 2015. 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. *Revista Brasileira de Ornitologia*, 23: 405–416.

Cabral, J. C.; Granzinolli, M. A. M. & Motta-Junior, J. C. 2006. Dieta do Quiriquiri, *Falco sparverius* (Aves: Falconiformes), na Estação Ecológica de Itirapina, SP. *Revista Brasileira de Ornitologia*, 14: 393–399.

Chapman, A. & Rosenberg, K. 1991. Diet of four sympatric Amazonian wodcreepers (Dendrocolaptidae). *Condor*, 93: 904–915.

Chaves, F. G. & Alves, M. A. S. 2013. Gender-related diet composition and morphometry of the Restinga Antwren, *Formicivora littoralis* (Aves: Thamnophilidae). Zoologia, 30: 601–606.

Costa, C.; Ide, S. & Simioka, C. E. 2006. *Insetos imaturos, metamorfose e identificação*. Ribeirão Preto: Editora Holos.

Costa-Pereira, R.; Severo-Neto, F.; Inforzato, I.; Laps, R. R. & Pizo, M. A. 2015. Nutrients drive termite nest geophagy in Yellow-chevroned Parakeets (*Brotogeris chiriri*). *Wilson Journal of Ornithology*, 127: 506–510.

Durães, R. & Marini, M. Â. 2005. A quantitative assessment of bird diets in the Brazilian Atlantic forest, with recommendations for future diet studies. *Ornitología Neotropical*, 16: 65–83.

Gibson, L. A. 2001. Seasonal changes in the diet and food availability of the Greater Bilby (*Macrotis lagotis*) in south-western Queensland. *Wildlife Research*, 28: 121–134.

Gomes, V. S. M.; Alves, V. S. & Ribeiro, J. R. I. 2001. Itens encontrados em amostras de regurgitação de *Pyriglena leucoptera* (Vieillot) (Aves, Thamnophilidae) em uma floresta secundária no estado do Rio de Janeiro. *Revista Brasileira de Zoologia*, 18: 1073–1079.

Griffiths, A. D. & Christian, K. A. 1996. Diet and habitat use of frillneck lizards in a seasonal tropical environment. *Oecologia*, 106: 39–46.

Hardy, L. M. & Crnkovic, A. C. 2006. Diet of amphibians and reptiles from the Engare Ondare River region of central Kenya, during the dry season. *African Journal of Herpetology*, 55: 143–159.

Hempel, A. 1949. Estudo da alimentação natural das aves silvestres do Brasil. *Arquivos do Instituto Biológico*, 19: 237–268.

Kirwan, G. M.; Mazar-Barnett, J. & Minns, J. 2001. Significant ornithological observations from the Rio São Francisco Valley, Minas Gerais, Brazil, with notes on conservation and biogeography. *Ararajuba*, 9: 145–161.

Kupriyanov, V. M. S.; Daza, J. D., Bauer, A. M.; Gaban-Lima, R.; Rocha-Brito, G. R. & Höfling, E. 2012. Six species of Amazonian woodcreepers (Aves: Dendrocolaptidae) preying upon lizards and frogs. *Journal of Natural History*, 46: 2985–2997.

Lopes, L. E.; Fernandes, A. M. & Marini, M. Â. 2005. Diet of some Atlantic Forest birds. *Ararajuba*, 13: 95–103.

Manhães, M. A.; Loures-Ribeiro, A. & Dias, M. M. 2010. Diet of understorey birds in two Atlantic Forest areas of southeast Brazil. *Journal of Natural History*, 44: 469–489.

Medeiros, J.; Araújo, A.; Araújo, H. F. P.; Queiroz, J. P. C. & Vasconcellos, A. 2012. Seasonal activity of *Dinoponera quadriceps* Santschi (Formicidae: Ponerinae) in the semi-arid Caatinga of northeastern Brazil. *Revista Brasileira de Entomologia*, 56: 81–85.

Moojen, J.; Carvalho, J. & Lopes, H. S. 1941. Observações sobre o conteúdo gástrico de aves brasileiras. *Memórias do Instituto Oswaldo Cruz*, 36: 405–444.

Nunes, F. A.; Segundo, G. B. M.; Vasconcelos, Y. B.; Azevedo, R. & Quinet, Y. 2011. Ground-foraging ants (Hymenoptera: Formicidae) and rainfall effect on pitfall trapping in a deciduous thorn woodland (Caatinga), northeastern Brazil. *Revista de Biología Tropical*, 59: 1637–1650.

Pelzeln, A. von. 1871. *Zur Ornithologie brasiliens: Resultate von Johann Natterers Reisen in den Jahren 1817 bis 1835.* Viena: A. Pichler's Witwe & Sohn.

Poulin, B.; Lefebvre, G. & McNeil, R. 1994. Diet of land birds from northeastern Venezuela. *Condor*, 96: 354–367.

Rafael, J. A.; Melo, G. A. R.; de Carvalho, C. J. B.; Casari, S. A. & Constantino, R. 2012. *Insetos do Brasil: diversidade e taxonomia.* Ribeirão Preto: Editora Holos.

Ralph, C. P.; Nagata, S. E. & Ralph, J. C. 1985. Analysis of droppings to describe diets of small birds. *Journal of Field Ornithology*, 56: 165–174.

Remsen, J. V.; Schmitt, G. C. & Schmitt, D. C. 1988. Natural history of some poorly known Bolivian birds, part 3. *Gerfaut*, 78: 178–192.

Schubart, O.; Aguirre, A. C. & Sick, H. 1965. Contribuição para o conhecimento da alimentação das aves brasileiras. *Arquivos de Zoologia*, 12: 95–249.

Sick, H. 1953. *Tapera*, *Dromococcyx*, *Neomorphus*, hábitos. *Revista Brasileira de Biologia*, 13: 145–168.

Teixeira, D. M. 1992. Sobre a biologia da "Maria-macambira", *Gyalophylax hellmayri* (Reiser, 1905) (Aves, Furnariidae). *Iheringia, Série Zoologia*, 72: 141–146.

Teixeira, D. M.; Nacinovic, J. B. & Luigi, G. 1989. Notes on some birds of northeastern Brazil. *Bulletin of the British Ornithologists' Club*, 109: 152–l57.

Vasconcelos, M. F.; Lopes, L. E. & Hoffmann, D. 2007. Dieta e comportamento de forrageamento de *Oreophylax moreirae* (Aves: Furnariidae) na Serra do Caraça, Minas Gerais, Brasil. *Revista Brasileira de Ornitologia*, 15: 439–442.

Vasconcellos, A.; Andreazze, R.; Almeida, A. M.; Araujo, H. F. P.; Oliveira, E. S. & Oliveira, U. 2010. Seasonality of insects in the semi-arid Caatinga of northeastern Brazil. *Revista Brasileira de Entomologia*, 54: 471–476.

Whitney, B. M. & Pacheco, F. 1994. Behavior and vocalizations of *Gyalophylax* and *Megaxenops* (Furnariidae), two little-known genera endemic to northeastern Brazil. *Condor*, 96: 559–565.

Associate Editor: Caio G. Machado.

APPENDIX I

Qualitative and quantitative descriptions of all samples examined. Abbreviations of prey types: Acari (Aca.), Araneae (Ara.), Blattaria (Bla.), Chilopoda (Chi.), Coleoptera (Col.), Dermaptera (Der.), Diplopoda (Dip.), Diptera (Dipt.), Formicidae (For.), Gastropoda (Gas.), Hemiptera (Hem.), Hymenoptera (Hym.), Lepidoptera (Lep.), Isoptera (Iso.), Neuroptera (Neu.), Odonata (Odo.), Opiliones (Opi.), Orthoptera (Ort.), Pseudoscorpione (Pse.), Scorpiones (Sco.).

Psittacidae - *Aratinga cactorum* (Cactus Parakeet), São Félix do Coribe, Bahia/XI-2010 = MNA 8180: soil fragments, seeds or fruit pulp fragments, stones; Inhuporanga, Ceará/III-1990 = MNA 6809: soil fragments, seeds or fruit pulp fragments, stones.

Cuculidae - *Neomorphus geoffroyi* (Rufous-vented Ground-cuckoo), REBIO de Sooterama, Espírito Santo = I-2007, MNA 5536: 28 Ara., 2 Opi., 8 Ort., 2 Chi., 2 Col.; Floresta da Companhia Vale do Rio Doce (CVRD), Buricicupu, Maranhão/IX-1985 = MPEG A5607: 4 Ort., 1 Chi., 6 Col., 6 For., 1 Hem., 1 Lep. larva, 2 Iso.

Picidae - *Picumnus pygmaeus* (Spotted Piculet), São Félix do Coribe, Bahia/IV-2010 = MNA 5330: 71 Iso., 5 For., 1 Col., MNA 5339: 65 Iso., 2 For., 2 Col., 22 Col. larvae, 1 Hem., MNA 5346: 156 Iso., 5 For., 2 Col., 1 Col. larvae, MNA 5347: 232 Iso., 4 For., MNA 5351: 87 Iso., 5 For., 1 Col., 1 Col. larva, 1 Hem., 1 Pse., MNA 6500: 94 Iso., 4 For., 5 Col. larvae, MNA 6501: 53 Iso., 1 For., 2 Col., MNA 6547: 25 Iso., 3 For., 3 Col., 1 Col. larvae; São Félix do Coribe, Bahia/XI-2010 = MNA 7443: 4 Iso., 9 For., 1 Col., 1 Lep. larvae, MNA 7683: 2 Iso., 1 Col. larvae, 15 Lep. larvae, MNA 7684: 5 Iso., 2 For., 1 Col., 1 Col. larvae

Furnariidae - *Megaxenops parnaguae* (Great Xenops), São Félix do Coribe, Bahia/IV-2010 = MNA 5238: 44 Iso., 7 For., 2 Col., 1 Col. larvae, 3 Ort., MNA 5263: 13 Iso., 9 For., 2 Col., 2 Ort., MNA 5269: 65 Iso., 9 For., 3 Col., 3 Ort., MNA 6300: 214 Iso., 3 For., 1 Col., 2 Ort., MNA 6426: 16 Iso., 2 For., 4 Col., 1 Ort., MNA 6503: 43 Iso., 1 Hym., 6 Ort., MNA 6526: 9 Iso., 5 For., 3 Col., 4 Lep. larvae, 2 Ort., MNA 6537: 6 Iso., 2 For., 1 Col., 1 Lep. larvae, 2 Ort., 1 Ara, 1 Chi., 20 seeds, MNA 6541: 2 Iso., 4 For., 3 Col., 1 Hem., 3 Ort., MNA 6705: 288 Iso., 31 For. (21 pupae), 4 Col., 1 Ara., MNA 6708: 10 Iso., 2 For., 2 Col., 1 Ort., MNA 6714: 43 Iso., 3 For., 3 Col., 1 Lep. larvae, 3 Ort.; São Félix do Coribe, Bahia/XI-2010 = MNA 7027: 4 Iso., 2 For., 1 Col., 2 Lep. larvae, MNA 7029: 1 Iso., 1 For., 1 Col., 1 Lep. larvae, 1 Odo., MNA 7041: 58 Iso., 1 Hym., 1 Col. larvae, 9 Lep. larvae, 1 Neu., MNA 7031: 12 Iso., 6 Col., 11 Lep. larvae, 1 Ort., MNA 7038: 3 Iso., 4 For., 2 Col., 4 Lep. larvae, MNA 7042: 1 For., 1 Col., 4 Lep. larvae, MNA 7400: 2 Col., 6 Lep. larvae; São Félix do Coribe, Bahia/IV-2011 = MNA 7201: 11 Iso., 7 For., 3 Col., 4 Ort., MNA 7202: 5 Iso., 4 For., 2 Col., 1 Col. larvae, 3 Ort., MNA 7263: 2 Iso., 7 For., MNA 7403: 45 Iso., 16 For., 1 Col., 1 Col. larvae, 1 Lep. larvea, 2 Ort.

Synallaxis hellmayri (Red-shouldered Spinetail), São Félix do Coribe, Bahia/IV-2010 = MNA 5201: 79 Iso., 3 For., 1 Col., 5 seeds, MNA 5271: 88 Iso., 10 For., 1 Col., 1 Col. larvae, 7 seeds, MNA 5365: 78 Iso., 4 For., 5 Col., 3 Lep. larvae, 6 seeds, MNA 5376: 224 Iso., 2 Col., 1 Lep. larvae, 2 Ara., 1 seed, MNA 6446: 2 For., 1 Lep. larvae, 1 Hem., 1 Ort., 1 seed, MNA 6492: 60 Iso., 5 For., 4 Col., 8 seeds, MNA 6495: 159 Iso., 10 For., 2 Col., 1 Lep., 22 seeds, MNA 6718: 35 Iso., 32 For., 1 Col., 1 Lep. larvae, 6 seeds, MNA 6719: 220 Iso., 6 For., 2 Col., 1 Col. larvae, 1 Ort., 1 Ara., 5 seeds, MNA 7256: 66 Iso., 3 For., 5 Col., 4 seeds, MNA 7260: 48 Iso., 1 For., 1 Col., 9 seeds; São Félix do Coribe, Bahia/XI-2010 = MNA 7505: 8 Iso., 13 Lep. larva, 1 Ort., 4 seeds. MNA 7506: 1 Col., 1 Col. larva, 16 Lep. larvae, 1 Ort., 2 Ara., 1 Neu. larva 1 seed.

Thamnophilidae - *Formicivora serrana* (Serra Antwren), Santana do Deserto, Minas Gerais/II-2014 = MN 50577: 1 Ort., MN 50580: 1 Lep. larva, 1 Hem., 4 Col., 3 Ort., 2 For.; Viçosa, Minas Gerais/III-2014 = MN 50578: 1 Lep. larva, 1 Hem., 1 Col., 2 Ort., 1 Pse., MN 50582: 4 Col., 1 Ort., 1 Ara., 1 seed, 4 Hym., MN 50587: 1 Lep. larva, 4 Col., 1 Ort., 4 For.; Ipatinga, Minas Gerais/III-2014 = MN 50581: 1 Lep. larva, 1 Col. larva, 1 Col., 3 Ort., 4 Ara., 10 For., 1 Iso., 10 seeds, MN 50584: 1 Ort., 1 Ara., 1 For., 14 Iso., 1 Pse., 1 seed, MN 50588: 1 Ort., 1 Ara., 2 For.; Praia de Tucuns, Armação dos Búzios, Rio de Janeiro/III-2014 = MN 50579: 1 Lep. larva, 5 Col., 2 Ara., 1 For., 1 Iso., MN 50582: 1 Lep. larva, 1 Hem., 3 Col., 2 Ort., 3 For., MN 50583: 1 Lep. larva, 1 Ort.; Ilha de Cabo Frio, Arraial do Cabo, Rio de Janeiro/I-2015 = MN 50136: 1 Lep. larva, 7 Col., 1 Ort., 2 For., 21 Iso., MN 50138: 7 Col., 1 Ort., 1 Ara., 5 For., 2 Iso., 1 Chi., MN 50139: 2 Lep. larva, 1 Hem., 16 Col., 1 Ort., 3 For., 8 Iso., MN 50140: 3 Lep. larvae, 2 Col. larva, 3 Col., 1 Ort., 2 Ara., 5 For., 23 Iso., 1 Hym., 2 Bla., MN 50141: 6 Col., 1 Ort., 1 Ara., 5 For., 4 Iso., MN 50142: 2 Hem., 15 Col., 1 Ara., 1 For.

Myrmorchilus strigilatus (Stripe-backed Antbird), São Félix do Coribe, Bahia/IV-2010 = MNA 5247: 10 Iso., 6 For., 1 Col., MNA 5248: 11 Iso., 36 For., MNA 5261: 51 Iso., 25 For., 2 Col., 1 Lep. larva, MNA 5276: 148 Iso., 7 For., 4 Col., MNA 5313: 9 Iso., 11 For., 1 Col., MNA 5318: 64 Iso., 137 For., 3 Col., 1 Pse.; São Félix do Coribe, Bahia/XI-2010 = MNA 7259: 35 Iso., 9 For., 2 Col., 6 Lep. larvae, 1 Chi., 1 Ort.; São Félix do Coribe, Bahia/IV-2011 = MNA 6900: 117 Iso., 60 For., 6 Col., 1 Hym., MNA 7261: 57 Iso., 41 For., 3 Col., 1 Lep.

Herpsilochmus sellowi (Caatinga Antwren), São Félix do Coribe, Bahia/IV-2010 = MNA 6483: 6 Col., 1 Ort., 5 For., 1 Lep., MNA 6484: 3 Col., 2 Ort., MNA 6485: 1 Hem., 5 Col., 8 For., MNA 6512: 1 Col., MNA 6514: 6 Col., 1 Ort., 6 For., MNA 6518: 1 Col., 1 Ort., 1 For., MNA 6521: 1 Lep. larva, 1 Hem., 4 Col., 2 Ort., 6 For., MNA 6523: 8 Col., 1 For., 14 seeds, MNA 6532: 1 Lep. larva, 2 Hem., 4 Col., 1 Ort., 5 For., MNA 6546: 1 Hem., 5 Col., 1 Ort., 1 Hym.; São Félix do Coribe, Bahia/XI-2010 = MNA 8481: 3 Lep. larvae, 6 Hem., 1 Gas., 5 Col., 1 Ort., MNA 8483: 8 Lep. larvae, 3 Hem., 10 Col., 1 Ara., 1 For., 1 Lep., MNA 8484: 2 Lep. larvae, 1 Hem., 3 Col., MNA 8485: 8 Lep. larvae, 1 Hem., 2 Col., 2 Ara., 2 For., MNA 8487: 4 Lep. larvae, 3 Hem., 2 Col., 1 Ort., 1 Iso., MNA 8489: 4 Lep. larvae, 2 Hem., 1 Col., MNA 8493: 11 Lep. larvae, 3 Hem., 4 Col., 3 For., 1 Pse.; São Félix do Coribe, Bahia/IV-2011 = MNA 6734: 5 Col., 47 For., 7 Iso.

Grallariidae - *Hylopezus ochroleucus* (White-browed Antpitta), São Félix do Coribe, Bahia/IV-2011 = MNA 7262: 26 Iso., 17 For., 4 Col., 1 Chi., MNA 7504: 30 Iso., 8 For., 7 Col., 2 Col. larvae, 1 Hem., 1 Ara., 1 seed; Catolândia, Bahia/VI-2013 = MNA 50315: 169 Iso., 8 For., 1 Neu. larva, 1 Dip., 1 Lep. larva, 3 Sco., 2 Ort., 4 Col., 1 Ara.

Rhinocryptidae - *Scytalopus speluncae* (Mouse-coloured Tapaculo), RPPN Santa Bárbara do Caraça, Santa Bárbara, Minas Gerais/III-2008 = MNA 4310: 28 For., 1 Iso., 7 Hem., 2 Col., 1 Ort., 1 Lep. larva, 1 Col. larva., 1 Ara., 1 Der., 1 Hym, 1 veg. material (Bryophyta), MNA 4311: 1 For., 1 Hem., 2 Col., 1 Ort., MNA 4312: 16 For., 6 Iso., 2 Hem., 3 Col., 1 Ort., MNA 4554: 1 For., 4 Col., 1 Ara., 1 Aca., 2 Dipt.; RPPN Santa Bárbara do Caraça, Santa Bárbara, Minas Gerais/VI-2008 = MNA 4555: 3 For., 3 Iso., 1 Hem., 3 Col., 1 Lep. larva, 1 Col. larva, 7 Opi.

Emberizidae - *Coryphospingus pileatus* (Pileated Finch), São Félix do Coribe, Bahia/IV-2010 = MNA 5207: 13 For., 1 Lep. larva, 10 seeds, MNA 5259: 16 Iso., 52 For., 3 Col., 2 seeds, stones, sand, MNA 5331: 49 Iso., 13 For., 1 Lep. larva, 2 Col., 5 seeds, MNA 5340: 35 For., 1 Col., 4 seeds, stones, MNA 5363: 2 Iso., 17 For., 1 Lep. larva, 1 Col., stones; São Félix do Coribe, Bahia/XI-2010 = MNA 3482: 3 Iso., 2 For., 1 Ort., 2 Col., stones, sand, leaf fragments, MNA 8190: 6 Lep. larvae, 3 Col.

Passerellidae - *Arremon franciscanus* (São Francisco Sparrow), Caetité, Bahia/II-2009 = MNA 8252: 6 Iso., 3 For., 2 Lep. larvae, 3 Col., 34 seeds; São Felix do Coribe, Bahia/iv-2010, MNA 5315: empty.

Revista Brasileira de Ornitologia, 24(2), 137-167
June 2016

ARTICLE

Birds from Cáceres, Mato Grosso: the highest species richness ever recorded in a Brazilian non-forest region

Leonardo Esteves Lopes[1,8], João Batista de Pinho[2], Aldo Ortiz[2], Mahal Massavi Evangelista[3], Luís Fábio Silveira[4,6], Fabio Schunck[4,5,6] and Pedro Ferreira Develey[7]

[1] Laboratório de Biologia Animal, Instituto de Ciências Biológicas e da Saúde, Universidade Federal de Viçosa, Campus Florestal, Rodovia LMG 818, km 6, s/n, CEP 35690-000, Florestal, MG, Brazil.
[2] Núcleo de Estudos Ecológicos do Pantanal, Instituto de Biociências, Universidade Federal de Mato Grosso, Avenida Fernando Corrêa da Costa, s/n, Boa Esperança, CEP 78060-900, Cuiabá, MT, Brazil.
[3] Faculdade de Ciências Biólogicas, Universidade de Cuiabá, Rua Manoel José de Arruda, 3100, Jardim Europa, CEP 78065-900, Cuiabá, MT, Brazil.
[4] Museu de Zoologia, Universidade de São Paulo, Avenida Nazaré, 481, Ipiranga, CEP 04263-000, São Paulo, SP, Brazil.
[5] Comitê Brasileiro de Registros Ornitológicos-CBRO, Brazil.
[6] Pós-Graduação, Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Rua do Matão, Travessa 14, 101, Cidade Universitária, CEP 05508-090, São Paulo, SP, Brazil.
[7] Sociedade para a Conservação das Aves do Brasil - SAVE, Rua Fernão Dias, 219 cj. 2, Pinheiros, CEP 05427-010, São Paulo, SP, Brazil.
[8] Corresponding author: leo.cerrado@gmail.com

Received on 30 January 2016. Accepted on 04 April 2016.

ABSTRACT: The municipality of Cáceres. Mato Grosso state, Brazil, lies in a contact zone between three semi-arid to arid ecoregions: the Chiquitano Dry Forests, the Cerrado and the Pantanal. In spite of being one of the best sampled non-forest sites for birds in Brazil, with thousands of specimens collected, no paper to date has ever compiled the information available for the region. In this paper, we present a checklist of the avifauna of Cáceres, gathering the historical data available together with our own unpublished observations during a series of expeditions to the region. During our fieldwork we recorded 374 species to the region. The analysis of literature data and museum specimens rises to 446 the number of species ever recorded in the municipality, 362 (81.2%) of which were documented with specimens. This is by far the highest bird species richness recorded for a non-forest site in Brazil.

KEY-WORDS: bird inventory, Cerrado, Chiquitano Dry Forest, Neotropics, Pantanal.

INTRODUCTION

A corridor of seasonally dry and predominantly non-forested areas extends from northwestern Argentina to northeastern Brazil, the so-called "diagonal of open formations" (Vanzolini 1976, Werneck 2011). This region is poorly sampled for birds (Silva 1995, Tubelis & Tomas 2003) and includes the Chaco, Pantanal, Cerrado and Caatinga biogeographic domains. Historical bird surveys in this region are scarce, because large portions of it were difficult to access during the 19th Century or even in the first half of the 20th Century. Therefore, much of what is known about the avifauna of these non-forested domains, especially in the Brazilian territory, results from modern bird surveys. An exception to this rule is the municipality of Cáceres, Mato Grosso state, which has been explored by several expeditions devoted to natural history studies. Nevertheless, in spite of being one of the best sampled sites of central-western Brazil, the extensive historical collections performed in Cáceres have never been subject to revision and critical analysis. In this paper, we present a checklist of the avifauna of Cáceres, gathering the historical data available together with our own unpublished observations during a series of expeditions to the region. We also present comments on the noteworthy species recorded.

METHODS

Study area

The study area was defined as the political boundaries of the municipality of Cáceres, adopting the political division in effect since 2008. Founded on the 18th Century with the name of "Villa Maria do Paraguay", Cáceres was once an enormous municipality that encompassed extensive areas in western Mato Grosso. Cáceres was subsequently subdivided in other municipalities (Ferreira 1997), until reaching the present day extension of about

24,350 km^2 and almost 88,000 inhabitants (IBGE 2015). Extensive cattle ranching has been the most traditional economic activity in the municipality, with historical records indicating that large farms, one of them with about 60,000 cattle heads, were present as early as 1827 (Florence 1977). Nowadays, cattle raising is still one of the most important economic activities in Cáceres, which harbors almost one million heads of stock. Agriculture (*e.g.*, cassava, sugar cane, soybean, corn, rubber tree and banana), aquaculture (indigenous fishes) and recreational fishing are also important economic activities (Ferreira 1997, IBGE 2015).

The climate is tropical with dry winter, Aw according to the Köppen climate classification system, with well-marked dry and rainy seasons (Alvares *et al.* 2014). The mean annual rainfall is 1250 mm, with rains falling from October to May, and the dry period lasts four months, from June to September (Nimer 1979). Mean annual temperature is 24°C, and September is the hottest month (maximal mean is 34°C), but with maximum temperatures often over 40°C (Nimer 1979). June and July are the coldest months, with minimal mean temperature below 20°C (Nimer 1979), but strong cold waves ("friagens") can eventually drop temperatures as low as 0°C (Willis 1976).

The southern half of Cáceres is located in the Pantanal region, the world's largest wetland, and is subject to seasonal flooding (Por 1995). Flooding starts on January and water level quickly reaches a peak from February to April, slowly decreasing (runoff) from May to August (Hamilton *et al.* 1996). From September to December, water level is relatively constant at their lowest value, exposing sand beaches used for nesting birds and freshwater turtles along the Rio Paraguai (Hamilton *et al.* 1996). Note that the dry season (June to September) does not agree with the low-water period (September to December) (Alho 2008).

Cáceres is a very interesting region from the biogeographic point of view, because it lies in a contact zone between three semi-arid to arid ecoregions: the Chiquitano Dry Forests, the Cerrado and the Pantanal (Olson *et al.* 2001). A marked Amazonian influence is observed in the forests along the Rio Paraguai, Rio Jauru and Rio Sepotuba (von Pelzeln 1868–1870, Willis 1976), and a slight Chacoan influence is also noted along the Brazilian border with Bolivia (IBGE 2004). The southwestern portion of Cáceres is an Important Bird and Biodiversity Area - IBA MT-09 (Luca *et al.* 2009).

Fieldwork in the study area was conducted in six sites, which are described below, all of them in the Pantanal. LEL also briefly visited the city of Cáceres on the morning of 28 August 2009, conducting limited fieldwork on the riparian forests along the Rio Paraguai.

Fazenda Baía de Pedra (16°28'S; 58°08'W, 110 m a.s.l.): an early 20th Century farm with disturbed semideciduous to deciduous forests, seasonally flooded

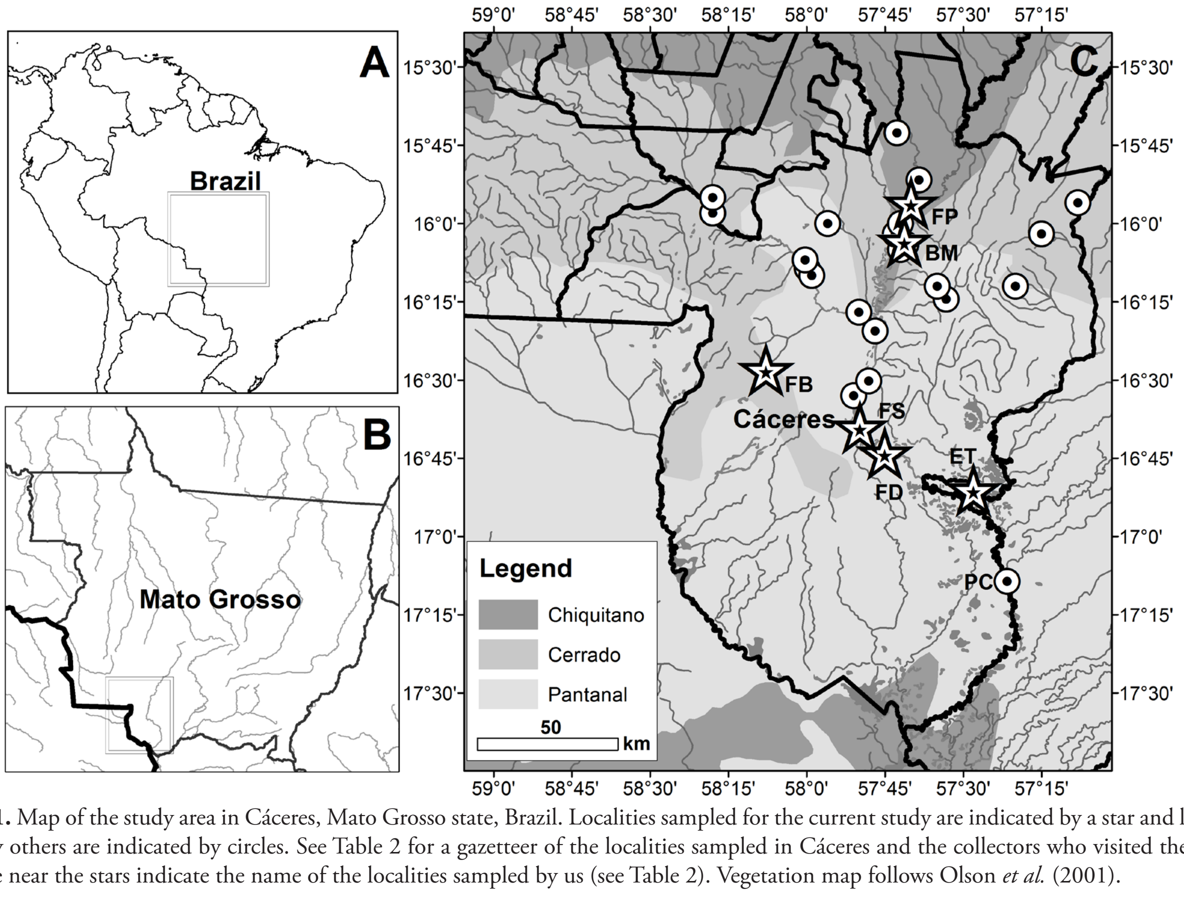

FIGURE 1. Map of the study area in Cáceres, Mato Grosso state, Brazil. Localities sampled for the current study are indicated by a star and localities sampled by others are indicated by circles. See Table 2 for a gazetteer of the localities sampled in Cáceres and the collectors who visited them. Two letters code near the stars indicate the name of the localities sampled by us (see Table 2). Vegetation map follows Olson *et al.* (2001).

savannas and grasslands, planted pastures, permanent marshes and small ponds. Extensive bamboo thickets (*Guadua* sp.) are found along roadsides and other disturbed areas. Gallery forests are absent. Data on the floristic composition of a cerrado patch in this site was presented by Lima-Jr. *et al.* (2008), and notes on the aquatic macrophytes found in Porto Limão, a nearby site, were presented by Silva & Carniello (2007). Visited by JBP, LEL, AO, and field assistants from 17–25 February 2008 (when the area was flooded) and from 22–30 August 2008 (beginning of the low-water period).

Fazenda Descalvados (16°44'S; 57°45'W, 110 m a.s.l.): a 19th Century farm on the right bank of the Rio Paraguai, with deciduous forests, artificial pastures, cultures, marshes and gallery forests. This farm was one of the biggest farms in Brazil, with more than 800,000 ha and a livestock of 300,000 heads of stock (Arruda 1938). Visited by LFS and FS from 1–9 September 2007, with some few noteworthy records published elsewhere (Vasconcelos *et al.* 2008). This locality has been previously visited by several other collectors in historical times (see below).

Fazenda Santo Antônio das Lendas (16°39'S; 57°50'W, 145 m a.s.l.): most part of the original semi-deciduous dry forest in this site was replaced by artificial pastures for cattle raising. The seasonally flooded lowlands are still preserved with patches of flooded forests and grasslands with Caranda Palms (*Copernicia alba*). Complementary surveys were carried out in the gallery forest of Rio Paraguai. Visited by PD from 17 to 28 November 1997, with some few opportunistic observations in the city of Cáceres published elsewhere (Tubelis & Tomas 2003).

Estação Ecológica de Taiamã (16°52'S; 57°28'W, 100 m a.s.l.): this conservation unit is located in an island in the Rio Paraguai, with an area of about 11,200 ha. Visited by MME on 19 and 20 August 2008.

Baía dos Malheiros (16°03'20''S; 57°41'16''W, 120 m a.s.l.): a small patch of riparian forest on the left bank of the Rio Paraguai. The area was visited weekly by MME from January to November 2002 and during one week in June 2008.

Fazenda Paraguatatuba (15°56'S; 57°40'W, 135 m a.s.l.): located along the road BR-174, km 14, at the confluence between Rio Sepotuba and Rio Paraguai. This farm is about 2500 ha, half of these covered by native vegetation and the other half covered by exotic Teak Tree (*Tectona grandis*) plantation. Sampled habitats included temporary lakes, marshes, seasonally flooded riparian forest, semideciduous forests, savannas and grasslands. Fieldwork was performed by MME during field trips to the area, each one lasting three days. The area was visited on January, February and March 2006/2007, April and May 2006/2007 and July, August and September 2006.

Sampling

Fieldwork took place during a series of expeditions with different purposes, what explain the lack of standardization of field methods. Observations with binoculars and recorders were conducted in all expeditions. Bird vocalizations were recorded with shotgun microphones Sennheiser ME-66 and ME-67, and a K7 recorder Sony TCM-5000 or a Mini Disc recorder Sony MZ-NH1.

In Fazenda Baía de Pedra, we conducted mist-net captures along five mist net lines (25 nets per line) settled 1 km apart one from another. Each mist net line was sampled once in each field campaign. Nets (10 m length × 2.5 m tall, mesh 32 mm) were opened from 06: h to 10:00 h, in a total netting effort of about 37,500 m^2.h. Habitats sampled covered all the main phytophysiognomies found in the area. We also conducted point count censuses along the same lines used for mist net captures. Three points per line, 125 m apart one from another, were censused once during 10 min in each field campaign, in a total effort of 450 min. All birds heard or seen were recorded. Point censuses and mist net captures were not conducted simultaneously in the same line. Specimens were collected using mist nets, airguns and shotguns, taxidermized and their carcasses preserved in 70% ethanol, being deposited in DZUFMG and UFMT (see Table 1 for the full name and location of the institutions cited along the text).

In Fazenda Santo Antônio das Lendas we conducted *ad libitum* observations and recording the vocalization of most species in the area. Mist nets (12.8 × 2.1 m, mesh size 32 mm) were also used, in a total netting effort of about 5200 m^2.h.

In Fazenda Descalvado, we conducted observations, recording of vocalizations, collection with shotguns and capture with mist-nets (20 nets, 12 × 2.75 m, mesh size 32 mm), opened from 06:00 h to 11:00 h, in a total netting effort of about 6000 m^2.h. All netted birds were photographed and all voucher material (specimens, photographs and recordings) was deposited in MZUSP.

In Estação Ecológica Taiamã, the entire length of the island was surveyed by boat on the morning of the first day of fieldwork. On the following day, riparian forests, marshes and two small lakes were surveyed. Total sampling effort in this area was 11 h.

In Baía dos Malheiros, in addition to observations with binoculars and recordings (575 h of observation), mist net captures (10 nets, 12 × 2.75 m, mesh size 36 mm) were conducted during a brief campaign on June 2008, in a total netting effort of about 5300 m^2.h.

In Fazenda Paraguatatuba, visual censuses were conducted in all habitat types, in a total effort of 80 h of observation. This method was complemented with mist net captures (9 nets, 12 × 2.75 m, mesh size 36 mm), in a total netting effort of about 3200 m^2.h.

TABLE 1. Institutions cited in the text and their acronyms.

Acronym	Institution
AMNH	American Museum of Natural History, New York, USA
ANSP	Academy of Natural Sciences of Philadelphia, Philadelphia, USA
BMNH	The Natural History Museum, Tring, UK
CG	Coleção Rolf Grantsau, São Bernardo do Campo, Brazil
DMNS	Denver Museum of Nature and Science, Denver, USA
DZUFMG	Centro de Coleções Taxonômicas, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
FMNH	Field Museum of Natural History, Chicago, USA
MBML	Museu de Biologia Professor Mello Leitão, Santa Teresa, Brazil
MNHN	Muséum National d'Histoire Naturelle, Paris, France
MNRJ	Museu Nacional, Rio de Janeiro, Brazil
MZSUP	Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil
NMW	Naturhistorisches Museum, Vienna, Austria
ROM	Royal Ontario Museum, Toronto, Canada
SMF	Senckenberg Museum, Frankfurt am Main, Germany
UFMT	Universidade Federal de Mato Grosso, Cuiabá, Brazil
UMMZ	University of Michigan Museum of Zoology, Ann Arbor, USA
USNM	National Museum of Natural History, Washington DC, USA
YPM	Yale University Peabody Museum, New Haven, USA
ZUEC	Museu de Zoologia Professor Adão José Cardoso, Universidade de Campinas, Campinas, Brazil

The history of scientific exploration in Cáceres was reviewed by means of consultation to the literature and museum collections. The ornithological gazetteer of Brazil (Paynter-Jr. & Traylor-Jr. 1991) was particularly helpful on the identification of key references and collections harboring specimens from Cáceres. An earlier compilation of the birds of Mato Grosso (Naumburg 1930) and a review on the itinerary of the Natterer's expedition (Vanzolini 1993) were also useful. We visited the following institutions while preparing this paper: AMNH, ANSP, BMNH, CG, DZUFMG, FMNH, MNRJ, MNW, MZUSP, UFMT, USNM and SMF. Nevertheless, our visits have other purposes, and we were not able to personally examine the majority of the specimens cited in this paper.

We checked for specimens collected in Cáceres in the Ornis (http://www.ornisnet.org, accessed on December 2014) and SpeciesLink (http://splink.cria.org.br, accessed on February 2015), two data portal that congregates information about museum specimens. We also checked for records obtained in Cáceres in the WikiAves (http://www.wikiaves.com.br, accessed on 25 August 2016), a website dedicated to birdwatchers that provides tools for the online publication of images and sounds of the Brazilian birds.

All species with published records or with specimens housed in museums or photo archives were included in this paper, but records were not accepted without a critical scrutiny. Species with available records to the area were allocated in one of three lists. The Main List includes those species with documental evidence or well known to occur in the region. The Secondary List includes those species that probably occur in the study area, but for which we are not sure about the reliability of the records available. The Tertiary List includes species with published records for the study area, but whose documental evidence is invalid or its occurrence in the area in unlikely. We inferred the probability of occurrence of a species in the area based on its known range, habitat used, and on more than 20 years of field work in Mato Grosso state.

RESULTS

Brief history of ornithological exploration

Several naturalists and collectors visited the municipality of Cáceres during the 19th and 20th Centuries, gathering a huge number of skins in the area. Although part of this material has been studied by previous authors (*e.g.*, von Pelzeln 1868–1870, Ménégaux 1917, Naumburg 1930, Stone & Roberts 1934), many specimens are still waiting for study in the drawers of natural history museums. Here we present a brief summary of the collectors who visited Cáceres, the collection stations sampled, and the period worked in the area, as well as the destination of the material collected. Geographical coordinates and elevation for each of these localities are presented in a gazetteer (Table 2).

TABLE 2. Gazetteer of the localities sampled for the current study and earlier collectors in the municipality of Cáceres. Some geographical coordinates differ slightly from that presented by traditional sources (*e.g.* Paynter-Jr. & Traylor-Jr. 1991), but the coordinates presented here are more accurate. All geographical coordinates are south of the Ecuador and western of Greenwich. Elevations are in meters above sea level.

Code	Locality	Geographical coordinates and elevation a.s.l.	Alternative names	Collectors
AR	Access road to Cáceres	Many		Mello & Santos Filho
BM	Baía dos Malheiros	16°03'20''; 57°41'16'', 120 m		This study
CA	Cambará	16°33'; 57°51', 110 m	Cambará, Xarayes Swamp	Garlepp, Mocquerys
CC	City of Cáceres	16°04'; 57°41', 125 m	Villa Maria, São Luiz de Cáceres	Natterer, Ruschi
ET	Estação Ecológica de Taiamã	16°52'; 57°28', 100 m	Reserva Taiamã, Fazenda Taiamã	Mattos
FB	Fazenda Baía de Pedra	16°28'S; 58°08', 110 m		This study
FC	Fazenda Caiçara	16°05'; 57°42', 115 m	Caissara, Cahyssara, Fazenda do Rey, Fazenda Nacional da Caiçara	Natterer
FD	Fazenda Descalvados	16°44'00''; 57°45'00'', 110 m	Água Verde de Descalvados, Capão de Onça de Descalvados, Bocaina de Descalvados, Santa Rosa de Descalvados, Tamanduá de Descalvados and Xarqueada de Descalvados	Cherrie, Miller, this study
FF	Fazenda Flechas, Rio das Flechas	16°02'; 57°15', 150 m	Flexas, Frechas, Ribeirão Flechas	Natterer
FG	Fazenda Sangradouro, Rio Sangradouro[1]	15°56'; 57°08', 150 m	Fazenda do Sangrador, Ribeirão Sangrador	Natterer
FJ	Fazenda Jacobina	16°14'30''; 57°33'17'', 280 m	Sítio do S. João Pereira Leite, Fazenda do Coronel Jao Pereira Leite	Natterer, Comissão Rondon
FP	Fazenda Paraguatatuba	15°56'; 57°40', 135 m		This study
FS	Fazenda Santo Antônio das Lendas	16°39'; 57°50', 145 m		This study
FU	Fumaça	15°58', 58°18', 140 m	Bandidos da Fumaça	Comissão Rondon
HF	Hotel Fazenda Barranquinho	16°17'; 57°50', 115 m	Barranquinho	Forrester
LC	Lagoa de Chacororé[2]	16°02'; 57°43', 120 m	Chacururé	Natterer
MC	Municipality of Cáceres	Many		
MT	Mata do Toscano	Not located, but certainly very close to the city of Cáceres	Matto do Tonam	Comissão Rondon
PC	Porto Conceição[3]	17°08'36''; 57°21'35'', 100 m	Conceição, Rio Paraguai	Cherrie
PD	Pouso dos Dois Irmãos, Campina	16°12'; 57°20', 160 m	Pouzo dos irmaos	Natterer
PL	Porto Limão	16°08'35''; 57°59'55'', 130 m		Willis & Oniki
PP	Porto do Campo[3]	15°42'38''; 57°42'41'', 125 m	Porto Campo	Comissão Rondon
PS	Pau Seco	16°00'; 57°56', 125 m	Pansecco, Pau-Seco	Natterer
QU	Quilombo	16°12'; 57°35', 350 m		Comissão Rondon
RC	Rio Cabaçal	16°00' 57°42', 120 m	Rio do Cabacal	Natterer
RE	Retiro	16°10' 57°59', 130 m	Retiro da Barra	Natterer
RJ	Rio Jauru, near mouth	16°20'38''; 57°46'55'', 120 m	Barra do Rio Jauru	Natterer, Forrester
RS	Rio Sepotuba	15°51'40''; 57°38'30'', 125 m	Rio do Sipotuba, Rio Tenente Lira	Natterer
SA	Salto Alegre, Rio Jauru	16°07'; 58°03', 125 m	Rio Jaurú - Salto	Comissão Rondon
TU	Tucum	16°30'10''; 57°48'08'', 110 m		Comissão Rondon
XA	Xavier[3]	15°55'; 58°18', 155 m		Natterer

1. This is not the homonymous "Sangrador" visited by Natterer on December 1823 (15°39'S; 53°54'W) and where he collected, among others, the syntypes of *Syndactyla dimidiata* (Lopes & Gonzaga 2014).
2. This is not the homonymous "Baía de Chacororé" (16°16'S; 55°53'W) in Rio Cuiabá, which is much larger.
3. These three historical localities are not in the municipality of Cáceres, but at their very border, which is demarcated by narrow rivers. Given that past collectors frequently used boats to collect along rivers, frequently crossing them, as well as to the fact that these rivers certainly do not represent a geographical or ecological barrier to birds, we decided to include records obtained in these localities in the main list.

In addition to the expeditions listed below, the extreme northern portion of the municipality of Cáceres was sampled, to an unknown extent, by those ornithologists who surveyed the Estação Ecológica Serra das Araras (Silva & Oniki 1988, Willis & Oniki 1990, Oniki & Oliveira 2002, Valadão 2012). This conservation unit, with about 28,700 ha of cerrado vegetation, is almost entirely located in the municipality of Porto Estrela, but its extreme southern portion extends to Cáceres (Valadão 2012). Given that fieldwork conducted by the above cited authors was almost exclusively restricted to the limits of Porto Estrela, as well as to the impossibility to precise which records were obtained in Cáceres, we did not include in this paper records obtained in Serra das Araras. We also did not include in our checklist the records presented by Scalon & Sigrist (2013) for the Estação Ecológica de Taiamã. This because the list presented by those authors apparently included records obtained in other parts of the Pantanal or in the adjacent Cerrado, also including some apparent identification mistakes. It is also not possible to ascertain if the photographs presented were taken in the Estação Ecológica de Taiamã or somewhere else.

"Viagem Philosophica" Expedition: leaded by Alexandre Rodrigues Ferreira, who spent 29 months in Mato Grosso, including brief visits to Cáceres region on 1790–1791 (Rodrigues-Ferreira 1933, Vanzolini 1996). Ferreira collected few bird specimens in Mato Grosso, which were formerly housed in the Real Museu da Ajuda, Lisbon, Portugal. These specimens were taken as war loot during the French invasion of Portugal by Napoleon's army in 1808 (Vanzolini 1996). Although there is some evidence that this material were labelled, such labels were inadvertently removed or replaced in Portugal (Vanzolini 1996, Soares & Ferrão 2005), which makes impossible to accurately precise the origin of these specimens (Vanzolini 1996).

Johann Natterer: this collector visited several localities in Cáceres from 15 July 1825 to 24 June 1826, when he fixed residence in the area. Natterer also briefly visited the municipality in two other occasions during his travels: from 8–21 October 1827 and from 14–23 July 1828 (Vanzolini 1993). Localities visited are as follows: Fazenda Sangradouro (15 July 1825, 20–21 October 1827), Fazenda Flechas (15–20 July 1825 and 19–20 October 1827), Pouso dos Dois Irmãos (23 July 1825), Fazenda Jacobina (24 July 1825, 17 October 1827, and 14 March to 3 April 1828), city of Cáceres (28 July to 28 September 1825, 16 October 1827, and 10–17 April 1828), Rio Cabaçal (17 August 1825), Rio Sepotuba (17 August 1825), Fazenda Caiçara (29 September 1825 to 18 June 1826, 9–16 October 1827 and 19–23 April 1828, with brief visits during this period to Lagoa dos Barreirinhos and Lagoa da Campina that, although not located, are probably inside this farm), Lagoa de Chacororé (19 June 1825), Pau Seco (20–24 June 1825, 8 October 1827), Retiro (4–5 October 1825) and Barra do Rio Jauru (8–10 October 1825 and 10–12 December 1825). Natterer collected hundreds of specimens that are housed in the NMW, with some skins exchanged with several other museums across the world. The BMNH received several exchanges, the majority of them cited elsewhere (British Museum 1874–1898).

Langsdorff Expedition: this expedition was leaded by the Baron Georg Heinrich von Langsdorff, and included, among others, the painter Hercule Florence and the astronomer Nester Rubtsov. Members of this expedition travelled through Cáceres territory from August to September 1827. Florence (1977) presented good descriptions of the region, including some localities visited by Natterer, such as the Rio das Flechas, Fazenda Jacobina, city of Cáceres and Barra do Rio Jauru. The botanist Ludwig Riedel and the painter Adrien Taunay, in his way to Vila Bela da Santíssima Trindade, also crossed Cáceres territory, visiting a Bororo Indian native village, named Pau Seco, on the beginning of December 1827 (Manizer 1967). Florence and Taunay left fascinating paintings, drawings and descriptions of the habits of local farmers and indigenous people. Nevertheless, given that none of these explorers was particularly interested in ornithology, apparently no bird specimen was collected in Cáceres.

Francis de Castelnau: the expedition leaded by Castelnau entered Cáceres region through Rio Paraguai, coming from Corumbá. They were on Barra do Rio Jauru on 14 May 1845 (Castelnau 1851). Four days later the expedition reached Cáceres and, soon after, on the end of May, they visited Fazenda Caiçara, Pau Seco and Rio Jauru (Castelnau 1851). During the brief period spent on Cáceres, some few specimens were collected and deposited in the MNHN, some of them studied elsewhere (des Murs 1855).

Gustav Garlepp: although this collector is well known by the large collection amassed by him and his brother Otto in Bolivia (Niethammer 1953), almost nothing is known about his activities in western Mato Grosso. Garlepp, in his journey to Bolivia, reached Cáceres region coming from Argentina, starting his collecting activities in Cambará, where he worked from the end of November to the beginning of December 1888. Subsequently, Garlepp collected in the Fazenda Descalvados from mid-December 1888 to at least January 1889, but possibly his activity extended until April–May 1889, because the first Bolivian specimens were collected by him only on the first days of June 1889 (Niethammer 1953). The Garlepp's collection was first deposited in the personal collection of Hans Graf von Berlepsch, but is now housed in the SMF (Naumburg 1931). Some of these skins are now housed in the AMNH and the ROM, probably exchanged. The collection gathered by Garlepp in Brazil has never been studied in details, and only few specimens were studied elsewhere (von Berlepsch 1911).

Comissão Rondon: a series of expeditions to Mato Grosso during the first two decades of the 20th Century and leaded by the Marshal Cândido Mariano da Silva Rondon is known under that name (Gonzaga 1989). A detailed itinerary of the expedition and results achieved are difficult to appreciate, because the information available is scattered in a myriad of hard-to-find publications. Material collected during these expeditions is of great interest, but its appreciation would require the detailed revision of a voluminous literature and the examination of hundreds of specimens in the MNRJ, what is out of the scope of the current study. The Comissão Rondon explored Cáceres from 1908 to at least 1914, and the main participants were Alípio de Miranda Ribeiro, Frederico Carlos Hoehne, Henrique Reinisch, Arnaldo Blake de Sant'Anna, João Geraldo Kuhlmann and Hermano Kuhlmann. Additional information about these expeditions can be found elsewhere (Miranda-Ribeiro 1914, 1916a, b, Gonzaga 1989, Sá *et al.* 2008).

M. Mocquerys: collected in Cáceres from March to September 1909, and from December 1909 to January 1910 (Simon 1912, Ménégaux 1917). Mocquerys also collected in Cambará on October 1908 and October 1909 (Simon 1912), sampling at least 90 specimens, which are deposited in the MNHN.

Roosevelt-Rondon Expedition: this expedition briefly visited the Fazenda Descalvados on 4 January, the city of Cáceres on 5–6 January, and Porto do Campo on 7–13 January 1914, when travelling to northern Mato Grosso (Naumburg 1930, Vasconcelos *et al.* 2014). Apparently no bird specimen was collected in the study area during this year, because members of the expedition, especially Theodore Roosevelt, former President of USA, were more concerned with the collection of large game mammals, such as jaguars and tapirs (Roosevelt 1914). George K. Cherrie, the ornithologist of the expedition, returned to Fazenda Descalvados in a supplementary expedition on 1916, where he worked from 17 November to 27 December, including brief visits to nearby stations, all of them inside the farm area or on its immediate environs (Água Verde de Descalvados, Capão de Onça de Descalvados, Bocaina de Descalvados, Santa Rosa de Descalvados, and Tamanduá de Descalvados). Fieldwork in the area resulted in the collection of 152 specimens which were deposited in the AMNH (Naumburg 1930). At least one bird was exchanged with the YPM.

Ernst Garbe: visited Cáceres from November to December 1917 (Pinto 1945), collecting about 80 specimens now housed in MZUSP. Lima (1920), in a confusing paper, cited some of those specimens, but it is not always possible to known if the specimens were collected in Cáceres or in Corumbá, another locality visited by Garbe. A complete list of specimens collected was published elsewhere (Pinto 1938, 1944). Pinto (1938) erroneously cited some specimens collected on November 1917 as being collected on February 1917. This is a misinterpretation of the handwriting labels of Garbe, who sometimes wrote the month in Roman numbers "XI" and sometimes in Arabic numbers "11", this last one misread as "II".

Colorado Museum Expedition: the former Colorado Museum of Natural History, nowadays DMNS, sent two expeditions to the Fazenda Descalvados. F. G. Brandenburg and F. E. D'Amour were the bird collectors in the first expedition, which explored the area from at least September 1925 to January 1926. A second expedition was conducted by F. G. Brandenburg and J. D. Figgins, who collected from at least April 1928 to July 1928. These two expeditions collected about 520 specimens, which are housed in the DMNS. This collection has never been published, and only some few specimens were studied by Oberholser (1931).

Marshall Field Expedition: the Field Museum of Natural History sent an expedition to Brazil in 1926–27 with grants from the Captain Marshall Field (Davies 1927). The chief of the expedition was the ornithologists G. K. Cherrie, who had hunted with Roosevelt during his expedition to Mato Grosso in 1914 (Roosevelt 1914, Davies 1927). Colin Sanborn and Mrs. Marshall Field were also members of the expedition (Davies 1927). The party sailed up the Rio Paraguai from Corumbá to Fazenda Descalvados, where they collected from August 1926, also briefly visiting Porto Conceição on 29 July. Sanborn returned to Fazenda Descalvados on the following year, when he collected from June to August 1927 (Paynter-Jr. & Traylor-Jr. 1991). The collection obtained in Cáceres summed almost 100 specimens, but have never been studied in full. Some specimens were occasionally cited by Naumburg (1930), but the majority was studied by Hellmayr (1918–1949).

J. A. G. Rehn: explored the Fazenda Descalvados from 16 June to 19 September 1931, during an expedition from the ANSP, collecting almost 500 specimens that were studied in details elsewhere (Stone & Roberts 1934). Some specimens were subsequently exchanged with the UMMZ.

Gabriel Pinto de Arruda: in a book describing many aspects of the municipality of Cáceres, Arruda (1938) presented a brief overview on its biological aspects. On the "ornithological" section, no scientific names are presented, but birds were tentatively grouped in taxonomic groups (*e.g.* "Gralatores"). Vernacular names, sometimes accompanied by a brief description of species, generally allow a safe identification of the species referred, and at least 70 species could be identified with certainty. Nevertheless, this book has a major drawback, because it was written 80 years ago, when Cáceres municipality encompassed several other municipalities now emancipated. Consequently, several species found only in the headwaters of the Rio Paraguai, in an area with a marked Amazonian influence, are cited along the text, such as *Odontophorus gujanensis*, and *Psophia viridis*. These species are probably not encountered inside the present day limits of Cáceres and, therefore, we opted to not include in the main list, or in the secondary or tertiary lists, those species recorded exclusively by Arruda (1938).

Alexander Daveron: a North American doctor who lived in Cáceres for more than 50 years. From June to November 1940, Daveron collected about 400 specimens along the Rio Paraguai, preparing then as skeletons, which are deposited in the USNM. This collection has never been studied. Given that we were unable to precise the localities visited by Daveron, which were somewhat vague (*e.g.* "Between Caceres, Concepcion, Rio Paraguay"), we opted not to include here records obtained by Daveron. Nevertheless, we believe that at least some of these specimens were collected inside the present day limits of the municipality of Cáceres, including some noteworthy species not recorded by others, such as *Syndactyla dimidiata* (USNM 346001) and *Clibanornis rectirostris* (USNM 345998–346000).

Augusto Ruschi: explored Cáceres region from January to February 1954 and from July to August 1955 (Ruschi 1955). Specimens collected by Ruschi were deposited in the MBML. Ruschi, on his voluminous publications, also mentioned specimens collected in Cáceres on other periods, but it is not possible to know if these specimens were collected by Ruschi himself or by a collaborator living in the city. These specimens are from October 1955, February, July and August 1956, August and October 1959, August 1960 and July 1967 (Ruschi 1955, 1961, 1962, MBML data, Vielliard 1994). Ruschi (1953) also commented on some hummingbird nests collected in Cáceres on January 1953.

Rolf Grantsau: briefly visited Fazenda Jacobina on 18 July 1966 and Cáceres from 19–21 July 1966. This expedition resulted in the collection of about 140 specimens, which are deposited in CG, with some few specimens exchanged with MNRJ, MPEG and MZUSP. The results of this expedition have never published in full, and only some few hummingbirds were cited elsewhere (Grantsau 1988).

José Carlos Reis de Magalhães: Reis-de-Magalhães (1994) says to have examined some tinamou specimens from "Fazenda Igara, municipality of Cáceres, high Rio Paraguai", but presented no further details. We were unable to discover in which institution these specimens are housed, and failed to precise if Reis-de-Magalhães himself have collected them or if he examined specimens collected by others. Furthermore, this locality may not be inside the present day limits of the municipality, and, therefore, we did not include these records in our main list.

Álvaro Coutinho Aguirre: briefly visited the Fazenda Descalvados from 18 September to 2 October 1957, collecting about 20 specimens (Schubart *et al.* 1965, Aguirre & Aldrighi 1983, 1987). Aguirre & Aldrighi (1983) also list two specimens of *Zenaida auriculata* collected in this area on October 1970.

Geraldo T. Mattos: briefly visited the Fazenda Taiamã from 14–15 September 1980. The 14 specimens collected are deposited in DZUFMG.

Edwin Willis & Yoshika Oniki: visited Porto Limão on an unspecified date from the "winter" 1987 and from 21–22 January 1988. Reconstruction of the itinerary of these researchers allowed us to point 31 July 1987 (possibly extending to the morning of 1 August) as the most probably day of fieldwork during winter. An erratum for this article had been published (Willis & Oniki 1991).

Bruce C. Forrester and others: visited the Hotel Fazenda Barranquinho, located near the Barra do Rio Jauru, on unspecified dates, presenting the results of their observations in a book devoted to birdwatchers (Forrester 1993). The checklist presented, with about 360 species, is a compilation of published papers and unpublished observations of Forrester himself and other birdwatchers, including C. Ireland and T. Ford on 1988, N. J. N. Pope on 1989 and D. Stemple on an unspecified date. Given that records presented in this book cover a large area extending from the city of Cáceres to Fazenda Descalvados, we consider these records for the municipality of Cáceres, and not to the Hotel Fazenda Barranquinho. A major drawback is that Forrester's book contains many errors and doubtful records, as we discussed elsewhere (Lopes *et al.* 2009). Furthermore, it is not possible to precise the site of record, nor even the author of the records presented. Given the reasons exposed above, we decided to include all species recorded exclusively by Forrester (1993) in the secondary or in the tertiary list.

Elisabete Segatto Melo & Manoel Santos-Filho: studied the road-killed vertebrates on the access road to Cáceres from November 2000 to October 2001, presenting a list of the run over species (Melo & Santos-Filho 2007).

Although we cannot precise the exact number of specimens collected by the above cited naturalists who visited the study area, we are confident that this number surpass 3000. This large number of specimens, the majority of them collected in a period when many South American birds were still undescribed, resulted in the description of twenty new taxa, the majority of them still valid (Table 3). This demonstrates the importance of the collections performed in the region not only to the knowledge of the natural history and distribution of birds, but also to the development of taxonomic studies on the Neotropical avifauna.

TABLE 3. Taxa described from specimens collected inside the present day limits of the municipality of Cáceres, Mato Grosso, Brazil. We only listed the type localities found inside the present day limits of the municipality of Cáceres, but readers must bear in mind that some of the species listed below were described from more than one specimen, with some of the syntypes collected in localities outside Cáceres.

Taxon	Current name	Type locality
Penelope ochrogaster von Pelzeln, 1870	Idem	Rio das Flechas
Penelope grayi von Pelzeln, 1870	*Pipile cumanensis grayi* (von Pelzeln, 1870)	Sangradouro
Pipile nattereri Reichenbach, 1862	*Pipile cujubi nattereri* Reichenbach, 1862	Rio das Flechas
Uropelia campestris figginsi Oberholser, 1931	Junior synonym of *Uropelia campestris* (von Spix, 1825)	Descalvados
Phaethornis nattereri von Berlepsch, 1887	Idem	Caiçara
Nonnula ruficapilla nattereri Hellmayr, 1921	Idem	Villa Maria
Trogon auratus Swainson, 1837	Junior synonym of *Trogon collaris castaneus* von Spix, 1824	Villa Maria
Picumnus aurifrons von Pelzeln, 1870	Idem	Caiçara
Picumnus arileucus Oberholser, 1931	Junior synonym of *Picumnus a. albosquamatus* d'Orbigny, 1840	Descalvados
Celeopicus lugubris Malherbe, 1851	*Celeus lugubris* (Malherbe, 1851)	Villa Maria, Caiçara
Picus nattereri Malherbe, 1845	*Colaptes melanochloros nattereri* (Malherbe, 1845)	Villa Maria, Caiçara
Picus olivinus Natterer & Malherbe, 1845	*Veniliornis passerinus olivinus* (Natterer & Malherbe, 1845)	Villa Maria
Conurus griseicollis des Murs, 1855	Junior synonym of *Myiopsitta monachus* (Boddaert, 1783)	Rio Paraguay [near Cáceres]
Attila validus von Pelzeln, 1868	Junior synonym of *Attila b. bolivianus* Lafresnaye, 1848	Villa Maria
Myiarchus gracilirostris von Pelzeln, 1868	Junior synonym of *Myiarchus t. tuberculifer* (d'Orbigny & Lafresnaye, 1837)	Villa Maria
Dysithamnus affinis von Pelzeln, 1868	*Dysithamnus mentalis affinis* von Pelzeln, 1868	Villa Maria
Pithys griseiventris von Pelzeln, 1868	*Willisornis poecilinotus griseiventris* (von Pelzeln, 1868)	Villa Maria
Hypocnemis maculicauda von Pelzeln, 1868	*Hypocnemoides maculicauda* (von Pelzeln, 1868)	Villa Maria
Sicalis pelzelni danisa Oberholser, 1931	Junior synonym of *Sicalis flaveola pelzelni* P.L. Sclater, 1872	Descalvados
Tachyphonus nattereri von Pelzeln, 1870	*Tachyphonus cristatus nattereri* von Pelzeln, 1870	Villa Maria

Sources: Swainson (1838), Natterer & Malherbe (1845), Malherbe (1851), des Murs (1855), Reichenbach (1862), von Pelzeln (1868–1870), von Berlepsch (1887), Hellmayr (1921), Oberholser (1931), Warren (1966), Schifter *et al.* (2007).

Birds from Cáceres

We recorded during our fieldwork in Cáceres, 266 species in Fazenda Descalvados, 253 in Fazenda Paraguatatuba, 245 in Fazenda Baía de Pedra, 217 in Fazenda Santo Antônio das Lendas, 183 in Baía dos Malheiros and 145 in Estação Ecológica de Taiamã. The number of species recorded during our expeditions sums up to 374 (Appendix I). During our fieldwork we collected 489 specimens.

The analysis of literature data and museum specimens rises the number of species ever recorded in the municipality to 446, of which 362 (81.2%) were documented with specimens (Appendix I). The number of documented species rises to 391 (88.5%) if we consider the photographs available in Wikiaves. The high percentage of documentation, rarely attained by modern bird surveys, assigns high credibility to the data presented here. The Secondary List includes other 13 species (Appendix II), and the Tertiary List includes 15 species (Appendix III).

The high bird species richness found in Cáceres is similar to that found in well sampled rich rain forest sites in Amazonia (*e.g.*, Stotz *et al.* 1997, Zimmer *et al.* 1997, Borges *et al.* 2001, Whittaker 2009). This is a remarkably high number of species for a predominantly non-forested area. For comparison, another large and well sampled non-forested area in central Brazil, Chapada dos Guimarães (a Cerrado area with some few Amazonian elements in central-south Mato Grosso) has 393 species (Lopes *et al.* 2009). Other large and well sampled areas in the central portion of Cerrado, where the influence of neighbor ecoregions is small, have significantly lower number of species. For example, well sampled areas, but lacking historical data, such as the municipalities of Unaí and Cabeceira Grande (a Cerrado area in northwestern Minas Gerais) has only 340 species recorded (Lopes *et al.* 2008, Mazzoni *et al.* 2015).

The high bird diversity found in Cáceres is attributable not only to the high diversity of habitat types found in the area, but also to its unique geographic location. Bird species endemic or almost restricted to all the ecoregions that come into contact in central South America can be found in Cáceres. Species typical to the Cerrado (Cavalcanti 1988, Silva 1997) are *Penelope ochrogaster*, *Heliactin bilophus*, *Alipiopsitta xanthops*, *Antilophia galeata*, *Herpsilochmus longirostris*, *Melanopareia torquata*, and *Saltatricula atricollis.* Species closely tied to the Chiquitano Dry Forests are *Phaethornis subochraceus* and *Thamnophilus sticturus* (Vasconcelos & Hoffmann 2006).

A small Chacoan influence is also observable in Cáceres, even though Chaco vegetation only reaches the southern border of the Pantanal, in the state of Mato Grosso do Sul (Silva & Caputo 2010). The Chaco has very few endemic taxa (Short 1975), but some species with wide range in southern South American only reach Bolivia and southwestern Brazil in areas under Chacoan influence, such as *Aratinga nenday*, *Alectrurus risora*, *Knipolegus hudsoni* and *Microspingus melanoleucus.*

A strong Amazonian influence is observable along the riparian forests of the upper Rio Paraguai and its main tributaries, with 50 typically Amazonian taxa (Silva 1996) recorded, such as *Pipile cujubi*, *Mitu tuberosum*, *Glaucidium hardyi*, *Trogon melanurus*, *Nonnula ruficapilla*, *Picumnus aurifrons*, *Piculus leucolaemus*, *Aratinga weddellii*, *Thamnophilus amazonicus*, *Drymophila devillei*, *Willisornis poecilinotus*, *Dendrocincla fuliginosa*, *Ramphotrigon ruficauda*, *Cephalopterus ornatus*, and *Gymnoderus foetidus*.

Kark *et al.* (2007) highlighted that transitional areas are rich in species not only due to the overlap between different communities, but also because ecotones hold concentrations of rare and range limited species. Nevertheless, this does not seem to be the case for Cáceres avifauna, which is represented almost exclusively by wide ranging species. A possible exception to this rule is *Tachyphonus cristatus nattereri*, an enigmatic taxon (see Zimmer 1945 for a discussion on its taxonomy) only known from the type specimen, a male collected by Natterer in the right bank of Rio Paraguai, nearby Cáceres, on August 1825 (von Pelzeln 1868–1870). Another syntype, a female obtained in the Amazonia by Natterer, is now considered an extreme of variation of *T. c. madeirae* (Hilty 2011). We searched for *T. c. nattereri* in several habitat types, especially in dry forests and bamboo thickets. We also searched in the seasonally flooded riparian forests of the Rio Paraguai, but failed to locate it. The taxonomic status of this taxon requieres further study.

Noteworthy records

Here we present some notes on the natural history, biogeography and conservation of noteworthy species. Additional notes on other interesting records obtained in Cáceres were published elsewhere (Vasconcelos *et al.* 2008, Lopes *et al.* 2011, 2012, 2013, Evangelista *et al.* 2012).

***Penelope ochrogaster*:** a common species in the area, inhabiting semideciduous and deciduous forests near to seasonally flooded areas, even in secondary forest fragments. Hunting pressure seems to be low in the region, but large tracts of semideciduous forests, the main habitat for the species, has been replaced by artificial pastures.

***Pipile* spp.:** *P. cujubi nattereri* and *P. cumanensis grayi* are found in the region, but not in the same locality. At Descalvados we have found *P. c. nattereri,* including breeding males (*e.g.* MZUSP 79223), and *P. c. grayi* in nearby areas. Both taxa are in contact, with no hybridization, in southwestern Mato Grosso and northern Mato Grosso do Sul.

Scolopacidae species: a simple analysis of the historical records of shorebirds in Mato Grosso makes us worry about the conservation status of some of these migratory species. Three Scolopacidae species (*Bartramia longicauda*, *Limosa haemastica* and *Steganopus tricolor*) recorded by Natterer in Cáceres during the 1820's were not recorded since then. These same species and six other Scolopacidae were also collected by Natterer in the nearby municipality of Vila Bela da Santíssima Trindade and were not recorded subsequently (Silveira & D'Horta 2002). Two other Scolopacidae with historical records for Chapada dos Guimarães (*B. longicauda* and *Calidris fuscicollis*) also lacks modern records (Lopes *et al.* 2009). Modern records of these species for the entire Pantanal are scarce (see some of these records in http://www.wikiaves.com.br).

***Chroicocephalus cirrocephalus*:** a single bird exhibiting summer plumage was observed in a beach of the Rio Paraguai (16°42'29''S; 57°40'63''W), attempting to prey upon eggs and nestlings of *Phaetusa simplex* and *Rynchops niger*, which were breeding in the area on September 2007. Inland records of this seabird are rare (Mitchell 1957, Sick 1997).

***Pionus* spp.:** Cáceres represents a contact zone between the distribution of the two *Pionus* species, with *P. menstruus* found northward and *P. maximiliani* found southward (Tubelis & Tomas 2003). We only recorded these species in syntopy in Fazenda Descalvados.

Xenopsaris albinucha**:** two adult birds observed in flooded areas in the Fazenda Descalvados. There is an old record of the species for Corumbá (Pinto 1944, MZUSP 30337) and several modern records of the species in the Pantanal region (see http://www.wikiaves.com.br/).

Capsiempis flaveola**:** one of the commonest species in the *Guadua* bamboo patches in Fazenda Baía de Pedra.

***Dendrocolaptes* spp.:** Cáceres lies in the narrow contact zone between the parapatric distributed *D. platyrostris* and *D. picumnus* (Marantz & Patten 2010). One specimen collected in Fazenda Baía de Pedra (UFMT 2963) closely approach the characters of *D. platyrostris intermedius,* the subspecies expected to occur in the region. Nevertheless, the specimen DZUFMG 5574, although tentatively referred to *D. picumnus pallescens* von Pelzeln, 1868, is somewhat intermediate between these two species, presenting a heavily barred belly and a streaked throat and breast, resembling *D. p. intermedius*. This specimen probably represents a hybrid.

Thraupidae species: it is interesting to note that, with some few remarkable exceptions (*e.g.*, *Eucometis penicillata*, *Ramphocelus carbo* and *Tangara sayaca*), tanagers are very rare in the area. This is a phenomenon observed along the entire Pantanal, where some tanagers commonly found in the Cerrado (*e.g., Tangara cayana*, *Tersina viridis*, *Dacnis cayana* and *Hemithraupis guira*) are absent or only rarely encountered.

Sporophila maximiliani**:** a single male observed in the border of a secondary forest with understory dominated by *Guadua* bamboos on 25 February 2008 in Fazenda Baía de Pedra. We also recorded this species in Paranorte, municipality of Juara (~10°23'S; 57°40'W, 370 m a.s.l.), in a similar habitat, on August 2006.

Turdus hauxwelli**:** an adult male was collected on 7 September 2007 in Fazenda Descalvados (MZUSP 79396). This species meets *T. fumigatus* in central Mato Grosso, but the range limits between these species are uncertain. Furthermore, the taxonomy of members of this complex deserves further investigation.

ACKNOWLEDGEMENTS

Part of our field work was supported by grants from *Núcleo de Estudos Ecológicos do Pantanal, Centro de Pesquisa do Pantanal, Instituto Nacional de Áreas Úmidas, Programa Ecológico de Longa Duração, and Ministério da Ciência e Tecnologia.* LEL benefited from grants and fellowships from FAPEMIG, FUNARBE and CNPq during part of this study. LFS benefited from grands from CNPq and FAPESP. Marcelo Pádua (Field Guides Inc.), Tânia de Freitas Raso and Patrícia Lopes (Universidade de São Paulo) provided logistic support and help during fieldwork. We thank all farmers that allowed us to conduct this study in their lands. We are grateful to all curators that allowed us to study specimens under their care. John Demboski provided us a complete database of the specimens collected in Cáceres and housed in the DMNS. We thank Ornisnet and Wikiaves for publishing online very useful databases of bird specimens and photographs, respectively. Collecting permits were issued by IBAMA and ICMBio. An anonymous reviewer and Vitor Piacentini provided constructive criticism on an earlier version of this paper.

REFERENCES

Aguirre, A. C. & Aldrighi, A. D. 1983. *Catálogo das aves do Museu da Fauna, primeira parte*. Rio de Janeiro: Delegacia Estadual do Estado do Rio de Janeiro, Instituto Brasileiro de Desenvolvimento Florestal.

Aguirre, A. C. & Aldrighi, A. D. 1987. *Catálogo das aves do Museu da Fauna, segunda parte*. Rio de Janeiro: Delegacia Estadual do Estado do Rio de Janeiro, Instituto Brasileiro de Desenvolvimento Florestal.

Albuquerque, J. L. B. 1985. Notes on the distribution of some Brazilian raptors. *Bulletin of the British Ornithologists' Club*, 105: 82–84.

Alho, C. J. R. 2008. Biodiversity of the Pantanal: response to seasonal flooding regime and to environmental degradation. *Brazilian Journal of Biology*, 68: 957–966.

Alvarenga, H. M. F. 1998. Sobre a ocorrência do Condor (*Vultur gryphus*) no Holoceno da região de Lagoa Santa, Minas Gerais, Brasil. *Ararajuba*, 6: 60–63.

Alvares, C. A.; Stape, J. L.; Sentelhas, P. C.; Gonçalves, J. L. M. & Sparovek, G. 2014. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift*, 22: 711–728.

Antas, P. T. Z. & Palo-Jr., A. 2009. *Pantanal - guia de aves: espécies da Reserva Particular do Patrimônio Natural do SESC Pantanal, 2ª ed.* Rio de Janeiro: SESC.

Arruda, G. P. 1938. *Um trecho do oeste brasileiro: São Luiz de Caceres, Mato Grosso*. Rio de Janeiro: Borsoi & Cia.

Borges, S. H.; Cohn-Haft, M.; Carvalhaes, A. M. P.; Henriques, L. M.; Pacheco, J. F. & Whittaker, A. 2001. Birds of Jaú National Park, Brazilian Amazon: species check-list, biogeography and conservation. *Ornitología Neotropical*, 12: 109–140.

British Museum. 1874-1898. *Catalogue of the birds in the British Museum, v. I to XXVII*. London: British Museum.

Castelnau, F. 1851. *Expédition dans les parties centrales de l'Amérique du Sud, de Rio de Janeiro a Lima, et de Lima au Para; exécutés par ordre du gouvernement Français pendant les années 1843 a 1847, sous la direction de Francis de Castelnau. Histoire du voyage, v. 3.* Paris: P. Bertrand.

Cavalcanti, R. B. 1988. Conservation of birds in the Cerrado of central Brazil, p. 59–66. *In*: Goriup, P. D. (ed.). *Ecology and conservation of grassland birds*. Cambridge: International Council for Bird Preservation.

Collar, N. J.; Gonzaga, L. P.; Krabbe, N.; Madroño-Nieto, A.; Naranjo, L. G.; Parker-III, T. A. & Wege, D. C. 1992. *Threatened birds of the America: the ICBP/IUCN Red Data Book*. Cambridge: International Council for Bird Preservation.

Darrieu, C. A. 1983. Revisión sistemática de las razas de *Pionus maximiliani* (Kuhl) (Aves, Psittacidae). *Hornero*, 12: 38–58.

Davies, D. C. 1927. Annual report of the director to the board of trustees for the year of 1926. *Field Museum of Natural History Publications, Report Series*, 2: 1–174.

des Murs, M. O. 1855. *Expédition dans les parties centrales de l'Amérique du Sud, de Rio de Janeiro a Lima, et de Lima au Para; exécutés par ordre du gouvernement Français pendant les années 1843 a 1847, sous la direction du comte Francis de Castelnau, part 7, v. 3, Animaux nouveaux ou rares recueillis pendant l'expédition, Oiseaux*. Paris: P. Bertrand.

Dickinson, E. C. & Christidis, L. 2014. *The Howard and Moore complete checklist of the birds of the World, 4th ed., v. 2, passerines*. Eastbourne: Aves Press.

Dickinson, E. C. & Remsen-Jr., J. V. 2013. *The Howard and Moore complete checklist of the birds of the World, 4th ed., v. 1, non-passerines*. Eastbourne: Aves Press.

Evangelista, M. M.; Andrade, M. L. F.; Almeida, S. M. & Buso-Jr., A. A. 2012. Predação de *Caiman yacare* (Spix, 1825) (Crocodilia, Alligatoridae) por *Busarellus nigricollis* (Latham, 1790) (Accipitriformes, Accipitridae) na Estação Ecológica de Taiamã, Alto Pantanal, Mato Grosso. *Revista Brasileira de Ornitologia*, 20: 73–74.

Ferreira, J. C. V. 1997. *Mato Grosso e seus municípios*. Cuiabá: Secretaria de Estado da Cultura.

Florence, H. 1977. *Viagem fluvial do Tietê ao Amazonas, 1825 a 1829*. São Paulo: Cultrix.

Forrester, B. C. 1993. *Birding Brazil: a checklist and site guide*. Irvine: John Geddes.

Gonzaga, L. P. 1989. Catálogo dos tipos na coleção ornitológica do Museu Nacional. I - Não-Passeriformes. *Boletim do Museu Paraense Emílio Goeldi, Série Zoologia*, 5: 9–40.

Grantsau, R. 1988. *Os beija-flores do Brasil*. Rio de Janeiro: Expressão e Cultura.

Greenewalt, C. H. 1960. *Hummingbirds*. Garden City: American Museum of Natural History.

Hamilton, S. K.; Sippel, S. J. & Melack, J. M. 1996. Inundation patterns in the Pantanal wetland of South America determined from passive microwave remote sensing. *Archiv für Hydrobiologie*, 137: 1–23.

Hellmayr, C. E. 1921. Zwei neue neotropische Vogelformen. *Anzeiger der Ornithologischen Gesellschaft in Bayern*, 1: 41–42.

Hellmayr, C. E. 1929. A contribution to the ornithology of northeastern Brazil. *Field Museum of Natural History Publications, Zoological Series*, 12: 235–501.

Hellmayr, C. E.; Cory, C. B. & Conover, B. 1918-1949. Catalogue of birds of the Americas and the adjacent islands in Field Museum of Natural History, parts I–XI. *Field Museum of Natural History Publications, Zoological Series*, 13.

Hilty, S. L. 2011. Family Thraupidae (tanagers), p. 46–329. *In*: del Hoyo, J.; Elliott, A. & Christie, D. (eds.). *Handbook of the birds of the world, v. 16 (tanagers to New World blackbirds)*. Barcelona: Lynx Edicions.

IBGE. 2004. *Mapa de vegetação do Brasil, 3rd ed.* Brasília: Instituto Brasileiro de Geografia e Estatística.

IBGE. 2015. *IBGE Cidades@*. http://www.cidades.ibge.gov.br/ (access on 12 June 2015).

Kantek, D. L. Z. & Onuma, S. S. M. 2013. Primeiro registro documentado da Gaivota-de-Franklin *Leucophaeus pipixcan* Wagler, 1831 para o bioma Pantanal, Brasil. *Ornithologia*, 6: 106–108.

Kark, S.; Allnut, T. F.; Levin, N.; Manne, L. L. & Williams, P. H. 2007. The role of transitional areas as avian biodiversity centres. *Global Ecology and Biogeography*, 16: 187–196.

Lima-Jr., G. A.; Rodrigues, N. B.; Barreto, D. S.; Pinto, L. B.; Couto, P. F. & Cunha, C. N. 2008. Distribuição e abundância de espécies arbóreas do cerrado *sensu strictu* no Pantanal, Mato Grosso, Brasil, CD Rom. Annals of IX Simpósio Nacional do Cerrado & II Simpósio Internacional de savanas Tropicais. Brasília: EMBRAPA.

Lima, J. L. 1920. Aves colligidas no estado de S. Paulo, Matto-Grosso e Bahia, com algumas formas novas. *Revista do Museu Paulista*, 12: 91–106.

Lopes, L. E. & Gonzaga, L. A. P. 2014. Taxonomy, distribution, natural history and conservation of the Russet-mantled Foliage-gleaner *Syndactyla dimidiata* (Pelzeln, 1859) (Aves: Furnariidae). *Zootaxa*, 3754: 435–449.

Lopes, L. E.; Malacco, G. B.; Vasconcelos, M. F.; Carvalho, C. E. A.; Duca, C.; Fernandes, A. M.; D'Angelo-Neto, S. & Marini, M. Â. 2008. Aves da região de Unaí e Cabeceira Grande, noroeste de Minas Gerais, Brasil. *Revista Brasileira de Ornitologia*, 16: 193–206.

Lopes, L. E.; Peixoto, H. J. C. & Hoffmann, D. 2013. Notas sobre a biologia reprodutiva de aves brasileiras. *Atualidades Ornitológicas*, 171: 33–49.

Lopes, L. E.; Pinho, J. B. & Benfica, C. E. R. T. 2011. Seasonal distribution and range of the Blackish-blue Seedeater *Amaurospiza moesta*, a bamboo-associated bird. *Wilson Journal of Ornithology*, 123: 797–802.

Lopes, L. E.; Pinho, J. B.; Bernardon, B.; Oliveira, F. F.; Bernardon, G.; Ferreira, L. P.; Vasconcelos, M. F.; Maldonado-Coelho, M.; Nóbrega, P. F. A. & Rubio, T. C. 2009. Aves da Chapada dos Guimarães, Mato Grosso, Brasil: uma síntese histórica do conhecimento. *Papéis Avulsos de Zoologia*, 49: 9–47.

Lopes, L. E.; Pinho, J. B.; Gaiotti, M. G.; Evangelista, M. M. & Vasconcelos, M. F. 2012. Range and natural history of seven poorly-known Neotropical rails. *Waterbirds*, 35: 470–478.

Luca, A. C.; Develey, P. F.; Bencke, G. A. & Goerck, J. M. 2009. *Áreas importantes para a conservação das aves no Brasil, parte II, Amazônia, Cerrado e Pantanal*. São Paulo: SAVE Brasil.

Malherbe, M. A. 1851. Notes sur quelques espèces de Picinées. *Bulletin de la Société d'Histoire Naturelle du Département de la Moselle*, 6: 73–86.

Manizer, G. C. 1967. *A expedição do acadêmico G. I. Langsdorff ao Brasil (1821–1828)*. São Paulo: Companhia Editora Nacional.

Marantz, C. A. & Patten, M. A. 2010. Quantifying subspecies analysis: a case study of morphometric variation and subspecies in the woodcreeper genus *Dendrocolaptes*. *Ornithological Monographs*, 67: 123–140.

Mazzoni, L. G.; Perillo, A.; D'Angelo-Neto, S.; Vasconcelos, M. F. & Santos, T. 2015. Additions to the avifauna of Unaí and Cabeceira Grande, north-west Minas Gerais. *Cotinga*, 37: 61–75.

Melo, E. S. & Santos-Filho, M. 2007. Efeitos da BR-070 na província serrana de Cáceres, Mato Grosso, sobre a comunidade de vertebrados silvestres. *Revista Brasileira de Zoociências*, 9: 185–192.

Ménégaux, A. 1917. Étude d'une collection d'oiseaux du Matto Grosso. *Revue Française d'Ornithologie*, 9: 24–26, 37–40, 55–58, 84–88.

Meyer de Schauensee, R. 1966. *The species of birds of South America with their distribution*. Narberth: Academy of Natural Sciences of Philadelphia.

Miranda-Ribeiro, A. 1914. *Expedição Scientifica Roosevelt-Rondon. História natural, zoologia: resultados zoológicos da expedição. Publicação no. 53 da Comissão de Linhas Telegraphicas Estrategicas de Matto Grosso ao Amazonas (Annexo no. 4 da Expedição Roosevelt)*. Rio de Janeiro.

Miranda-Ribeiro, A. 1916a. *A Comissão Rondon e o Museu Nacional. Publicação no. 49 da Comissão de Linhas Telegraphicas Estrategicas de Matto Grosso ao Amazonas*. Rio de Janeiro: Pap. Luiz Macedo.

Miranda-Ribeiro, A. 1916b. *Relatório dos trabalhos realizados durante o anno de 1908. Expedição scientifica Roosevelt-Rondon: resultados zoológicos da expedição. Publicação no. 27 da Comissão de Linhas Telegraphicas Estrategicas de Matto Grosso ao Amazonas (Annexo no. 4)*. Rio de Janeiro: Pap. Luiz Macedo.

Miranda-Ribeiro, A. 1920. Revisão dos psittacideos brasileiros. *Revista do Museu Paulista*, 12: 1–82.

Miranda-Ribeiro, A. 1929. Notas ornithológicas. IX. Os capitonídeos basileiros. *Boletim do Museu Nacional do Rio de Janeiro*, 5: 57–70.

Miranda-Ribeiro, A. 1931. Notas ornithológicas. XI. Corácias brasileiras (Momotinae): systemática. *Boletim do Museu Nacional do Rio de Janeiro*, 7: 73–90.

Miranda-Ribeiro, A. 1938. Notas ornitológicas. XII. A seriema. *Revista do Museu Paulista*, 23: 35–90 + 30 plates.

Miranda-Ribeiro, A. & Soares, E. C. 1920. *Psittacidae. Publicação no. 63 da Comissão de Linhas Telegraphicas Estrategicas de Matto Grosso ao Amazonas (Annexo no. 5: Historia Natural)*. Rio de Janeiro: Pap. Luiz Macedo.

Mitchell, M. H. 1957. *Observations on birds of southeastern Brazil*. Toronto: Toronto University Press.

Natterer, J. & Malherbe, M. A. 1845. Notice sur quelques espèces de Pics du Brésil. *Mémoires de la Société Royale des Sciences de Liège*, 2: 65–70.

Naumburg, E. M. B. 1930. The birds of Mato Grosso, Brazil: a report on the birds secured by the Roosevelt-Rondon expedition. *Bulletin of the American Museum of Natural History*, 60: 1–432.

Naumburg, E. M. B. 1931. The Senckenberg Museum, Frankfort-on-Main, Germany. *Auk*, 68: 379–384.

Niethammer, G. 1953. Zur vogelwelt Boliviens. *Bonner Zoologische Beitrage*, 4: 195–303.

Nimer, E. 1979. *Climatologia no Brasil*. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística, Superintendência de Recursos Naturais e Meio Ambiente.

Novaes, F. C. 1949. Variação nos tucanos brasileiros do gênero *Ramphastos* L. (Ramphastidae, Piciformes). *Revista Brasileira de Biologia*, 9: 285–296.

Oberholser, H. C. 1931. New birds from Brazil. *Proceedings of the Colorado Museum of Natural History*, 10: 24–28.

Olson, D. M.; Dinerstein, E.; Wikramanayake, E. D.; Burgess, N. D.; Powell, G. V. N.; Underwood, E. C.; D'Amico, J. A.; Itoua, I.; Strand, H. E.; Morrison, J. C.; Loucks, C. J.; Allnutt, T. F.; Ricketts, T. H.; Kura, Y.; Lamoreux, J. F.; Wettengel, W. W.; Hedao, P. & Kassem, K. R. 2001. Terrestrial ecoregions of the world: a new map of life on Earth. *BioScience*, 51: 933–938.

Oniki, Y. & Oliveira, D. M. 2002. Análise ecológica das aves capturadas na Estação Ecológica Serra das Araras, Mato Grosso, Brasil. *Garcia de Orta, Série Zoologia*, 24: 1–6.

Pacheco, J. F. 2000. De onde provém o registro original do beija-flor *Taphrospilus hypostictus* (Gould, 1862) para o Brasil? Há razões para suspeitar dessa ocorrência? *Nattereria*, 1: 25–26.

Paynter-Jr., R. A. & Traylor-Jr., M. A. 1991. *Ornithological gazetteer of Brazil, v. 1 & 2*. Cambridge: Museum of Comparative Zoology.

Piacentini, V. Q.; Aleixo, A.; Agne, C. E.; Maurício, G. N.; Pacheco, J. F.; Bravo, G. A.; Brito, G. R. R.; Naka, L. N.; Olmos, F.; Posso, S. R.; Silveira, L. F.; Betini, G. S.; Carrano, E.; Franz, I.; Lees, A. C.; Lima, L. M.; Pioli, D.; Schunck, F.; Amaral, F. R.; Bencke, G. A.; Cohn-Haft, M.; Figueiredo, L. F. A.; Straube, F. C. & Cesari, E. 2015. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia*, 23: 91–298.

Pinto, O. M. O. 1938. Catálogo das aves do Brasil e lista dos exemplares que as representam no Museu Paulista. 1ª parte: Aves não Passeriformes e Passeriformes não Oscines excluída a fam. Tyrannidae e seguintes. *Revista do Museu Paulista*, 22: i–xviii + 1–566.

Pinto, O. M. O. 1944. *Catálogo das aves do Brasil e lista dos exemplares existentes na coleção do Departamento de Zoologia, 2ª parte. Ordem Passeriformes (continuação): superfamília Tyrannoidea e subordem Passeres*. São Paulo: Departamento de Zoologia, Secretaria da Agricultura, Indústria e Comércio.

Pinto, O. M. O. 1945. Cinqüenta anos de investigação ornitológica. *Arquivos de Zoologia*, 4: 261–340.

Pinto, O. M. O. 1978. *Novo catálogo das aves do Brasil, primeira parte - Aves não Passeriformes e Passeriformes não Oscines, com exclusão da família Tyrannidae*. São Paulo: Empresa Gráfica da Revista dos Tribunais.

Por, E. D. (ed.). 1995. *The Pantanal of Mato Grosso (Brazil): world's largest wetlands*. Dordrecht: Kluwer Academic Publishers.

Raposo, M. A. & Höfling, E. 2003. Alpha taxonomy of the *Xiphorhynchus spixii* species group with the validation of *X. juruanus* Ihering, 1904. *Cotinga*, 20: 72–80.

Reichenbach, H. G. L. 1862. *Die vollständigste Naturgeschichte der Tauben und taubenartigen Vögel*. Dresden, Germany: Expedition der vollständigsten Naturgeschichte.

Reis-de-Magalhães, J. C. 1994. Sobre alguns tinamídeos florestais brasileiros. *Boletim do Centro de Estudos Ornitológicos*, 10: 16–26.

Rodrigues-Ferreira, A. 1933. Roteiro das viagens que fez pelas Capitanias do Pará, Rio Negro, Mato Grosso e Cuiabá. Alexandre Rodrigues Ferreira, a quem acompanharão os desenhistas, Joseph Joachim Freire, Joachim Joseph Codina e o jardineiro botanico, Agostinho Joachim do Cabo. *Boletim do Museu Nacional*, 9: 103–118.

Roosevelt, T. 1914. *Through the Brazilian wilderness*. New York: Charles Scribner's Sons.

Ruschi, A. 1951. Trochilídeos do Museu Nacional. *Boletim do Museu de Biologia Professor Mello Leitão, Série Biologia*, 10: 1–115.

Ruschi, A. 1953. Ninhos, ovos e algumas observações sôbre os trochilídeos: *Psilomycter theresiae theresiae* (Da Silva Maia); *Lophornis verreauxi* Bourcier; *Lophornis gouldii* (Lesson); *Phaethornis nattereri* (Berlepsch); *Chrysuronia oenone josephinae* (Bourcier & Mulsant); *Gouldomyia langsdorfii melanosternon* (Gould) e *Anthracothorax viridigula* (Boddaert). *Boletim do Museu de Biologia Professor Mello Leitão, Série Biologia*, 15: 1–13.

Ruschi, A. 1955. Algumas observações sôbre a trochilifauna da região do Pantanal Matogrossense, compreendida entre Cáceres e Tapirapoan, ou seja, entre o Pantanal norte e a Encosta dos Parecis. *Boletim do Museu de Biologia Professor Mello Leitão, Série Biologia*, 17: 1–24.

Ruschi, A. 1961. A coleção viva de Trochilidae do Museu de Biologia Prof. Mello Leitão, nos anos de 1934 até 1961. *Boletim do Museu de Biologia Professor Mello Leitão, Série Biologia*, 30: 1–41.

Ruschi, A. 1962. A muda nos Trochilidae. *Boletim do Museu de Biologia Professor Mello Leitão, Série Biologia*, 38: 1–16.

Sá, D. M.; Sá, M. R. & Lima, N. T. 2008. Telégrafos e inventário do território no Brasil: as atividades científicas da Comissão Rondon (1907–1915). *História, Ciências, Saúde*, 15: 779–810.

Scalon, L. & Sigrist, T. 2013. *Taiamã, a vida às margens do Pantanal*. Vinhedo: Avis Brasilis.

Schifter, H.; Bauemfeind, E. & Schifter, T. 2007. *Kataloge der wissenschaftlichen Sammlungen des Naturhistorischen Museums in Wien, Band 20, Aves, Heft 1, Die Typen der Vogelsammlung des Naturhistorischen Museums Wien. Teil I. Nonpasseres*. Wien: Naturhistorisches Museum.

Schubart, O.; Aguirre, Á. C. & Sick, H. 1965. Contribuição para o conhecimento da alimentação das aves brasileiras. *Arquivos de Zoologia*, 12: 95–249.

Short, L. L. 1975. A zoogeographical analysis of the South American Chaco avifauna. *Bulletin of the American Museum of Natural History*, 154: 163–352.

Sick, H. 1960. Zur Systematik und Biologie der Bürzelstelzer (Rhinocryptidae), speziell Brasiliens. *Journal für Ornithologie*, 101: 141–173.

Sick, H. 1997. *Ornitologia Brasileira*. Rio de Janeiro: Nova Fronteira.

Silva, J. M. C. 1995. Avian inventory of the Cerrado region, South America: implications for biological conservation. *Bird Conservation International*, 5: 291–304.

Silva, J. M. C. 1996. Distribution of Amazonian and Atlantic birds in gallery forests of the Cerrado region, South America. *Ornitología Neotropical*, 7: 1–18.

Silva, J. M. C. 1997. Endemic bird species and conservation in the Cerrado Region, South America. *Biodiversity and Conservation*, 6: 435–450.

Silva, J. M. C. & Oniki, Y. 1988. Lista preliminar da avifauna da Estação Ecológica Serra das Araras, Mato Grosso, Brasil. *Boletim do Museu Paraense Emílio Goeldi, Série Zoologia*, 4: 123–143.

Silva, J. S. V. & Caputo, A. C. B. 2010. Localização e distribuição da vegetação Savana Estépica (Chaco) no Pantanal brasileiro, p. 314–323. *In*: Silva, J. S. V. (ed.) Annals of 3º Simpósio de Geotecnologias no Pantanal. Cáceres: Embrapa Informática Agropecuária, INPE.

Silva, R. M. M. & Carniello, M. A. 2007. Ocorrência de macrófitas em lagoas intermitentes e permanentes em Porto Limão Cáceres-MT. *Revista Brasileira de Biociências*, 5: 519–521.

Silveira, L. F. & D'Horta, F. M. 2002. A avifauna da região de Vila Bela da Santíssima Trindade, Mato Grosso. *Papéis Avulsos de Zoologia*, 42: 265–286.

Simon, E. 1912. Note sur quelques Trochilidae du Matto-Grosso (Brésil). *Bulletin du Muséum National d'Histoire Naturelle*, 18: 500–502.

Soares, J. P. M. & Ferrão, C. (org.). 2005. *Viagem ao Brasil de Alexandre Rodrigues Ferreira, v. 1, coleção etnográfica*. Belo Horizonte: Kapa Editorial.

Stone, W. & Roberts, R. 1934. Zoological results of the Matto Grosso expedition to Brazil in 1931 - III. Birds. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 86: 363–397.

Stotz, D. F.; Lanyon, S. M.; Schulenberg, T. S.; Willard, D. E.; Peterson, A. T. & Fitzpatrick, J. 1997. An avifaunal survey of two tropical forest localities on the middle Rio Jiparaná, Rondônia, Brazil. *Ornithological Monographs*, 48: 763–781.

Swainson, W. 1838. *Animals in Menageries*. London, UK: Printed for Longman, Orme, Brown, Green, & Longmans, and John Taylor.

Tubelis, D. P. & Tomas, W. M. 2003. Bird species of the Pantanal wetland, Brazil. *Ararajuba*, 11: 5–37.

Valadão, R. M. 2012. As aves da Estação Ecológica Serra das Araras, Mato Grosso, Brasil. *Biota Neotropica*, 12: 263–281.

Vanzolini, P. E. 1976. On the lizards of the Cerrado - Caatinga contact: evolutionary and zoogeographical implications. *Papéis Avulsos de Zoologia*, 29: 111–119.

Vanzolini, P. E. 1993. As viagens de Johann Natterer no Brasil, 1817–1835. *Papéis Avulsos de Zoologia*, 38: 17–60.

Vanzolini, P. E. 1996. A contribuição zoológica dos primeiros naturalistas viajantes no Brasil. *Revista USP*, 30: 190–238.

Vasconcelos, M. F. & Hoffmann, D. 2006. Os bosques secos chiquitanos também são nossos! *Atualidades Ornitológicas*, 130: 10–11.

Vasconcelos, M. F.; Lopes, L. E.; Hoffmann, D.; Silveira, L. F. & Schunck, F. 2008. New and noteworthy records of birds from the Pantanal, Chiquitano dry forest and Cerrado of south-western Brazil. *Bulletin of the British Ornithologists' Club*, 128: 57–67.

Vasconcelos, M. F.; Valério, F. A.; Pacheco, J. F. & Gomes, H. B. 2014. Centenário da Expedição Roosevelt-Rondon e suas contribuições à ornitologia brasileira. *Atualidades Ornitológicas*, 180: 38–50.

Vielliard, J. M. E. 1989. Uma nova espécie de *Glaucidium* (Aves, Strigidae) da Amazônia. *Revista Brasileira de Zoologia*, 6: 685–693.

Vielliard, J. M. E. 1994. *Catálogo dos Troquilídeos do Museu de Biologia Mello Leitão*. Santa Teresa: Ministério da Cultura, Instituto Brasileiro do Patrimônio Cultural, Museu de Biologia Mello Leitão.

von Berlepsch, H. G. 1887. Descriptions of new species and subspecies of Trochilidae. *Ibis, 5th series*, 5: 289–298.

von Berlepsch, H. G. 1911. Revision der Tanagriden, p. 1001–1161. *In*: Schalow, H. (ed.). *Verhandlungen des V Internationalen Orithologen-Kongresses*. Berlin: Deutsche Ornithologische Gesellschaft.

von Pelzeln, A. 1868-1870. *Zur ornithologie Brasiliens: resultate von Johann Natterers reisen in den Jahren 1817 bis 1835, parts I-IV*. Vienna, Austria: Pichler's Withwe & Sohn.

Warren, R. L. M. 1966. *Type-specimens of birds in the British Museum (Natural History), v. 1, non-passerines*. London: British Museum.

Werneck, F. P. 2011. The diversification of eastern South American open vegetation biomes: historical biogeography and perspectives. *Quaternary Science Reviews*, 30: 1630–1648.

Whittaker, A. 2009. Pousada Rio Roosevelt: a provisional avifaunal inventory in south- western Amazonian Brazil, with information on life history, new distributional data and comments on taxonomy. *Cotinga*, 31: 20–43.

Willis, E. O. 1976. Effects of a cold wave on an Amazonian avifauna in the upper Paraguay drainage, Western Mato Grosso, and suggestions on Oscine-Suboscine relationships. *Acta Amazonica*, 6: 379–394.

Willis, E. O. & Oniki, Y. 1990. Levantamento preliminar das aves de inverno em dez áreas do sudoeste de Mato Grosso, Brazil. *Ararajuba*, 1: 19–38.

Willis, E. O. & Oniki, Y. 1991. Avifaunal transects across the open zones of northern Minas Gerais, Brazil. *Ararajuba*, 2: 41–58.

Zimmer, J. T. 1945. Studies of Peruvian birds. L. The genera *Ramphocelus*, *Piranga*, *Habia*, *Lanio*, and *Tachyphonus*. *American Museum Novitates*, 1304: 1–26.

Zimmer, K. J.; Parker-III, T. A.; Isler, M. L. & Isler, P. R. 1997. Survey of a southern Amazonian avifauna: the Alta Floresta region, Mato Grosso, Brazil. *Ornithological Monographs*, 48: 887–918.

Associate Editor: Marcos P. Dantas.

APPENDIX I

PRIMARY LIST. Bird species recorded in the municipality of Cáceres, Mato Grosso, Brazil. Taxonomy and systematics of the species follow the 4th edition of the Howard and Moore Checklist (Dickinson & Christidis 2014, Dickinson & Remsen-Jr. 2013). We only cited museums as source of records when the record has not been published before. Otherwise, the museums that contained specimens are indicated only in the "specimens" column. Table 1 present the full name of the institutions cited and Table 2 presents a gazetteer of the localities of records.

Taxa	Localities of records and sources	Month of record	Photo	Specimen
ORDER RHEIFORMES				
Family Rheidae				
Rhea americana (Linnaeus, 1758)	FB[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[3,12]	2,5,7,8,9,10,11	WA	ANSP, DMNS, NMW
Order Tinamiformes				
Family Tinamidae				
Crypturellus soui (Hermann, 1783)	MC[12] PL[48]	1		
Crypturellus undulatus (Temminck, 1815)	CA[40] CC[30,47] FB[50] FC[47] FD[41,50] FJ[20] FP[50] FS[50] MC[3,12] PL[48] RJ[47]	1,2,3,4,5,7,8,9,10,11	WA	ANSP, BMNH, MZUSP, MNRJ, NMW, SMF
Crypturellus parvirostris (Wagler, 1827)	CC[30] FB[50] FC[47] FD[41,50] FP[50] FS[50] MC[12] PL[48] PS[47]	1,2,3,4,5,6,7,8,9,11		ANSP, MZUSP, NMW
Crypturellus tataupa (Temminck, 1815)	CC[18] FB[50] FP[50] FS[50] MC[12] PL[48]	1,2,4,5,7,8,9,11		MNHN
Rhynchotus rufescens (Temminck, 1815)	FB[50] FD[16,27] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,7,8,9,11,12	WA	AMNH, FMNH
ORDER ANSERIFORMES				
Family Anhimidae				
Chauna torquata (Oken, 1816)	BM[50] CC[47,50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[3,12] RC[47]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, NMW
Family Anatidae				
Dendrocygna viduata (Linnaeus, 1766)	BM[50] CC[30] ET[50] FB[50] FC[47] FD[9,27,40,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, MZUSP, NMW, SMF
Dendrocygna autumnalis (Linnaeus, 1758)	BM[50] ET[50] FB[50] FC[47] FD[9,40,41,50] FP[50] LC[47] MC[12]	1,2,3,4,5,6,8,9,10,11,12	WA	ANSP, DMNS, NMW, SMF
Nomonyx dominicus (Linnaeus, 1766)	FC[47]	1		NMW
Neochen jubata (von Spix, 1825)	LC[47]	3		NMW
Amazonetta brasiliensis (J.F. Gmelin, 1789)	BM[50] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11	WA	
Sarkidiornis melanotos (Pennant, 1769)	LC[47]	3		NMW
Cairina moschata (Linnaeus, 1758)	BM[50] ET[50] FB[50] FC[47] FD[9,27,37,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, MNRJ, NMW
ORDER GALLIFORMES				
Family Cracidae				
Penelope superciliaris Temminck, 1815	CC[30] MC[12]	12		MZUSP
Penelope ochrogaster von Pelzeln, 1870	CC[6] FB[50] FD[9,27] FF[47] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,11	WA	AMNH, DMNS, DZUFMG, MNRJ, NMW, UFMT
Pipile cumanensis grayi (von Pelzeln, 1870)	FG[47]	7,9	WA	NMW
Pipile cujubi nattereri Reichenbach, 1861	CC[30,47] ET[50] FD[9,27,50] FF[47] FP[50] FS[50] MC[3,12]	2,3,4,7,8,9,11	WA	AMNH, DMNS, MZUSP, NMW
Ortalis canicollis (Wagler, 1830)	CC[47] ET[50] FB[50] FC[47] FD[9,16,41,50] FP[50] FS[50] MC[3,12]	1,2,3,4,5,7,8,9,10,11	WA	ANSP, DMNS, FMNH, MZUSP, NMW, UFMT
Crax fasciolata von Spix, 1825	ET[50] FB[50] FC[47] FD[9,27,41,50] FP[50] FS[50] MC[3,12] RC[47] RS[47]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, BMNH, DMNS, MZUSP, NMW, UFMT
Mitu tuberosum (von Spix, 1825)	MC	1	WA	

Taxa	Localities of records and sources	Month of record	Photo	Specimen
ORDER PHOENICOPTERIFORMES				
Family Podicipedidae				
Podilymbus podiceps (Linnaeus, 1758)	FD[50]	9		
Tachybaptus dominicus (Linnaeus, 1766)	BM[50] ET[50] FC[47] FD[50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	NMW
ORDER COLUMBIFORMES				
Family Columbidae				
Columba livia J.F. Gmelin, 1789	BM[50]	1,2,3,4,5,6,7,8,9,10,11	WA	
Patagioenas speciosa (J.F. Gmelin, 1789)	CC[30] FB[50] FD[50] MC[12] PL[48]	2,7,8,9		MZUSP
Patagioenas picazuro (Temminck, 1813)	BM[50] CC[18] ET[50] FB[50] FD[41,50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, MNHN
Patagioenas cayennensis (Bonnaterre, 1792)	BM[50] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	
Patagioenas subvinacea (Lawrence, 1868)	FD[50]	9		
Leptotila verreauxi Bonaparte, 1855	BM[50] CC[50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, MZUSP
Leptotila rufaxilla (Richard & Bernard, 1792)	FP[50]	1,2,3,4,5,7,8,9	WA	
Zenaida auriculata (Des Murs, 1847)	FD[37,41] FP[50] FS[50] MC[3,12]	4,5,6,7,8,9,11		ANSP, MNRJ
Columbina squammata (Lesson, 1831)	BM[50] FB[50] FD[50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	UFMT
Columbina minuta (Linnaeus, 1766)	CC[30] FD[9] MC[12]	12	WA	DMNS, MZUSP
Columbina talpacoti (Temminck, 1810)	AR[17] BM[50] CC[18] ET[50] FB[50] FD[9,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	DMNS, MNHN, UFMT
Columbina picui (Temminck, 1813)	BM[50] CC[5,18,47] ET[50] FB[50] FC[47] FD[9,16,41] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, BMNH, CG, DMNS, FMNH, MNHN, NMW, UFMT
Claravis pretiosa (Ferrari-Pérez, 1886)	FB[50] FD[41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,11		
Uropelia campestris (von Spix, 1825)	CA[16] CC[5] FB[50] FD[29,41,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11	WA	ANSP, CG, DMNS, DZUFMG
ORDER EURYPYGIFORMES				
Family Eurypygidae				
Eurypyga helias (Pallas, 1781)	CC[47] FB[50] FC[47] FD[50] MC[3,12] RJ[4]	2,5,7,9,10	WA	NMW
ORDER CAPRIMULGIFORMES				
Family Nyctibiidae				
Nyctibius grandis (J.F. Gmelin, 1789)	FB[50] FC[47] FD[11]	1,8	WA	FMNH, NMW, UFMT
Nyctibius griseus (J.F. Gmelin, 1789)	BM[50] FB[50] FD[50] FP[50] MC[3]	1,2,3,4,5,6,7,8,9,11	WA	UFMT
Family Caprimulgidae				
Chordeiles nacunda (Vieillot, 1817)	CC[30] FB[50] FD[27,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11	WA	MZUSP, UFMT
Chordeiles pusillus Gould, 1861	FS[50]	11,12		NMW
Chordeiles minor (J.R. Forster, 1771)	MC[12] PL[48]	1		
Lurocalis semitorquatus (J.F. Gmelin, 1789)	FD[50] MC[12] PL[48]	1,9		
Nyctiprogne leucopyga (von Spix, 1825)	FD[9,50] FS[50] MC[12]	9,11,12		DMNS, MZUSP
Nyctidromus albicollis (J.F. Gmelin, 1789)	AR[17] BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, DMNS, NMW, UFMT
Setopagis parvula (Gould, 1837)	BM[50] CC[47] ET[50] FD[41,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		ANSP, BMNH, NMW
Hydropsalis torquata (J.F. Gmelin, 1789)	CC[27] FD[27,50] MC[12] PL[48]	1,7,8		FMNH, MNHN
Nyctiphrynus ocellatus (von Tschudi, 1844)	FS[42,50]	10,11		

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Antrostomus rufus (Boddaert, 1783)	FD[50]	9		
Family Apodidae				
Chaetura meridionalis Hellmayr, 1907	FB[50] FS[50]	2,8,11		
Tachornis squamata (Cassin, 1853)	FD[50] FS[42,50]	9,10,11		
Family Trochilidae				
Glaucis hirsutus (J.F. Gmelin, 1788)	BM[50] CC[36] FD[27] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,11		AMNH
Phaethornis nattereri von Berlepsch, 1887	CC[35,36] FB[50] FC[45] FD[50] FP[50] FS[50]	1,2,3,4,7,8,9,11		MBML, MZUSP
Phaethornis subochraceus Todd, 1915	FD[19] MC[12] PL[48]	7,9		AMNH, MZUSP
Phaethornis pretrei (Lesson & Delattre, 1839)	BM[50] CC[36] ET[50] FB[50] FD[50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10		
Heliactin bilophus (Temminck, 1820)	CC[5,34,36] FB[50] FJ[5] MC[12]	7,8		CG, MBML, MNRJ
Polytmus guainumbi (Pallas, 1764)	CC[5,36,39] FB[50] FC[47] FD[50] FJ[5] MC[12]	2,3,7,8,9		CG, MBML, MNHN, NMW
Chrysolampis mosquitus (Linnaeus, 1758)	CC[14] FD[9] FP[50]	1,3,4,7,8		DMNS
Anthracothorax nigricollis (Vieillot, 1817)	BM[50] CC[5,36,50] FD[27,50] FP[50] MC[12] PP[34]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, CG, MNRJ
Lophornis gouldii (Lesson, 1832)	CC[13,35,36] MC[12]	1,7		CG
Chlorostilbon lucidus (Shaw, 1812)	CC[5,36,39] ET[50] FD[50] FJ[5] MC[12]	7,8,9		CG, MBML, MNHN
Eupetomena macroura (J.F. Gmelin, 1788)	BM[50] CC[5,34,36] FB[50] FD[9,41,50] FJ[5] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, CG, DMNS, MBML, MNRJ
Thalurania furcata (J.F. Gmelin, 1788)	CA[39] CC[13,36] FB[50] FD[9,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11	WA	CG, DMNS, MBML
Amazilia chionogaster (von Tschudi, 1845)	CC[36] MC[12]	7		MBML
Amazilia versicolor (Vieillot, 1818)	CC[36] ET[50] FJ[5] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,11		CG
Amazilia fimbriata (J.F. Gmelin, 1788)	BM[50] CC[5,39,44] ET[50] FB[50] FC[47] FD[40,41,50] FJ[5] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, CG, MBML, MNHN, MNRJ, MZUSP, NMW, SMF, UFMT
Hylocharis cyanus (Vieillot, 1818)	CA[39] ET[50] FD[50]	8,9,10		MNHN
Hylocharis chrysura (Shaw, 1812)	CA[39] CC[13,34,36] ET[50] FB[50] FD[9,11,27,41,50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11		AMNH, ANSP, CG, DMNS, FMNH, MBML, MNHN, MNRJ, MZUSP
Heliomaster longirostris (Audebert & Vieillot, 1801)	CC[36] FD[50]	9		
Heliomaster furcifer (Shaw, 1812)	CC[13,34,36] FB[50] FD[9] FJ[26] MC[12] PL[48]	5,7,8	WA	CG, DMNS, MBML, MZUSP, MNRJ
Calliphlox amethystina (Boddaert, 1783)	CC[13,36] FD[27] MC[12]	7,12	WA	AMNH, CG, MBML, MZUSP
ORDER CUCULIFORMES				
Family Cuculidae				
Crotophaga major J.F. Gmelin, 1788	BM[50] CC[30] ET[50] FB[50] FC[47] FD[9,27,50] FP[50] MC[12]	1,2,3,4,5,8,9,11,12	WA	AMNH, DMNS, MZUSP, NMW
Crotophaga ani Linnaeus, 1758	AR[17] BM[50] CC[50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS
Guira guira (J.F. Gmelin, 1788)	AR[17] BM[50] CC[50] FB[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, NMW
Tapera naevia (Linnaeus, 1766)	BM[50] FB[50] FD[11,50] FP[50] MC[12]	5,6,7,8,9,10,11		FMNH
Dromococcyx phasianellus (von Spix, 1824)	BM[50] FD[27] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11		AMNH
Dromococcyx pavoninus von Pelzeln, 1870	FB[50]	8		
Coccycua minuta (Vieillot, 1817)	BM[50] CC[30,47] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11,12	WA	BMNH, MZUSP, NMW
Piaya cayana (Linnaeus, 1766)	BM[50] CC[50] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, MZUSP, UFMT
Coccyzus euleri Cabanis, 1873	BM[50] FP[50]	1,2,3,4,5,6,7,8,9		
Coccyzus melacoryphus Vieillot, 1817	FD[27] MC[12]			AMNH

Taxa	Localities of records and sources	Month of record	Photo	Specimen
ORDER GRUIFORMES				
Family Rallidae				
Laterallus exilis (Temminck, 1831)	FD[50]	9		MZUSP
Aramides cajaneus (Statius Muller, 1776)	BM[50] CC[50] ET[50] FB[50] FD[16,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, FMNH, MZUSP, UFMT
Porzana albicollis (Vieillot, 1819)	FD[50] FP[50] MC[12] PL[48]	1,2,3,4,5,7,8,9		
Porphyrio martinicus (Linnaeus, 1766)	BM[50] FC[47] FD[50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	NMW
Porphyrio flavirostris (J.F. Gmelin, 1789)	FB[50] FC[47] FD[27] MC[12]	2,11,12	WA	AMNH, DZUFMG, NMW
Gallinula chloropus (Linnaeus, 1758)	FC[47] FD[50]	3,4,9		NMW
Family Heliornithidae				
Heliornis fulica (Boddaert, 1783)	ET[50] FD[41,50] FS[50] MC[12]	8,9,11	WA	
Family Aramidae				
Aramus guarauna (Linnaeus, 1766)	BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,16,41,50] FP[50] FS[50] MC[3,12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, NMW, UFMT
ORDER PELECANIFORMES				
Family Ciconiidae				
Mycteria americana Linnaeus, 1758	BM[50] CC[47] ET[50] FB[50] FC[47] FD[9,27,41,50] FP[50] FS[50] MC[3,12] PL[48] RE[47]	1,2,3,4,5,7,8,9,10,11,12	WA	DMNS, NMW
Ciconia maguari (J.F. Gmelin, 1789)	FB[50] FC[47] FD[9,27,50] FP[50] MC[12]	2,3,4,5,6,8,9,10	WA	DMNS, NMW
Jabiru mycteria (M.H.C. Lichtenstein, 1819)	BM[50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[3,12] PC[11] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH
Family Ardeidae				
Tigrisoma lineatum (Boddaert, 1783)	BM[50] CC[18] ET[50] FB[50] FC[47] FD[9,27,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, MNHN, MZUSP, NMW, FMT, UFMT
Agamia agami (J.F. Gmelin, 1789)	FC[47] MC[12] RC[47]	1,8	WA	NMW
Cochlearius cochlearius (Linnaeus, 1766)	FB[50] FC[47] FD[41,50] MC[12] RC[47]	6,8,9	WA	ANSP, DZUFMG, NMW, UFMT
Zebrilus undulatus (J.F. Gmelin, 1789)	FC[47]	2,9	WA	NMW
Ixobrychus exilis (J.F. Gmelin, 1789)	FD[50]	9,12	WA	
Nycticorax nycticorax (Linnaeus, 1758)	FB[50] FC[47] FD[9,41,50] MC[12] PL[48]	2,3,6,7,8,9,11	WA	ANSP, DMNS, MZUSP, NMW, UFMT
Butorides striata (Linnaeus, 1758)	BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,16,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, NMW
Bubulcus ibis (Linnaeus, 1758)	BM[50] CC[50] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		
Ardea cocoi Linnaeus, 1766	CC[50] ET[50] FB[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,7,8,9,10,11,12	WA	ANSP, DMNS, NMW
Ardea alba Linnaeus, 1758	BM[50] CC[36] ET[50] FB[50] FC[47] FD[9,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, DMNS, NMW
Syrigma sibilatrix (Temminck, 1824)	BM[50] FB[50] FD[50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	
Pilherodius pileatus (Boddaert, 1783)	BM[50] CC[47] ET[50] FB[50] FC[47] FD[9,16,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, NMW
Egretta caerulea (Linnaeus, 1758)	FD[37] FP[50]	2,3,4,5,9	WA	MNRJ
Egretta thula (Molina, 1782)	BM[50] CC[36] ET[50] FB[50] FC[47] FD[37,50] FP[50] FS[50] MC[12] PL[48] PS[47]	1,2,3,4,5,6,7,8,9,10,11	WA	MNRJ, NMW, UFMT
Family Threskiornithidae				
Platalea ajaja Linnaeus, 1758	CC[47] ET[50] FB[50] FC[47] FD[9,41,50] FP[50] MC[3,12]	2,3,4,5,6,7,8,9,11	WA	ANSP, DMNS, MZUSP, NMW, UFMT
Theristicus caerulescens (Vieillot, 1817)	CC[47] FB[50] FC[47] FD[9,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, BMNH, DMNS, MZUSP, NMW, UFMT
Theristicus caudatus (Boddaert, 1783)	BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,50] FP[50] FS[50] MC[3,12]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, NMW, UFMT
Mesembrinibis cayennensis (J.F. Gmelin, 1789)	BM[50] CC[5,50] ET[50] FB[50] FC[47] FD[41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, CG, NMW, UFMT

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Phimosus infuscatus (M.H.C. Lichtenstein, 1823)	BM[50] CA[40] ET[50] FB[50] FC[47] FD[9,27] FP[50] MC[3,12]	1,2,3,4,5,6,7,8,9,10,11	WA	BMNH, DMNS, NMW, SMF, UFMT
Plegadis chihi (Vieillot, 1817)	FC[47] PS[47]	3?,4,5,6,10		NMW
Family Phalacrocoracidae				
Phalacrocorax brasilianus (J.F. Gmelin, 1789)	BM[50] CC[50] ET[50] FB[50] FD[9,27,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS
Family Anhingidae				
Anhinga anhinga (Linnaeus, 1766)	BM[50] ET[50] FB[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[3,12] PC[11] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, BMNH, DMNS, FMNH, MZUSP, NMW
ORDER CHARADRIIFORMES				
Family Recurvirostridae				
Himantopus himantopus melanurus Vieillot, 1817	FB[50] FC[47] FD[50] FP[50] MC[12] PL[48] PS[47]	1,2,3,4,6,7,8,9	WA	BMNH, MZUSP, NMW, UFMT
Family Charadriidae				
Pluvialis dominica (Statius Muller, 1776)	CC[47] FD[50] MC[12]	9	WA	BMNH, MZUSP, NMW
Charadrius collaris Vieillot, 1818	BM[50] ET[50] FC[47] FD[9,41,50] FP[50] MC[12]	5,6,7,8,9	WA	ANSP, DMNS, MZUSP, NMW
Vanellus chilensis (Molina, 1782)	BM[50] CA[40] CC[50] ET[50] FB[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[3,12] PC[27] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, NMW, SMF, UFMT
Vanellus cayanus (Latham, 1790)	CA[40] CC[50] ET[50] FB[50] FD[9,41,50] FS[50] MC[12] PL[48]	1,2,7,8,9,11,12	WA	ANSP, DMNS, MZUSP, SMF
Family Jacanidae				
Jacana jacana (Linnaeus, 1766)	BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, BMNH, DMNS, NMW, UFMT
Family Scolopacidae				
Bartramia longicauda (Bechstein, 1812)	MC[12] RJ[47]	10		NMW
Numenius borealis (J.R. Forster, 1772)	XA[47]	10		NMW
Limosa haemastica (Linnaeus, 1758)	FC[47]	11		NMW
Calidris fuscicollis (Vieillot, 1819)	FC[47] FD[41,50] MC[12]	9,10		ANSP, MZUSP, NMW
Calidris subruficollis (Vieillot, 1819)	MC	4	WA	
Gallinago paraguaiae (Vieillot, 1816)	CC[18,30] FB[50] FC[47] FD[50] MC[12]	2,3,4,8,9	WA	BMNH, MNHN, MZUSP, NMW
Actitis macularius (Linnaeus, 1766)	BM[50] ET[50] FC[47] FD[50] FP[50] FS[50]	5,6,7,8,9,10,11	WA	NMW
Tringa solitaria A. Wilson, 1813	ET[50] FB[50] FC[47] FD[9,37,50] FS[50] MC[12]	1,2,3,8,9,11	WA	DMNS, DZUFMG, MNRJ, MZUSP, NMW, UFMT
Tringa flavipes (J.F. Gmelin, 1789)	FB[50] FC[47] FD[50] FS[50] MC[12]	8,9,10,11	WA	MZUSP, NMW
Tringa melanoleuca (J.F. Gmelin, 1789)	FC[47] FD[50]	9,11		MZUSP, NMW
Steganopus tricolor Vieillot, 1819	FC[47]	9	WA	BMNH, NMW
Family Laridae				
Rynchops niger Linnaeus, 1758	BM[50] FB[50] FC[47] FD[9,40,41,50] FP[50] FS[50] MC[3,12] PL[48] RC[47]	1,4,5,6,7,8,9,11	WA	ANSP, DMNS, MZUSP, NMW, SMF
Chroicocephalus cirrocephalus (Vieillot, 1818)	FD[50]	9		
Leucophaeus pipixcan (Wagler, 1831)	ET[51]	5		
Sternula superciliaris (Vieillot, 1819)	BM[50] ET[50] FD[9,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, MZUSP
Phaetusa simplex (J.F. Gmelin, 1789)	BM[50] CC[50] ET[50] FC[47] FD[9,41,50] FP[50] FS[50] MC[3,12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, MZUSP, NMW
ORDER ACCIPITRIFORMES				
Family Cathartidae				
Cathartes aura (Linnaeus, 1758)	BM[50] CC[50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS
Cathartes burrovianus Cassin, 1845	BM[50] ET[50] FB[50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Coragyps atratus (Bechstein, 1793)	BM[50] CC[50] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	
Sarcoramphus papa (Linnaeus, 1758)	FC[47] FD[50] FJ[47] FS[50] MC[3,12]	7,9,10,11	WA	NMW
Family Pandionidae				
Pandion haliaetus (Linnaeus, 1758)	FC[47] FD[50] FS[50] MC[12]	9,10,11	WA	NMW
Family Accipitridae				
Elanus leucurus (Vieillot, 1818)	FD[50]	9		
Gampsonyx swainsonii Vigors, 1825	BM[50] FC[47] FD[9,40,41,502] FP[50] FS[50] MC[12] PL[48] RJ[47]	1,2,3,4,5,6,7,8,9,10,11,12		ANSP, DMNS, NMW, SMF
Leptodon cayanensis (Latham, 1790)	FB[50] FD[50] MC[12] PL[48]	1,2,7,9	WA	
Chondrohierax uncinatus (Temminck, 1822)	FD[41,50] FG[47] MC[12]	7,9	WA	ANSP, NMW
Elanoides forficatus (Linnaeus, 1758)	BM[50] FB[50] FD[50] FP[50] MC[12]	1,2,3,4,5,9,10,11	WA	
Spizaetus tyrannus (zu Wied-Neuwied, 1820)	CC[30] MC[12]	2	WA	MZUSP
Spizaetus melanoleucus (Vieillot, 1816)	CC[47] FB[50] MC[12]	2,8		NMW
Spizaetus ornatus (Daudin, 1800)	MC[12] PL[48]	7		
Accipiter bicolor (Vieillot, 1817)	FD[29] MC[12] RJ[47]	10,12		DMNS, NMW
Busarellus nigricollis (Latham, 1790)	BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,16,41,50] FP[50] FS[50] MC[12] PL[48] RC[47]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, MZUSP, NMW, UFMT
Geranospiza caerulescens (Vieillot, 1817)	BM[50] CA[40] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[12] PS[47] RJ[47]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, NMW, SMF
Ictinia plumbea (J.F. Gmelin, 1788)	BM[50] FB[50] FC[47] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11	WA	NMW
Rostrhamus sociabilis (Vieillot, 1817)	BM[50] CC[47] ET[50] FB[50] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, NMW, YPM, UFMT
Rupornis magnirostris (J.F. Gmelin, 1788)	AR[17] BM[50] CC[50] ET[50] FB[50] FC[47] FD[41,50] FP[50] FS[50] MC[12] PC[11] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, FMNH, MZUSP, NMW, UFMT
Buteogallus meridionalis (Latham, 1790)	BM[50] CC[50] ET[50] FB[50] FD[16,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DZUFMG, FMNH, NMW, UFMT
Buteogallus urubitinga (J.F. Gmelin, 1788)	BM[50] CC[47] ET[50] FC[47] FD[16,41,50] FP[50] FS[50] MC[12] RC[47]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, FMNH, MZUSP, NMW
Geranoaetus albicaudatus (Vieillot, 1816)	BM[50] FD[50] FF[47] FP[50] FS[50]	5,7,8,9,11	WA	NMW
Pseudastur albicollis (Latham, 1790)	CC[5] FS[42,50]	7,10,11		CG
Buteo nitidus (Latham, 1790)	CC[30] FB[50] FC[47] FD[9,50] FS[50] MC[12]	2,4,9,11		DMNS, MZUSP, NMW
Buteo albonotatus Kaup, 1847	FB[50]	8	WA	
ORDER STRIGIFORMES				
Family Tytonidae				
Tyto alba (Scopoli, 1769)	ET[50] FD[41,50] FP[50] MC[12]	1,2,3,4,5,7,8,9		ANSP
Family Strigidae				
Glaucidium hardyi Vielliard, 1989	FC[43]	2		NMW
Glaucidium brasilianum (J.F. Gmelin, 1788)	R[17] BM[50] FB[50] FD[9,27,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12		AMNH, ANSP, DMNS, UFMT
Athene cunicularia (Molina, 1782)	BM[50] FB[50] FD[50] FP[50] FS[50]	1,2,3,4,5,6,7,8,9,10,11	WA	UFMT
Asio clamator (Vieillot, 1808)	FP[50]	2,3,5,7		
Megascops choliba (Vieillot, 1817)	BM[50] CC[5] FB[50] FD[50] FP[50]	1,2,3,4,5,6,7,8,9,10,11		CG
Bubo virginianus (J.F. Gmelin, 1788)	FD[41,50] FP[50] FS[50] MC[12]	1,2,4,6,7,9,11	WA	ANSP
ORDER TROGONIFORMES				
Family Trogonidae				
Trogon melanurus Swainson, 1838	CC[30,47] MC[12] RS[47]	7,8,9,11	WA	MZUSP, NMW

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Trogon viridis Linnaeus, 1766	CC[47] RS[47]	8		NMW
Trogon curucui Linnaeus, 1766	CC[30,47,50] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11	WA	ANSP, MZUSP, NMW, UFMT
Trogon collaris Vieillot, 1817	CC[47]	8		NMW
ORDER PICIFORMES				
Family Galbulidae				
Brachygalba lugubris (Swainson, 1838)	CC[30] MC[12]	11,12		MZUSP
Galbula ruficauda Cuvier, 1816	BM[50] CC[30,47,50] ET[50] FB[50] FD[9,15,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, MZUSP, NMW
Family Bucconidae				
Nystalus chacuru (Vieillot, 1816)	BM[50] FB[50] FC[47] FD[9,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, NMW
Nystalus maculatus (J.F. Gmelin, 1788)	BM[50] CC[5] FC[47] FD[50] FP[50] RE[47]	1,2,3,4,5,7,8,9,10,11		CG, NMW
Nonnula ruficapilla (von Tschudi, 1844)	CC[30,47,50] MC[12]	7,8,9,11		BMNH, MZUSP, NMW
Monasa nigrifrons (von Spix, 1824)	BM[50] CC[30,47,50] ET[50] FB[50] FC[47] FD[9,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, MZUSP, NMW, UFMT
Chelidoptera tenebrosa (Pallas, 1782)	BM[50] FD[50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		
Family Picidae				
Picumnus aurifrons von Pelzeln, 1870	FC[47]	10		NMW
Picumnus albosquamatus d'Orbigny, 1840	CC[50] FB[50] FD[27,29,41,50] FF[47] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, DZUFMG, MZUSP, NMW, UFMT
Dryocopus lineatus (Linnaeus, 1766)	FB[50] FD[9,27,37,41,502] FS[50] MC[12] PL[48]	2,3,7,8,9,11	WA	AMNH, ANSP, DMNS, MNRJ, UFMT
Celeus torquatus (Boddaert, 1783)	FC[47] MC[12]	10,11		NMW
Celeus lugubris (Malherbe, 1851)	CC[30,47,50] ET[50] FB[50] FC[47] FD[11,27,37,41] FS[50] MC[12] PL[48]	1,2,6,7,8,9,11,12	WA	AMNH, ANSP, DZUFMG, FMNH, MNRJ, MZUSP, NMW, UFMT
Piculus leucolaemus (Natterer & Malherbe, 1845)	CC[5]	7		CG
Piculus chrysochloros (Vieillot, 1818)	FB[50] FD[50] MC[12]	2,8,9	WA	DZUFMG, MZUSP, UFMT
Colaptes melanochloros (J.F. Gmelin, 1788)	BM[50] CC[47] FB[50] FC[47] FD[9,11,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, FMNH, NMW
Colaptes campestris (Vieillot, 1818)	BM[50] CC[50] FB[50] FD[9,37,50] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,10,11,12	WA	DMNS, MNRJ, UFMT
Campephilus melanoleucos (J.F. Gmelin, 1788)	BM[50] CC[30,47] ET[50] FB[50] FC[47] FD[9,11,41,50] FP[50] FS[50] MC[12] PL[48] RJ[47]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, MZUSP, NMW, UFMT
Melanerpes candidus (Otto, 1796)	BM[50] CC[50] FB[50] FC[47] FD[50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	NMW
Melanerpes cruentatus (Boddaert, 1783)	BM[50] CC[5,47] FC[47] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	CG, NMW
Veniliornis passerinus (Linnaeus, 1766)	BM[50] CC[5,30,47] ET[50] FB[50] FC[47] FD[11,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11,12	WA	ANSP, BMNH, CG, FMNH, MZUSP, NMW
Veniliornis affinis (Swainson, 1821)	CC[47]	8		NMW
Family Ramphastidae				
Capito dayi Cherrie, 1916	RJ[21]			MNRJ
Ramphastos toco Statius Muller, 1776	BM[50] CC[5,18,28] ET[50] FB[50] FC[47] FD[9,11,27,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, CG, DMNS, FMNH, MNHN, MNRJ, MZUSP, NMW
Ramphastos tucanus Linnaeus, 1758	RJ[28]			MNRJ
Ramphastos vitellinus M.H.C. Lichtenstein, 1823	CC[47] RS[47]	8		NMW
Pteroglossus inscriptus Swainson, 1822	MC	5	WA	
Pteroglossus castanotis Gould, 1834	AR[17] BM[50] CC[18,30] FB[50] FC[47] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, MNHN, MZUSP, NMW, UFMT

Taxa	Localities of records and sources	Month of record	Photo	Specimen
ORDER CORACIIFORMES				
Family Momotidae				
Momotus momota (Linnaeus, 1766)	CC[47] ET[50] FB[50] FD[50] FJ[20] FP[50] FS[50] MC[12] PL[48] QU[22] RJ[22] RS[22] TU[22]	1,2,3,4,5,7,8,9,11	WA	MNRJ, NMW
Family Alcedinidae				
Megaceryle torquata (Linnaeus, 1766)	BM[50] CC[50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, MZUSP
Chloroceryle amazona (Latham, 1790)	BM[50] CC[18] ET[50] FB[50] FD[9,11,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, MNHN, UFMT
Chloroceryle aenea (Pallas, 1764)	FB[50] FC[47] FD[27,50] FS[50] MC[12]	2,3?,8,9,10,11	WA	AMNH, NMW
Chloroceryle americana (J.F. Gmelin, 1788)	BM[50] CC[50] FB[50] FD[9,11,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, UFMT
Chloroceryle inda (Linnaeus, 1766)	FB[50] FS[50]	2,11		
Family Cariamidae				
Cariama cristata (Linnaeus, 1766)	FB[50] FD[41,50] FS[50] MC[3,12] PD[47] PP[23]	1,2,5,6,7,8,9,11	WA	MNRJ, UFMT
ORDER FALCONIFORMES				
Family Falconidae				
Herpetotheres cachinnans (Linnaeus, 1758)	BM[50] CC[30,50] FB[50] FC[47] FD[9,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, MZUSP, NMW
Micrastur ruficollis (Vieillot, 1817)	FD[50]	9		
Micrastur semitorquatus (Vieillot, 1817)	CC[47] FB[50] FD[50] FP[50] MC[12]	2,8,9		NMW
Caracara plancus (J.F. Miller, 1777)	BM[50] CC[50] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP
Milvago chimachima (Vieillot, 1816)	BM[50] CC[18] FB[50] FD[9,41,50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11		ANSP, DMNS, MNHN
Falco sparverius Linnaeus, 1758	BM[50] CC[1,5] FB[50] FD[50] FJ[1] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	CG, MNRJ, UFMT
Falco rufigularis Daudin, 1800	FB[50] FC[47] FD[50] FS[50] MC[12] PL[48]	1,2,5,9,11,12	WA	NMW
Falco femoralis Temminck, 1822	BM[50] FB[50] FC[47] FD[16,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	FMNH, NMW
Falco peregrinus Tunstall, 1771	CC[18] MC[12]	3		MNHN
ORDER PSITTACIFORMES				
Family Psittacidae				
Myiopsitta monachus (Boddaert, 1783)	CC[8] ET[50] FB[50] FD[9,27,41,50] FS[50] MC[3,12]	1,5,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, MNHN, MZUSP
Brotogeris chiriri (Vieillot, 1818)	AR[17] BM[50] CA[2,33] CC[5,18,30] ET[50] FB[50] FD[9,11,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, CG, DMNS, FMNH, MNHN, MZUSP, ROM, UFMT
Pionus maximiliani (Kuhl, 1820)	BM[50] ET[50] FD[9,11,41,50] FJ[7] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, MNRJ
Pionus menstruus (Linnaeus, 1766)	CC[30,47] FB[50] FD[9,50] FG[47] MC[12]	2,4,5,7,8,9,10,11	WA	DMNS, MZUSP, NMW
Alipiopsitta xanthops (von Spix, 1824)	FG[47] FJ[47] MC[3]	3,7		NMW
Amazona aestiva (Linnaeus, 1758)	BM[50] CC[30] ET[50] FB[50] FD[9,11,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, MNRJ, MZUSP, UFMT
Amazona amazonica (Linnaeus, 1766)	BM[50] CC[5,18,24,30,47,50] ET[50] FB[50] FD[9,41,50] FP[50] MC[12] MT[24] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, CG, DMNS, MNHN, MNRJ, MZUSP, NMW
Forpus xanthopterygius (von Spix, 1824)	ET[50] FD[50]	8,9		
Pyrrhura perlata (von Spix, 1824)	SA[20]	12		MNRJ
Anodorhynchus hyacinthinus (Latham, 1790)	FB[50] FD[9,11,27,41] FF[47] FS[50] MC[3,12]	2,7,8,11,12	WA	AMNH, ANSP, DMNS, FMNH, NMW
Eupsittula aurea (J.F. Gmelin, 1788)	BM[50] CC[30] ET[50] FB[50] FD[2,9,11,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11,12,12	WA	AMNH, ANSP, CG, DMNS, FMNH, MZUSP, UFMT

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Aratinga weddellii (Deville, 1851)	FU[24], PL[48]	1,11,12	WA	MNRJ
Aratinga nenday (Vieillot, 1823)	ET[50] FD[27,50] FS[50] MC[12]	8,9,11	WA	AMNH
Primolius auricollis (Cassin, 1853)	BM[50] CA[2] CC[47] FB[50] FD[9,27,41,50] FJ[20] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, BMNH, DMNS, DZUFMG, NMW, UFMT
Ara ararauna (Linnaeus, 1758)	BM[50] FB[50] FD[50] FP[50] MC[3] RJ[24]	1,2,3,4,5,6,7,8,9,10,11,12	WA	MNRJ
Ara chloropterus G.R. Gray, 1859	BM[50] FB[50] FC[47] FD[27] FF[47] FJ[20] FP[50] FS[50] MC[3,12]	1,2,3,4,5,6,7,8,9,11	WA	MNRJ, NMW
Diopsittaca nobilis (Linnaeus, 1758)	BM[50] ET[50] FB[50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	
Psittacara acuticaudatus (Vieillot, 1818)	FD[9,11] FF[47] FS[50] MC[12]	7,10,11,12		DMNS, NMW
Psittacara leucophthalmus (Statius Muller, 1776)	BM[50] ET[50] FB[50] FD[2,9,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS
ORDER PASSERIFORMES				
Family Pipridae				
Neopelma pallescens (Lafresnaye, 1853)	FD[50] FP[50]	1,2,3,4,5,6,7,8,9,10,11		
Manacus manacus (Linnaeus, 1766)	FP[50]	1,2,3,4,5,7,8,9		
Pipra fasciicauda Hellmayr, 1906	CC[31,47] FB[50] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,7,8,9,11		AMNH, ANSP, MZUSP, NMW
Antilophia galeata (M.H.C. Lichtenstein, 1823)	FD[27] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11		AMNH
Family Cotingidae				
Cephalopterus ornatus E. Geoffroy Saint-Hilaire, 1809	CC[8,47] FC[47] RC[8]	2,8		NMW
Gymnoderus foetidus (Linnaeus, 1758)	CC[47] FB[50] FC[47] FD[27,50] FS[50] MC[12] RC[47] RE[47]	1,2,8,9,10,11,12	WA	AMNH, BMNH, DZUFMG, NMW
Family Onychorhynchidae				
Family Tityridae				
Schiffornis turdina (zu Wied-Neuwied, 1831)	CC[47]	8		NMW
Tityra inquisitor (M.H.C. Lichtenstein, 1823)	CC[30] FB[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		MZUSP
Tityra cayana (Linnaeus, 1766)	FB[50] FD[50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,11	WA	
Tityra semifasciata (von Spix, 1825)	MC[12] PL[48]	1		
Xenopsaris albinucha (Burmeister, 1869)	FD[50]	9		
Pachyramphus viridis (Vieillot, 1816)	CC[18] FB[50] MC[12]	5,8		MNHN
Pachyramphus validus (M.H.C. Lichtenstein, 1823)	FB[50] FP[50] MC[12]	3,4,5,7,8,9		
Pachyramphus marginatus (M.H.C. Lichtenstein, 1823)	MC	12	WA	
Pachyramphus polychopterus (Vieillot, 1818)	FB[50] FD[27,50] FS[50] MC[12] RJ[47]	2,9,10,11		AMNH, NMW
Family Pipromorphidae				
Corythopis delalandi (Lesson, 1831)	CC[47] FS[50]	8,11		NMW
Mionectes oleagineus (M.H.C. Lichtenstein, 1823)	FP[50]	2,3,4,7,8,9		
Leptopogon amaurocephalus von Tschudi, 1846	FD[50] FP[50] FS[50]	1,2,3,4,5,7,8,9,11		
Tolmomyias sulphurescens (von Spix, 1825)	CC[50] FB[50] FD[27,41,50] MC[12] PL[48]	1,2,6,8,9		AMNH, ANSP, MZUSP
Myiornis ecaudatus (d'Orbigny & Lafresnaye, 1837)	FP[50]	4,5,7,8,9		
Hemitriccus striaticollis (Lafresnaye, 1853)	CC[31,47] FD[27,50] FP[50] MC[12]	1,2,3,4,5,7,8,9,11	WA	AMNH, BMNH, MZUSP, NMW
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	CC[18] FB[50] FD[27,41] FP[50] FS[50] MC[12] PL[48] RJ[47]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, MNHN
Poecilotriccus latirostris (von Pelzeln, 1868)	BM[50] ET[50] FB[50] FD[9,27,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, DMNS, DZUFMG, MZUSP
Todirostrum cinereum (Linnaeus, 1766)	BM[50] CC[18] ET[50] FC[47] FD[9,16,27,41] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, NMW, MNHN

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Family Tyrannidae				
Hirundinea ferruginea (J.F. Gmelin, 1788)	FD[50]	9		
Inezia inornata (Salvadori, 1897)	FB[50] FD[50] MC[12] PL[48]	7,8,9		MZUSP
Euscarthmus meloryphus zu Wied-Neuwied, 1831	BM[50] FB[50] FD[16,50] FP[50] MC[12] PL[48]	4,5,6,7,8,9,10,11		DMNS, FMNH, MZUSP, UFMT
Camptostoma obsoletum (Temminck, 1824)	CC[5,18] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11	WA	ANSP, CG, MNHN, UFMT
Elaenia flavogaster (Thunberg, 1822)	BM[50] CC[18] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		MNHN
Elaenia parvirostris von Pelzeln, 1868	FB[50] MC[12]	5		UFMT
Elaenia spectabilis von Pelzeln, 1868	CC[5] FD[50]	7,9		CG
Elaenia chiriquensis Lawrence, 1865	FD[50]	5,9		MZUSP, UFMT
Elaenia albiceps chilensis Hellmayr, 1927	FB[50]	5		UFMT
Myiopagis caniceps (Swainson, 1835)	FD[50] MC[12] PL[48]	1,9		
Myiopagis gaimardii (d'Orbigny, 1840)	FB[50] FD[50] FP[50] MC[12] PL[48]	1,2,3,4,7,8,9		
Myiopagis viridicata (Vieillot, 1817)	FB[50] FD[27] MC[12] PL[48]	1,2		AMNH
Capsiempis flaveola (M.H.C. Lichtenstein, 1823)	FB[50] MC[12] PL[48]	1,2,7,8		UFMT
Phyllomyias fasciatus (Thunberg, 1822)	FD[50]	9		
Phaeomyias murina (von Spix, 1825)	CC[18] FD[9,50] MC[12]	1,3,9,11	WA	DMNS, MNHN
Pseudocolopteryx sclateri (Oustalet, 1892)	FD[50] PS[47]	6,9		NMW
Attila bolivianus Lafresnaye, 1848	CC[47] FB[50] FD[27,50] FP[50] FS[50] MC[12]	1,2,3,8,9,11	WA	AMNH, MZUSP, NMW
Legatus leucophaius (Vieillot, 1818)	BM[50] FB[50] FD[27,50] FP[50] FS[50] PL[48]	1,2,3,4,5,6,7,8,9,10,11		AMNH
Ramphotrigon ruficauda (von Spix, 1825)	CC[47] MC[12]	?		NMW
Pitangus sulphuratus (Linnaeus, 1766)	AR[17] BM[50] CC[50] ET[50] FB[50] FD[9,16,27,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, MZUSP
Pitangus lictor (M.H.C. Lichtenstein, 1823)	FB[50] FD[16] MC[12]	2,7,8	WA	FMNH
Machetornis rixosa (Vieillot, 1819)	BM[50] FB[50] FD[11,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	FMNH
Megarynchus pitangua (Linnaeus, 1766)	BM[50] CC[18] ET[50] FB[50] FD[9,27] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12		AMNH, DMNS, MNHN
Myiodynastes maculatus (Statius Muller, 1776)	BM[50] FB[50] FD[9,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS
Myiozetetes cayanensis (Linnaeus, 1766)	BM[50] ET[50] FB[50] FD[27,41] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP
Empidonomus varius (Vieillot, 1818)	BM[50] ET[10] FB[50] FD[50] FP[50] MC[12] PL[48] RJ[47]	1,2,3,4,5,6,7,8,9,10,11	WA	DZUFMG, NMW, UFMT
Griseotyrannus aurantioatrocristatus (d'Orbigny & Lafresnaye, 1837)	CC[30] FD[50] MC[12] PL[48]	1,9,11		MZUSP
Tyrannus albogularis Burmeister, 1856	BM[50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10	WA	
Tyrannus melancholicus Vieillot, 1819	BM[50] ET[50] FB[50] FD[9,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS
Tyrannus savana Daudin, 1802	BM[50] CC[18] FB[50] FD[9,37,41,50] FP[50] FS[50] MC[12]	2,3,5,8,9,10,11	WA	ANSP, DMNS, MNHN
Casiornis rufus (Vieillot, 1816)	ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11	WA	ANSP, MZUSP, UFMT
Sirystes sibilator (Vieillot, 1818)	FB[50] FP[50] MC[12] PL[48]	1,2,3,4,5,7,8,9		DZUFMG
Myiarchus swainsoni Cabanis & Heine, 1859	FB[50] FD[50] MC[12]	2,8,9		
Myiarchus tuberculifer (d'Orbigny & Lafresnaye, 1837)	CC[47] MC[12]			NMW
Myiarchus ferox (J.F. Gmelin, 1789)	BM[50] CC[50] ET[10,50] FB[50] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, DZUFMG
Myiarchus tyrannulus (Statius Muller, 1776)	BM[50] CC[5] FB[50] FD[9,16,41,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, CG, DMNS, FMNH, MZUSP
Colonia colonus (Vieillot, 1818)	FP[50] MC[12]	3,4,5,7		

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Myiophobus fasciatus (Statius Muller, 1776)	FD[11,50] MC[12] PL[48]	1,7,9		FMNH
Sublegatus modestus (zu Wied-Neuwied, 1831)	CC[18] ET[50] FB[50] FD[41,50] FP[50] MC[12] PL[48]	5,6,7,8,9	WA	ANSP, MNHP, MZUSP, UFMT
Pyrocephalus rubinus (Boddaert, 1783)	CC[18,50] ET[50] FB[50] FD[9,41] FP[50] MC[3,12] PC[11]	2,3,4,5,6,7,8,9	WA	ANSP, DMNS, FMNH, MNHN
Fluvicola albiventer (von Spix, 1825)	BM[50] CC[18] ET[50] FB[50] FD[41] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, MNHN
Arundinicola leucocephala (Linnaeus, 1764)	BM[50] CC[18] FB[50] FD[9,50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	DMNS, MNHN
Gubernetes yetapa (Vieillot, 1818)	PS[47]	3,6	WA	NMW
Alectrurus risora (Vieillot, 1824)	PS[47]	6		NMW
Hymenops perspicillatus (J.F. Gmelin, 1789)	PS[47]	6		NMW
Knipolegus hudsoni P.L. Sclater, 1872	ET[50] FD[41] FP[50] MC[12]	1,2,3,4,5,8?,9		ANSP
Satrapa icterophrys (Vieillot,1818)	MC[12]	6	WA	
Xolmis cinereus (Vieillot, 1816)	BM[50] FB[50] FD[33] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	ROM
Xolmis velatus (M.H.C. Lichtenstein, 1823)	FB[50] FD[9,11,27] MC[12] PL[48]	2,7,8,11,12	WA	AMNH, DMNS, FMNH, UFMT
Cnemotriccus fuscatus (zu Wied-Neuwied, 1831)	CC[18] ET[50] FB[50] FD[27,41,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9		AMNH, ANSP, MNHN, MZUSP, UFMT
Lathrotriccus euleri (Cabanis, 1868)	FD[27,50] FS[50]	9,11		AMNH, MZUSP
Contopus cinereus (von Spix, 1825)	MC[12] PL[48]	7		
Family Thamnophilidae				
Myrmophylax atrothorax (Boddaert, 1783)	CC[30,47,50] MC[12]	7,8,12		BMNH, MZUSP, NMW
Formicivora grisea (Boddaert, 1783)	FS[50] MC[12] PL[48]	1,7,11		
Formicivora melanogaster von Pelzeln, 1868	FB[50] FD[50] MC[12] PL[48]	2,7,8,9		UFMT
Formicivora rufa (zu Wied-Neuwied, 1831)	CC[5,18] FB[50] FD[9,16,27,41] FP[50] MC[12]	1,2,3,4,5,7,8,9,10	WA	AMNH, ANSP, CG, DMNS, MNHN, UFMT
Myrmotherula axillaris (Vieillot, 1817)	CC[47]	8		NMW
Dysithamnus mentalis (Temminck, 1823)	CC[30,47] FS[50] MC[12]	8,11		MZUSP, NMW
Herpsilochmus longirostris von Pelzeln, 1868	FD[27,50] FP[50] MC[12]	1,2,3,4,5,7,8,9		AMNH
Taraba major (Vieillot, 1816)	BM[50] CC[50] ET[50] FB[50] FD[9,11,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, MZUSP, UFMT
Thamnophilus doliatus (Linnaeus, 1764)	BM[50] CC[18,50] FB[50] FD[9,41] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, DZUFMG, MNHN, UFMT
Thamnophilus sticturus von Pelzeln, 1868	BM[50] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		DZUFMG, MZUSP, UFMT
Thamnophilus amazonicus P.L. Sclater, 1858	BM[50] CC[47] MC[12]	1,2,3,4,5,7,8		NMW
Cercomacra melanaria (Ménétries, 1835)	BM[50] CA[16] CC[18,47,50] ET[50] FD[9,11,27,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, MNHN, MZUSP, NMW, UFMT, UMMZ
Drymophila devillei (Menegaux & Hellmayr, 1906)	FB[50] MC[12] PL[48]	1,2		DZUFMG
Hypocnemis ochrogyna J.T. Zimmer, 1932	CC[47]	7,8		NMW
Willisornis poecilinotus (Cabanis, 1847)	CC[47] MC[12]	9		NMW
Hypocnemoides maculicauda (von Pelzeln, 1868)	CC[47] FD[11,27,50] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, FMNH, NMW, MZUSP
Pyriglena leuconota (von Spix, 1824)	CC[30] FB[50] FF[47] FP[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11	WA	DZUFMG, MZUSP, NMW, UFMT
Family Melanopareiidae				
Melanopareia torquata (zu Wied-Neuwied, 1831)	CC[38]	9		MNRJ
Family Dendrocolaptidae				
Sittasomus griseicapillus (Vieillot, 1818)	CC[5] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		CG, MZUSP

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Dendrocincla fuliginosa (Vieillot, 1818)	MC[12] PL[48]	7		
Glyphorynchus spirurus (Vieillot, 1819)	FP[50]	3,4,7,8,9		
Dendrocolaptes picumnus M.H.C. Lichtenstein, 1820	FB[50] FD[50] FS[50] MC[12] PL[48]	1,2,7,8,9,11		DZUFMG
Dendrocolaptes platyrostris von Spix, 1824	FB[50]	5	WA	UFMT
Xiphocolaptes major (Vieillot, 1818)	BM[50] FB[50] FC[47] FD[9,11] FP[50] MC[12] PL[48] RE[47] RJ[47]	1,2,3,4,5,6,7,8,9,10,11,12		DMNS, DZUFMG, FMNH, NMW
Xiphorhynchus elegans (von Pelzeln, 1868)	RS[32]			MNRJ
Xiphorhynchus guttatus (M.H.C. Lichtenstein, 1820)	CC[5,47] FB[50] FD[27,50] FS[50] MC[12] PL[48]	1,2,6,7,8,9,11	WA	AMNH, CG, MZUSP, NMW, UFMT
Dendroplex picus (J.F. Gmelin, 1788)	BM[50] CC[47,50] ET[50] FB[50] FC[47] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		AMNH, ANSP, MZUSP, NMW, UFMT, UMMZ
Campylorhamphus trochilirostris (M.H.C. Lichtenstein, 1820)	CC[30] ET[50] FB[50] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,4,5,7,8,9,11	WA	AMNH, ANSP, MZUSP, UFMT
Lepidocolaptes angustirostris (Vieillot, 1818)	BM[50] CC[5] FB[50] FC[47] FD[11,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	CG, FMNH, NMW
Family Furnariidae				
Xenops rutilus Temminck, 1821	CC[47] MC[12] PL[48]	7,9		NMW
Furnarius leucopus Swainson, 1838	BM[50] ET[50] FD[27,41,50] FP[50] MC[3,12]	1,2,3,4,5,6,7,8,9	WA	AMNH, ANSP, MZUSP
Furnarius rufus (J.F. Gmelin, 1788)	BM[50] CC[18,50] ET[50] FB[50] FD[9,37,41] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, MNHN, MNRJ
Phacellodomus rufifrons (zu Wied-Neuwied, 1821)	BM[50] CC[18] ET[50] FD[9,11,27,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, DMNS, FMNH, MNHN
Phacellodomus ruber (Vieillot, 1817)	CC[47] FB[50] FD[27] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	NMW
Cranioleuca vulpina (von Pelzeln, 1856)	BM[50] CC[47,50] ET[50] FD[9,11,27,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, MZUSP, NMW, UFMT
Pseudoseisura unirufa (d'Orbigny & Lafresnaye, 1838)	BM[50] CC[47,50] ET[50] FB[50] FD[9,11,27,41] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, NMW, UMMZ
Schoeniophylax phryganophilus (Vieillot, 1817)	FD[9,11,41,50] FF[47] MC[12] PL[48]	3,7,9	WA	ANSP, DMNS, FMNH, MZUSP, NMW
Certhiaxis cinnamomeus (J.F. Gmelin, 1788)	BM[50] CC[50] ET[50] FB[50] FD[9,27,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	DMNS, FMNH
Synallaxis scutata P.L. Sclater, 1859	FB[50] MC[12] PL[48]	1,8		
Synallaxis albilora von Pelzeln, 1856	BM[50] CC[47,50] ET[50] FB[50] FD[9,11,27,41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, DZUFMG, FMNH, MZUSP
Synallaxis albescens Temminck, 1823	FC[47]			NMW
Synallaxis frontalis von Pelzeln, 1859	CC[18] FD[41,50] FS[50] MC[12] PL[48]	1,4,7,9,11		ANSP, MNHN, MZUSP
Family Vireonidae				
Cyclarhis gujanensis (J.F. Gmelin, 1789)	BM[50] CC[50] ET[50] FB[50] FD[9,16,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, FMNH, MZUSP, UFMT
Vireo olivaceus (Linnaeus, 1766)	BM[50] CC[18] FB[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		MNHN
Hylophilus pectoralis P.L. Sclater, 1866	CC[47,50] ET[50] FD[9,50] FS[50] MC[12]	8,9,11,12		DMNS, MZUSP, NMW
Family Corvidae				
Cyanocorax cyanomelas (Vieillot, 1818)	BM[50] CC[30] FB[50] FC[47] FD[9,41] FJ[47] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, MZUSP, NMW, UFMT
Cyanocorax cristatellus (Temminck, 1823)	FP[50]	1,2,3,4,5,7,8,9		
Family Passeridae				
Passer domesticus (Linnaeus, 1758)	BM[50] CC[50] FD[50] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,10,11	WA	
Family Motacillidae				
Anthus lutescens Pucheran, 1855	BM[50] FB[50] FD[50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	UFMT
Family Fringillidae				
Euphonia chlorotica (Linnaeus, 1766)	BM[50] CC[5] FB[50] FD[9,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, CG, DMNS, MZUSP
Euphonia laniirostris d'Orbigny & Lafresnaye, 1837	CC[47]	8	WA	NMW

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Family Passerellidae				
Ammodramus humeralis (Bosc, 1792)	BM[50] CC[5,18] FB[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	CG, MNHN
Arremon flavirostris Swainson, 1838	CC[18] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11	WA	MNHN
Zonotrichia capensis (Statius Muller, 1776)	FD[50] FP[50] FS[50] MC[12]	4,5,7,8,9,11		
Family Parulidae				
Geothlypis aequinoctialis (J.F. Gmelin, 1789)	BM[50] FD[16,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,11	WA	ANSP, FMNH
Setophaga pitiayumi (Vieillot, 1817)	BM[50] CC[5,18,50] ET[50] FB[50] FD[41,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, CG, MNHN, UFMT
Myiothlypis flaveola S.F. Baird, 1865	BM[50] CC[5,18] FB[50] FD[27,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,5,6,7,8,9,11,10,12		AMNH, CG, MNHN, UFMT
Basileuterus culicivorus hypoleucus Bonaparte, 1850	CC[5] FD[50] FS[50]	7,9,11	WA	CG
Family Icteridae				
Leistes superciliaris (Bonaparte, 1850)	ET[50] FC[47] FD[9,41] MC[12] PS[47]	6,7,8,9,10		ANSP, DMNS, BMNH, NMW
Psarocolius decumanus (Pallas, 1769)	CC[30] ET[50] FB[50] FD[9,27,41] FS[50] MC[12]	2,8,11	WA	ANSP, DMNS, MZUSP
Procacicus solitarius (Vieillot, 1816)	CC[50] ET[50] FB[50] FD[9,16,41,50] FS[50] MC[12]	2,5,6,7,8,9,11	WA	ANSP, DMNS, FMNH, MZUSP, UFMT
Cacicus cela (Linnaeus, 1758)	AR[17] BM[50] CC[31,47] ET[50] FD[41] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, MZUSP, NMW
Icterus croconotus (Wagler, 1829)	BM[50] CC[49,50] ET[50] FB[50] FD[9,16,27,41] FF[47] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, FMNH, NMW, UFMT, ZUEC
Icterus pyrrhopterus (Vieillot, 1819)	BM[50] CC[18,31] ET[50] FB[50] FD[9,16,27,41,50] FF[47] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, MNHN, MZUSP, NMW, UFMT
Molothrus oryzivorus (J.F. Gmelin, 1788)	BM[50] ET[50] FB[50] FC[47] FD[50] FP[50] FS[50] LC[47] MC[12]	1,2,3,5,6,7,8,9,10,11	WA	NMW, USNM
Molothrus bonariensis (J.F. Gmelin, 1789)	BM[50] ET[50] FB[50] FD[27,41] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, UFMT
Amblyramphus holosericeus (Scopoli, 1786)	FD[9,37] MC[12] PS[47] RJ[47]	6,9,10,11	WA	DMNS, MNRJ, NMW
Gnorimopsar chopi (Vieillot, 1819)	BM[50] CC[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	
Agelaioides badius (Vieillot, 1819)	BM[50] ET[50] FB[50] FD[41] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP
Agelasticus cyanopus (Vieillot, 1819)	ET[10,50] FB[50] FD[9,27,37,41] MC[12]	2,8,9,11,12	WA	AMNH, ANSP, DMNS, DZUFMG, MNRJ
Chrysomus ruficapillus (Vieillot, 1819)	FD[50]	9		
Family Cardinalidae				
Pheucticus aureoventris (d'Orbigny & Lafresnaye, 1837)	CC[47] FB[50] FD[41] MC[12] PL[48]	7,8,9		ANSP, NMW
Amaurospiza moesta (Hartlaub, 1853)	FB[50]	2		DZUFMG
Cyanoloxia brissonii (M.H.C. Lichtenstein, 1823)	FB[50] FD[41] MC[3,12] PL[48]	1,2,7,9		ANSP
Piranga flava (Vieillot, 1822)	FD[50] FJ[5]	7,9		CG
Family Thraupidae				
Nemosia pileata (Boddaert, 1783)	BM[50] CC[30] FB[50] FD[9,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	DMNS, MZUSP
Hemithraupis guira (Linnaeus, 1766)	CC[5] FB[50] FD[50] MC[12] PL[48]	1,2,7,8,9		CG
Conirostrum speciosum (Temminck, 1824)	CC[30] ET[50] FB[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,7,8,9,11,12	WA	MZUSP
Sicalis flaveola (Linnaeus, 1766)	BM[50] CA[16] CC[18] FB[50] FD[9,27,29,41,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, MNHN
Volatinia jacarina (Linnaeus, 1766)	BM[50] ET[50] FB[50] FD[16,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		ANSP, FMNH, MZUSP, UFMT
Tachyphonus luctuosus d'Orbigny & Lafresnaye, 1837	CC[47] ET[50]	8		NMW
Tachyphonus cristatus nattereri von Pelzeln, 1870	CC[47] MC[12]	8		NMW
Tachyphonus rufus (Boddaert, 1783)	CC[30] FB[50] FD[50] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,10,11	WA	MZUSP

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Eucometis penicillata (von Spix, 1825)	CC[31,47] FB[50] FD[27,50] FP[50] FS[50] MC[12]	1,2,3,4,5,7,8,9,10,11	WA	AMNH, MZUSP, NMW, UFMT
Coryphospingus cucullatus (Statius Muller, 1776)	BM[50] CC[5,18] ET[10,50] FB[50] FD[9,27,41] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, CG, DMNS, DZUFMG, MNHN
Ramphocelus carbo (Pallas, 1764)	BM[50] CC[5,31,47,50] ET[50] FB[50] FD[9,16,27,41,46,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, CG, DMNS, DZUFMG, FMNH, MZUSP, NMW
Charitospiza eucosma Oberholser, 1905	FJ[5]	7		CG
Cyanerpes cyaneus (Linnaeus, 1766)	FB[50]	8		
Tersina viridis (Illiger, 1811)	FP[50]	3,4,5,7,8,9		
Dacnis cayana (Linnaeus, 1766)	CC[42] FD[50] FP[50] MC[12]	2,3,4,5,7,8,9,11	WA	
Sporophila lineola (Linnaeus, 1758)	BM[50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11	WA	
Sporophila leucoptera (Vieillot, 1817)	BM[50] CC[18] FD[9,11,41] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS, FMNH, MNHN
Sporophila hypoxantha Cabanis, 1851	FD[27] MC[12]	12		AMNH
Sporophila angolensis (Linnaeus, 1766)	BM[50] FB[50] FD[27,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, MZUSP, UFMT
Sporophila maximiliani (Cabanis, 1851)	FB[50] MC[3]	2		
Sporophila nigricollis (Vieillot, 1823)	MC[3,12] PL[48]	1,7	WA	
Sporophila caerulescens (Vieillot, 1823)	BM[50] FB[50] FD[27] FP[50] MC[3,12] PL[48]	2,3,4,5,6,7,8,9	WA	AMNH
Sporophila plumbea (zu Wied-Neuwied, 1830)	FD[50]	9		
Sporophila collaris (Boddaert, 1783)	AR[17] BM[50] CC[18] FB[50] FD[27,37,41] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, DZUFMG, MNHP, MNRJ, MZUSP, UFMT
Saltatricula atricollis (Vieillot, 1817)	AR[17] FJ[25] MC[12]	12	WA	MNRJ
Saltator maximus (Statius Muller, 1776)	CC[42] MC[12]	1	WA	
Saltator coerulescens Vieillot, 1817	BM[50] CC[18] ET[10,50] FB[50] FD[9,16,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, DZUFMG, FMNH, MNHN, MZUSP, UFMT
Saltator similis d'Orbigny & Lafresnaye, 1837	BM[50] FB[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		UFMT
Emberizoides herbicola (Vieillot, 1817)	BM[50] CC[30] FD[50] FP[50]	2,4,5,7,8,9,10,11	WA	MZUSP
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	BM[50] ET[50] FD[41,50] FP[50] FS[50]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, MZUSP
Microspingus melanoleucus (d'Orbigny & Lafresnaye, 1837)	MC[12] PL[48]	7		
Coereba flaveola (Linnaeus, 1758)	BM[50] CC[18,50] FD[41,50] FP[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, MNHN
Tiaris obscurus (d'Orbigny & Lafresnaye, 1837)	FD[50]	9		MZUSP
Paroaria coronata (J.F. Miller, 1776)	FB[50] FD[9,27,41,50] FS[50] MC[3,12]	2,8,9,10,11,12	WA	AMNH, ANSP, DMNS, DZUFMG, MZUSP, UFMT
Paroaria capitata (d'Orbigny & Lafresnaye, 1837)	BM[50] CA[16] CC[18,47,50] ET[50] FB[50] FC[47] FD[9,16,27,41,50] FP[50] FS[50] MC[3,12] PC[11] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, ANSP, DMNS, DZUFMG, FMNH, MNHN, MZUSP, NMW, UFMT
Schistochlamys melanopis (Latham, 1790)	FD[50] PL[48]	1		
Cissopis leverianus (J.F. Gmelin, 1788)	FS[42,50] MC[12]	1,10,11	WA	
Tangara sayaca (Linnaeus, 1766)	BM[50] CC[5,50] ET[50] FB[50] FD[9,41] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, CG, DMNS, UFMT
Tangara palmarum (zu Wied-Neuwied, 1821)	BM[50] CC[18,31,47,50] FB[50] FD[9,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	DMNS, MNHN, MZUSP, NMW, UFMT
Tangara cayana (Linnaeus, 1766)	FD[50]	9		
Family Donacobiidae				
Donacobius atricapilla (Linnaeus, 1766)	ET[50] FD[9,16,41,50] FS[50] MC[12]	6,7,8,9,11,12	WA	ANSP, DMNS, FMNH

Taxa	Localities of records and sources	Month of record	Photo	Specimen
Family Hirundinidae				
Hirundo rustica Linnaeus, 1758	BM[50] FB[50] FP[50] MC[12]	1,2,3		
Riparia riparia (Linnaeus, 1758)	FC[47]	4		NMW
Tachycineta albiventer (Boddaert, 1783)	BM[50] ET[50] FB[50] FD[9,16] FP[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	DMNS, FMNH
Tachycineta leucorrhoa (Vieillot, 1817)	ET[50] FS[50] MC[12]	8,11	WA	
Progne tapera (Linnaeus, 1766)	BM[50] CC[50] ET[50] FB[50] FC[47] FD[9,27,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11,12	WA	AMNH, DMNS, NMW
Progne chalybea (J.F. Gmelin, 1789)	BM[50] ET[50] FC[47] FD[50] FP[50] FS[50] MC[12]	4,5,6,7,8,9,10,11	WA	MZUSP, NMW
Stelgidopteryx ruficollis (Vieillot, 1817)	BM[50] ET[50] FC[47] FD[27,41,50] FP[50] FS[50] MC[12] PL[48]	1,3,4,5,6,7,8,9,11	WA	AMNH, ANSP, NMW
Pygochelidon cyanoleuca (Vieillot, 1817)	FD[41,50] FP[50] FS[50] MC[12]	1,2,3,4,5,8,9,11		ANSP
Family Troglodytidae				
Troglodytes aedon Vieillot, 1809	BM[50] FD[9,50] FP[50] FS[50] MC[3,12] PL[48]	1,2,3,4,5,6,7,8,9,10,11		DMNS
Campylorhynchus turdinus (zu Wied-Neuwied, 1821)	BM[50] CC[31,50] ET[50] FB[50] FD[2,9,16,27,41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, DMNS, FMNH, MZUSP, UFMT
Pheugopedius genibarbis (Swainson, 1837)	BM[50] CC[18,31,50] ET[50] FB[50] FD[27,41,50] FP[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	AMNH, ANSP, MNHN, MZUSP, UFMT
Cantorchilus leucotis (Lafresnaye, 1845)	BM[50] CC[50] ET[50] FD[27,50] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12		AMNH, MZUSP
Family Polioptilidae				
Polioptila dumicola (Vieillot, 1817)	BM[50] CC[5,18] ET[50] FB[50] FD[41,50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, CG, MNHN, MZUSP
Family Mimidae				
Mimus saturninus (M.H.C. Lichtenstein, 1823)	BM[50] ET[50] FB[50] FD[9,41] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	ANSP, DMNS, UFMT
Mimus triurus (Vieillot, 1818)	FD[41] MC[12]	8,9		ANSP
Family Turdidae				
Turdus leucomelas Vieillot, 1818	BM[50] FD[50] FP[50] FS[50] MC[12] PL[48]	1,2,3,4,5,6,7,8,9,10,11	WA	
Turdus hauxwelli Lawrence, 1869	FD[50]	9		MZUSP
Turdus rufiventris Vieillot, 1818	BM[50] CC[50] ET[50] FB[50] FD[9,41] FP[50] FS[50] MC[12]	1,2,3,4,5,6,7,8,9,10,11,12	WA	ANSP, DMNS
Turdus amaurochalinus Cabanis, 1851	BM[50] ET[50] FB[50] FD[50] FP[50] FS[50] MC[12] PL[48]	4,5,6,7,8,9,10,11	WA	MZUSP, UFMT

Sources: 1 - Albuquerque (1985); 2 - AMNH; 3 - Arruda (1938); 4 - Castelnau (1851); 5 - CG; 6 - Collar *et al.* (1992); 7 - Darrieu (1983); 8 - des Murs (1855); 9 - DMNS; 10 - DZUFMG; 11 - FMNH; 12 - Forrester (1993); 13 - Grantsau (1988); 14 - Greenewalt (1960); 15 - Hellmayr (1929); 16 - Hellmayr *et al.* (1918–1949); 17 - Melo & Santos-Filho (2007); 18 - Ménégaux (1917); 19 - Meyer de Schauensee (1966); 20 - Miranda-Ribeiro (1920); 21 - Miranda-Ribeiro (1929); 22 - Miranda-Ribeiro (1931); 23 - Miranda-Ribeiro (1938); 24 - Miranda-Ribeiro & Soares (1920); 25 - MNRJ; 26 - MZUSP; 27 - Naumburg (1930); 28 - Novaes (1949); 29 - Oberholser (1931); 30 - Pinto (1938); 31 - Pinto (1944); 32 - Raposo & Höfling (2003); 33 - ROM; 34 - Ruschi (1951); 35 - Ruschi (1953); 36 - Ruschi (1955); 37 - Schubart *et al.* (1965); 38 - Sick (1960); 39 - Simon (1912); 40 - SMF; 41 - Stone & Roberts (1934); 42 - Tubelis & Tomas (2003); 43 - Vielliard (1989); 44 - Vielliard (1994); 45 - von Berlepsch (1887); 46 - von Berlepsch (1911); 47 - von Pelzeln (1868–1870); 48 - Willis & Oniki (1990); 49 - ZUEC; 50 - This study; 51 - Kantek & Onuma (2013).

APPENDIX II

SECONDARY LIST. Species with probable occurrence in the municipality of Cáceres, Mato Grosso, Brazil, but for which we are not confident about the reliability of the records available.

***Tinamus tao*:** Reis-de-Magalhães (1994) reports specimens collected in "Fazenda Igara, municipality of Cáceres, high Rio Paraguai". We were unable to locate those specimens, and failed to trace this locality. Silva & Oniki (1988) recorded the species in Serra das Araras. Given that these localities might not be inside the present day limits of the municipality, we opted to exclude this record from the main list.

***Dendrocygna bicolor*:** a migratory and accidental species in the region (Forrester 1993).

***Coccycua cinerea*:** an accidental species in the region (Forrester 1993).

***Vultur gryphus*:** this species is said to visit the Rio Jauru in the beginning of the dry season (May/June) to feed on cattle carcasses deposited on the beaches of a river island named "Ilha dos Urubus" (Sick 1979), which we were unable to locate. This fact was noticed in 1974 by Arne Sucksdorff, a Sweden movie director who lived in Mato Grosso, where he produced some nature documentaries. There is no modern documented record of the species for Brazil, even though it is known from bone remains from the beginning of the Holocene of the Lagoa Santa region, Minas Gerais (Alvarenga 1998). The species is currently included in the secondary list of Brazilian birds (Piacentini *et al.* 2015).

***Buteogallus coronatus*:** the single record of the species for Cáceres is presented by Stone & Roberts (1934), who said that "no specimens obtained or seen, but said to occur occasionally at Descalvados".

***Celeus flavus*:** an accidental species in the region (Forrester 1993).

***Campephilus rubricollis*:** a scarce species in the region (Forrester 1993).

Cyanocorax chrysops: a scarce species in the region (Forrester 1993).

***Leistes militaris*:** three specimens collected in the Fazenda Descalvados were referred to the species (Schubart *et al.* 1965, Aguirre & Aldrighi 1987). Nevertheless, we and several other collectors only recorded the congeneric *L. superciliaris* in Cáceres, with *L. militaris* being restricted to northern parts of Mato Grosso. We were unable to personally examine the specimens referred to *L. militaris* and preferred to exclude the species from the main list.

***Cyanerpes caeruleus*:** reported to occur in Cáceres by Tubelis & Tomas (2003), based on an undocumented sight record attributed to F. M. D'Horta. Silva & Oniki (1988) recorded the species in Serra das Araras.

***Sporophila nigrorufa*:** a doubtful record of this species for Porto Limão was presented elsewhere (Willis & Oniki 1990).

***Sporophila hypochroma*:** a migratory species in the region (Forrester 1993).

***Tangara mexicana*:** a scarce species in the region (Forrester 1993).

APPENDIX III

TERTIARY LIST. Species with records published for the municipality of Cáceres, Mato Grosso, Brazil, but whose documental evidence is invalid or occurrence in the area is unlikely.

***Anhima cornuta*:** cited by Forrester (1993) as a historical record. Although the species occur near to Cáceres, we failed to find records of the species for the municipality in the sources consulted by the author.

***Chaetura brachyura*:** an uncertain record of the species for Porto Limão was presented by Willis & Oniki (1990).

***Anopetia gounellei*:** a record for Fazenda Descalvados (Naumburg 1930) is an identification mistake that should be reverted to *Phaethornis subochraceus* (Meyer de Schauensee 1966).

***Phaethornis longuemareus*:** the alleged specimens from Caiçara (von Pelzeln 1868–1870) refer to *P. nattereri,* an undescribed species at that time (von Berlepsch 1887).

***Phaethornis hispidus*:** cited as a historical record by Forrester (1993), there is no record for Cáceres in the references used by this author. Pinto (1978) includes Cáceres in the range of the species, but there is no specimen of *P. hispidus* from Cáreces in MZUSP and we were unable to trace the source of this record. Vitor Piacentini (pers. com.) suggested that Cáceres was included by mistake in the range of the species by Pinto (1978).

***Taphrospilus hypostictus*:** the occurrence of the species in Cáceres (and the only occurrence for Brazil), was first presented by Meyer de Schauensee (1966), and since then reproduced by several authors without criticism. Pacheco (2000) presented convincing evidence that this occurrence is a mistake derived from a typographical error.

***Amazilia versicolor millerii*:** an alleged male collected by Ruschi (1955) and deposited in MBML was subsequently reidentified as *A. fimbriata nigricauda* (Vielliard 1994). The subspecies *A. v. milleri* is restricted to the north o Rio Amazonas, and *A. v. kubtchecki* is the subspecies expected to be found in Cáceres (Dickinson & Remsen-Jr. 2013).

***Hylocharis sapphirina*:** cited by Forrester (1993) as a historical record, we failed to find records of the species in the sources consulted by this author.

***Glaucidium minutissimum*:** the alleged specimen from Caiçara cited elsewhere (von Pelzeln 1868–1870) refers to *G. hardyi,* an undescribed species at that time (Vielliard 1989).

***Nystalus maculatus striatipectus*:** the subspecies that occur in Cáceres in the nomynotypical one. This was a nomenclatural mistake of Tubelis & Tomas (2003).

***Tolmomyias assimilis*:** a scarce species in the region accordingly to Forrester (1993).

***Inezia subflava*:** an uncertain record of this species for Porto Limão was presented by Willis & Oniki (1990).

***Serpophaga subcristata*:** an accidental species in the region accordingly to Forrester (1993).

***Myiozetetes similis*:** recorded by Forrester (1993), this species seems to be extremely rare in Mato Grosso, where the similar looking *M. cayanensis* is ubiquitous (Tubelis & Tomas 2003, Antas & Palo-Jr. 2009).

***Cantorchilus guarayanus*:** recorded by Forrester (1993), it is probably a misinterpretation of the data presented by Lima (1920) and cited by Naumburg (1930). Lima (1920) commented on some specimens collected in Cáceres and Corumbá, without clearly pointing the exact locality in which each specimen was collected. Naumburg (1930) correctly pointed that the *C. guarayanus* specimens cited were collected in "Corumbá or São Luiz de Caceres". Forrester (1993), who probably did not check the original source, inadvertently assumed that these specimens were from Cáceres, when it is known that they came from Corumbá (Pinto 1944). There is a poor quality photograph attributed to the species in Wikiaves (WA 1666170), but that do not allow a safe identification of the species.

Revista Brasileira de Ornitologia, 24(2), 168-184
June 2016

ARTICLE

A collection of birds from Presidente Kennedy and adjacent areas, Tocantins: a further contribution to knowledge of Amazonian avifauna between the Araguaia and Tocantins Rivers

Guilherme R. R. Brito[1,2], Guy M. Kirwan[1,3], Claydson P. Assis[1,4], Daniel H. Firme[1,4], Daniel M. Figueira[1], Nelson Buainain[1] and Marcos A. Raposo[1]

[1] Setor de Ornitologia, Museu Nacional / UFRJ, Departamento de Vertebrados, Horto Botânico, Quinta da Boa Vista s/n, São Cristóvão, CEP 20940-040, Rio de Janeiro, RJ, Brazil.
[2] Departamento de Zoologia, Instituto de Biologia / UFRJ, Av. Carlos Chagas Filho, 373, Ilha do Fundão, Cidade Universitária, CEP 21941-941, Rio de Janeiro, RJ, Brazil.
[3] Field Museum of Natural History, 1400 South Lakeshore Drive, Chicago, IL 60605, USA.
[4] Instituto de Biociências da Universidade de São Paulo, Rua do Matão, travessa 14, nº 321, Cidade Universitária, CEP 05508-090, São Paulo, SP, Brazil.
[5] Corresponding author: grenzobrito@gmail.com

Received on 25 August 2015. Accepted on 13 June 2016.

ABSTRACT: We report on a collection of birds made at a study site in Presidente Kennedy, midway between the Araguaia and Tocantins Rivers, in north-central Tocantins state, Brazil. Interesting records are presented for 22 species, most of them principally Amazonian taxa with comparatively few previous records for the state of Tocantins, and generally amplifying their local ranges either further south, from the north of the state, or further east, from the banks of the Araguaia River. Among them, we report the first specimen records for Tocantins of hybrids/intermediaries *Pyrrhura* parakeets of the "*P. perlata-coerulescens*" complex (which was common at our study site), Pearly-breasted Cuckoo *Coccyzus euleri*, Yellow-billed Cuckoo *C. americanus*, Rufous-tailed Flatbill *Ramphotrigon ruficauda* and Sooty Grassquit *Tiaris fuliginosus*. Our surveys emphasize once more the unusually high component of Amazonian species within the scattered taller forests of this region of predominantly Cerrado physiognomies.

KEY-WORDS: Amazonia, Brazil, new records, ornithology, *Pyrrhura perlata-coerulescens* complex.

INTRODUCTION

Brazil's newest state, Tocantins, was created in 1988, encompassing what had formerly been the northern part of the state of Goiás. Construction of its capital, Palmas, commenced in 1989; most other cities in the state date back to the Portuguese colonial period. Most of Tocantins (except the extreme western and northern parts) is situated within the Cerrado biome. The western boundary of the state is formed by the floodplain of the Araguaia River, which includes extensive wetlands and Amazonian forest. The Ilha do Bananal, formed by two branches of the Araguaia, is generally stated to be the largest river island in the world, and consists of marshlands and seasonally flooded savannas with gallery forest; where the two branches meet, they form the Cantão inland delta, now protected as part of a state park, with typical Amazonian *igapó* flooded forest.

Among the most important historical data on the ornithology of Tocantins were the 20th century surveys by Emilie and Heinrich E. Snethlage, and later on by José Hidasi . Emilie Snethlage, famous for her prodigious collections and publications on Brazilian birds, visited what is now Tocantins in 1927 (at the time part of Goiás state), more specifically the Ilha do Bananal, and the locality of Furo de Pedra (*c.* 10°28'S; 50°23'W) on the banks of the Araguaia River, where she collected the type series of Bananal Antbird *Cercomacra ferdinandi* and *Serpophaga araguayae* – the latter, shown to be a misidentification of male Grey Elaenia *Myiopagis caniceps* (Silva 1990, Teixeira 1990, Sick 1997). Although Snethlage published little concerning her findings in Tocantins (Silva 1989), several of the noteworthy records reported in the present work are the first for the state since then.

Thereafter, Dr. Emil Heinrich Snethlage, Emilie Snethlage's nephew spent approximately four months in this general region, between November 1925 and February 1926, at the localities of Carolina, in Maranhão state, and Philadelphia, Santo Antonio and Boa Vista, in present-day Tocantins. However, due to a rebellion and his own poor health, very little collecting was possible (Hellmayr 1929).

José Hidasi, the most prolific bird collector in Tocantins state, started his work in the 1960s, and founded the "Museu Ornitológico de Goiânia" in 1968, where the majority of bird skins collected by him in the state are housed (although many others are now in other institutions elsewhere in Brazil, and still more have been sold to collections as far afield as North America and Europe), including several from the central portion of the state and directly related to the present work (Perotti 2005).

More recently, De Luca *et al.* (2009) delineated four Important Bird Areas (IBAs) in the Araguaia–Tocantins interfluvium. The most important (geographically) in relation to the present study being TO04 and TO05. Cantão State Park (TO04) is situated north of Bananal Island on the floodplains between the Coco, Araguaia and Javaés Rivers, with *c.* 90,000 ha of fully protected areas with Cerrado and dense ombrophylous Amazonian forests in the municipality of Pium. For detailed avifaunal information, see Buzzetti (2004), Pacheco & Olmos (2006), Pinheiro & Dornas (2009) and Dornas & Pinheiro (2011).

The gallery forests of the Coco River and tributaries (TO05), and the adjacent areas of Caseara, Marianópolis do Tocantins, Divinópolis do Tocantins, Pium, Chapada de Areia and Monte Santo do Tocantins municipalities comprise *c.* 138,000 ha covering the same biomes as the previous IBA, but comparatively little of the area is protected, despite the presence of several globally threatened species (De Luca *et al.* 2009). Our purpose here is report on a survey of birds made at a locality in north-central Tocantins, in particular record the Amazonian component of its avifauna.

METHODS

Ornithological survey

The inventory was undertaken via three surveys performing a total of 19 days each (the first one on 6–13 August 2010, the second on 18–22 November 2010 and the last on 18–23 August 2011), with the main objective to carry out a comprehensive analysis of the relationship between birds and power-transmission lines in Brazil, with Presidente Kennedy being one of the focus areas (Raposo *et al.* 2013). Systematic sampling of the avifauna consisted of three different methods: mist-net captures, point counts and opportunistic observations (the latter with help of shotguns).

Point counts were performed following the methodology of Blondel *et al.* (1970) wherein all contacts (auditory and visual) were registered within a 50 m radius at each point, separated from one another by 250 m. The starting point was randomly selected to determine the order of sampling, and a total of 60 point counts per survey were sampled.

A line of 35 mist-nets (each 12 m in length and 2.5 m high) was erected parallel to the powerline, extending through the forest interior for *c.* 420 m, and was opened for a minimum period of 8 h, with a total sampling effort of 2100 net-hours. Opportunistic observations were made while transiting between the core sample areas, and by stopping in suitable areas where birds congregate (ponds, lakes, swamps). Important specimens were also shot throughout the survey period.

All collected specimens are housed at the Museu Nacional/UFRJ ornithological collection (MN). Other acronyms used in the present study were: MZUSP (Museu de Zoologia da USP, São Paulo, SP); MPEG (Museu Paraense Emilio Goeldi, Belém, PA); MOG (Museu Ornitológico de Goiânia, Goiânia, GO); COMB (Coleção Ornitológica Marcelo Bagno da UnB, Brasília, DF); COCEULP/ULBRA (Coleção Ornitológica do Centro Universitário Luterano de Palmas/Universidade Luterana do Brasil, Palmas, TO); MZJH (Museu de Zoologia José Hidasi da UNITINS, Palmas, TO); FMNH (Field Museum of Natural History, Chicago, IL, USA) and WA (Wikiaves, www.wikiaves.com.br). The software QUANTUM GIS 2.6.1-Brighton Application was used to generate the map showing the study site and adjacent locations. Spatial data were obtained at http://www.diva-gis.org.

Because the objective of the present study is report the most interesting findings, particularly the records of uncommon species and new records that increase our knowledge on the distribution and composition of Amazonian avifaunal elements within the state of Tocantins, no quantitative data are presented, but these are available in Raposo *et al.* (2013). The species list present on Table 1 was the outline for the elected species accounts, with type of record (heard only, visual, sound-recorded or specimen with ascension numbers).

Study site

The study site was located at 08°31'34.69''S; 48°28'10.64''W (250 m a.s.l.), at the northwestern tip of a forest fragment of *c.* 53,508 ha, *c.* 4 km east of Presidente Kennedy. It is predominantly characterized by Cerrado vegetation, albeit with a strong Amazonian influence, and a canopy height varying between *c.* 10 m and 16 m (Figures 1 and 2). Lying in the northern half of Tocantins state, within the Araguaia–Tocantins interfluvium, main waterbodies in the site are the Feio, Água Fria and São

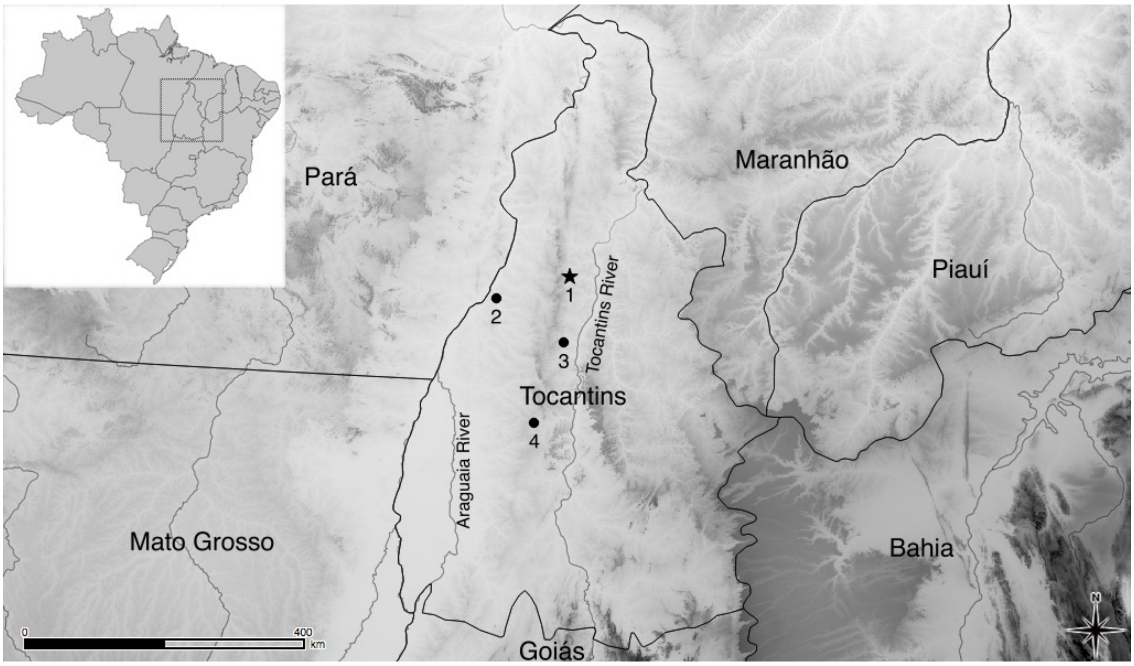

FIGURE 1. Map depicting the main localities surveyed in Tocantins state, Brazil. 1 - Presidente Kennedy; 2 - Guaraí-Araguacema Road; 3 - Rio dos Bois; 4 - Pium.

João Rivers, all of which are left-bank tributaries of the Tocantins River. The study site lies near the centre of the municipality of Presidente Kennedy, beside the main BR-153 road, and comprises a fragment of native vegetation at Fazenda Água Fria, on the left bank of the river of the same name, on undulating terrain with dystrophic red-yellow latosols. The LT 500 kV Imperatriz–Samambaia powerline at its westernmost border, which has isolated several small, narrow strips of vegetation, intersects the forest fragment. Evidence of burning is present in both portions of the forest fragment either side of the powerline.

Overall, the region lies within the transition zone between the Cerrado and Amazonian forest biomes. According to the map of Project RadamBrasil (1981), there is a matrix of habitats, but the predominant vegetation is typical of the central Brazilian savannas (Cerrado *sensu lato*), with wooded savannas covering the interfluvium. *Várzea* borders the rivers, *i.e.* gallery forests with floristic elements associated with the phytogeographic system of open ombrophylous forests, whose composition resembles those of lowland Amazonia.

Due these characteristics, Project RadamBrasil (1981) characterized forest patches of the region as a kind of floristic contact or ecological tension zone between the savannas and open ombrophylous forests. According to Veloso *et al.* (1991), areas of contact can exist between two or more phytoecological regions. Contact zones can take the form of enclaves, as well ecotones, where species of savanna and open ombrophylous forest occur together. Haidar *et al.* (2013) attests that these ecotonal forest patches in Tocantins are similar to those found in northern Mato Grosso state, reinforcing its transitional nature and the need for an efficient nomenclature for these forest types in relation to the regular deciduous and semi-deciduous forests present in the state. One of the main characteristics of the vegetation at the study site is that the majority of the forest area is deciduous, with small patches of evergreen forest on soils with a higher water table; this forest mosaic is better perceived in the dry season.

FIGURE 2. Overall appearance of the main study site in Tocantins state, Brazil.

TABLE 1. Species of birds recorded at our Presidente Kennedy, TO, study site and adjacent localities. Status (*sensu* Piacentini *et al.* 2015): R – resident, VN – seasonal visitor (northern hemisphere), E – Brazilian endemic; Record type: Ho – heard only; V – visual; C – collected. * - specimen found run over on highway. In accordance with the recommendations in Lees *et al.* (2014) we include registration numbers for the specimens collected (MN – skin / MNA – anatomical / TERNA – field number [specimen still in processing for taxidermy or skeleton preparation]).

Taxon	English Name	Status in Brazil	Presidente Kennedy	Adjacent Localities	Register type	Ascension numbers
Rheidae						
Rhea americana (Linnaeus, 1758)	Greater Rhea	R	X		V	
Tinamidae						
Crypturellus strigulosus (Temminck, 1815)	Brazilian Tinamou	R	X		C, Ho	MN 50101
Crypturellus parvirostris (Wagler, 1827)	Small-billed Tinamou	R	X		C, Ho	MN 49834
Rhynchotus rufescens (Temminck, 1815)	Red-winged Tinamou	R	X		Ho	
Cracidae						
Penelope superciliaris Temminck, 1815	Rusty-margined Guan	R	X		C	MN 47660
Cathartidae						
Cathartes aura (Linnaeus, 1758)	Turkey Vulture	R	X		C, V	TERNA 1363
Coragyps atratus (Bechstein, 1793)	Black Vulture	R	X		V	
Sarcoramphus papa (Linnaeus, 1758)	King Vulture	R	X		V	
Accipitridae						
Elanus leucurus (Vieillot, 1818)	White-tailed Kite	R	X		V	
Ictinia plumbea (Gmelin, 1788)	Plumbeous Kite	R	X		C, V	MN 48849
Rupornis magnirostris (Gmelin, 1788)	Roadside Hawk	R	X		V, Ho	
Geranoetus albicaudatus (Vieillot, 1816)	White-tailed Hawk	R	X		V	
Buteo nitidus (Latham, 1790)	Gray-lined Hawk	R	X		C	MN 47650
Spizaetus tyrannus (Wied, 1820)	Black Hawk-Eagle	R	X		V, Ho	
Falconidae						
Caracara plancus (Miller, 1777)	Southern Caracara	R	X		V	
Milvago chimachima (Vieillot, 1816)	Yellow-headed Caracara	R	X		V, Ho	
Falco femoralis Temminck, 1822	Aplomado Falcon	R	X		V	
Falco peregrinus Tunstall, 1771	Peregrine Falcon	VN	X		V	
Cariamidae						
Cariama cristata (Linnaeus, 1766)	Red-legged Seriema	R	X		V, Ho	
Jacanidae						
Jacana jacana (Linnaeus, 1766)	Wattled Jacana	R	X		V	
Columbidae						
Columbina minuta (Linnaeus, 1766)	Plain-breasted Ground Dove	R	X		C, V	TERNA 507
Columbina talpacoti (Temminck, 1811)	Ruddy Ground Dove	R	X		C, V	TERNA 1386

Taxon	English Name	Status in Brazil	Presidente Kennedy	Adjacent Localities	Register type	Ascension numbers
Claravis pretiosa (Ferrari-Perez, 1886)	Blue Ground Dove	R	X		C, V, Ho	MN 49593
Patagioenas speciosa (Gmelin, 1789)	Scaled Pigeon	R	X		C, V, Ho	MN 49838
Psittacidae						
Ara ararauna (Linnaeus, 1758)	Blue-and-yellow Macaw	R	X		V	
Orthopsittaca manilata (Boddaert, 1783)	Red-bellied Macaw	R	X		V	
Primolius auricollis (Cassin, 1853)	Yellow-collared Macaw	R	X		V	
Psittacara leucophthalmus (Statius Muller, 1776)	White-eyed Parakeet	R	X		V, Ho	
Eupsittula aurea (Gmelin, 1788)	Peach-fronted Parakeet	R	X		V	
Pyrrhura lepida (Wagler, 1832)	Pearly Parakeet	R, E	X		C, V	MN 47649; MN 49580; MN 49581
Cuculidae						
Piaya cayana (Linnaeus, 1766)	Squirrel Cuckoo	R	X		C, V, Ho	MNA 6549
Coccyzus americanus (Linnaeus, 1758)	Yellow-billed Cuckoo	VN	X		C, V	MN A6567
Coccyzus euleri Cabanis, 1873	Pearly-breasted Cuckoo	R	X		C, V	MN 48847
Crotophaga ani Linnaeus, 1758	Smooth-billed Ani	R	X		V	
Tapera naevia (Linnaeus, 1766)	Striped Cuckoo	R	X		Ho	
Dromococcyx pavoninus Pelzeln, 1870	Pavonine Cuckoo	R	X		C, Ho	MN 47661
Strigidae						
Glaucidium brasilianum (Gmelin, 1788)	Ferruginous Pygmy-Owl	R	X		C, Ho	MN 49827
Caprimulgidae						
Caprimulgus parvulus Gould, 1837	Little Nightjar	R	X		C	TERNA 497
Apodidae						
Tachornis squamata (Cassin, 1853)	Fork-tailed Palm-Swift	R	X		V	
Trochilidae						
Phaethornis ruber (Linnaeus, 1758)	Reddish Hermit	R	X		V	
Phaethornis pretrei (Lesson & Delattre, 1839)	Planalto Hermit	R	X		V	
Anthracothorax nigricollis (Vieillot, 1817)	Black-throated Mango	R	X		C, V	TERNA 380
Thalurania furcata (Gmelin, 1788)	Fork-tailed Woodnymph	R	X		C, V	MN 49841; MN 49901
Trogonidae						
Trogon viridis Linnaeus, 1766	Green-backed Trogon	R	X		C, V, Ho	TERNA 488; TERNA 489
Trogon curucui Linnaeus, 1766	Blue-crowned Trogon	R	X		V, Ho	
Momotidae						
Momotus momota (Linnaeus, 1766)	Amazonian Motmot	R	X	Guaraí-Araguacema Road	C, Ho	MN 48839
Alcedinidae						
Chloroceryle inda (Linnaeus, 1766)	Green-and-rufous Kingfisher	R		Guaraí-Araguacema Road	C, V	MN 50609

Taxon	English Name	Status in Brazil	Presidente Kennedy	Adjacent Localities	Register type	Ascension numbers
Galbulidae						
Brachygalba lugubris (Swainson, 1838)	Brown Jacamar	R	X		C, V	MN 49585; MN 49586
Galbula ruficauda Cuvier, 1816	Rufous-tailed Jacamar	R	X		C, V, Ho	MN 47644; MN 50246; MN 48826; MN 49598
Bucconidae						
Notharchus tectus (Boddaert, 1783)	Pied Puffbird	R	X		C, V	MN 49579
Bucco tamatia Gmelin, 1788	Spotted Puffbird	R	X		C	TERNA 903
Nystalus maculatus (Gmelin, 1788)	Spot-backed Puffbird	R	X		C, V	MN 49905
Monasa nigrifrons (Spix, 1824)	Black-fronted Nunbird	R	X		C, V, Ho	TERNA 391; TERNA 437
Chelidoptera tenebrosa (Pallas, 1782)	Swallow-winged Puffbird	R	X		C, V	MN 49594
Ramphastidae						
Ramphastos toco Statius Muller, 1776	Toco Toucan	R	X		V	
Ramphastos tucanus Linnaeus, 1758	White-throated Toucan	R	X		V, Ho	
Ramphastos vitellinus Lichtenstein, 1823	Channel-billed Toucan	R	X		C, V, Ho	MNA 8144
Selenidera gouldii (Natterer, 1837)	Gould's Toucanet	R	X		C, Ho	MNA 8218
Picidae						
Melanerpes cruentatus (Boddaert, 1783)	Yellow-tufted Woodpecker	R	X		C, V	MN 49161; MN 49163
Veniliornis affinis (Swainson, 1821)	Red-stained Woodpecker	R	X		C, V, Ho	MN 49909
Piculus flavigula (Boddaert, 1783)	Yellow-throated Woodpecker	R	X		V	
Celeus ochraceus (Spix, 1824)	Blond-crested Woodpecker	R	X		C, V, Ho	MN 47658; MN 47659; MN 47669; MN 49064
Celeus flavus (Statius Muller, 1776)	Cream-colored Woodpecker	R	X		C, V, Ho	MN 47667; MN 47668
Celeus obrieni Short, 1973	Kaempfer's Woodpecker	R, E	X	Pium and Rio dos Bois - TO	C, V, Ho	MN 49065; MN 48828; MN 48362; MN 49286
Thamnophilidae						
Taraba major (Vieillot, 1816)	Great Antshrike	R	X		C, V	MN4 9903
Thamnophilus pelzelni Hellmayr, 1924	Planalto Slaty-Antshrike	R, E	X		C, V, Ho	MNA 6562; MN A6550; MNA 6561
Thamnophilus amazonicus Sclater, 1858	Amazonian Antshrike	R	X		C, V	MN 50161
Dysithamnus mentalis (Temminck, 1823)	Plain Antvireo	R	X		C, V, Ho	MN 47606; MN 47607; MN 47632; MN 47666
Myrmotherula axillaris (Vieillot, 1817)	White-flanked Antwren	R	X		C, Ho	MN 50310
Herpsilochmus atricapillus Pelzeln, 1868	Black-capped Antwren	R	X		C, V, Ho	MN 48840; MN 48842; MN 49592
Formicivora grisea (Boddaert, 1783)	White-fringed Antwren	R	X		C, V, Ho	MN 47610; MN 47614; MN 50215; MN 47615
Cercomacra ferdinandi Snethlage, 1928	Bananal Antbird	R, E	X		V, Ho	
Willisornis vidua (Cabanis, 1847)	Scale-backed Antbird	R	X		C, V	MN 47608; MN 47611; MN 47612; MN 47641
Formicariidae						
Formicarius colma Boddaert, 1783	Rufous-capped Antthrush	R	X		C, Ho	MN 50167; MN 50223; MN 47637

Taxon	English Name	Status in Brazil	Presidente Kennedy	Adjacent Localities	Register type	Ascension numbers
Dendrocolaptidae						
Dendrocincla fuliginosa (Vieillot, 1818)	Plain-brown Woodcreeper	R	X		C	MN 47639; MN 50210; MN 50209; MN 49587
Sittasomus griseicapillus (Vieillot, 1818)	Olivaceous Woodcreeper	R	X		C, V, Ho	MN 50272
Dendroplex picus (Gmelin, 1788)	Straight-billed Woodcreeper	R	X		C, V	TERNA 511; TERNA 416
Xiphorhynchus spixii (Lesson, 1830)	Spix's Woodcreeper	R, E	X		C, V	MN 47664
Furnariidae						
Synallaxis scutata Sclater, 1859	Ochre-cheeked Spinetail	R	X		C, Ho	MN 47651; MN 48846; MN 49906
Certhiaxis cinnamomeus (Gmelin, 1788)	Yellow-chinned Spinetail	R		Guaraí-Araguacema Road	C, V	MN 49597
Xenops minutus (Sparrman, 1788)	Plain Xenops	R	X		C, V, Ho	MN 8200
Tyrannidae						
Corythopis torquatus (Tschudi, 1844)	Ringed Antpipit	R	X		V, Ho	
Hemitriccus striaticollis (Lafresnaye, 1853)	Stripe-necked Tody-Tyrant	R	X		C, Ho	MN 48841
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	Pearly-vented Tody-Tyrant	R	X		C, Ho	MN 50610
Myiornis ecaudatus (d'Orbigny & Lafresnaye, 1837)	Short-tailed Pygmy-Tyrant	R	X		C, V	MN 49840
Poecilotriccus fumifrons (Hartlaub, 1853)	Smoky-fronted Tody-Flycatcher	R	X	Pium - TO	C, Ho	MN A8527
Myiopagis gaimardii (d'Orbigny, 1839)	Forest Elaenia	R	X		Ho	
Myiopagis viridicata (Vieillot, 1817)	Greenish Elaenia	R	X		C, Ho	MN 50252
Camptostoma obsoletum (Temminck, 1824)	Southern Beardless-Tyrannulet	R	X		C, V, Ho	MN 47630; MN 47629
Capsiempis flaveola (Lichtenstein, 1823)	Yellow Tyrannulet	R	X		C, V, Ho	TERNA 1448
Tolmomyias sulphurescens (Spix, 1825)	Yellow-olive Flycatcher	R	X		C, V, Ho	MNA 6566
Tolmomyias flaviventris (Wied, 1831)	Yellow-breasted Flycatcher	R	X		C, V, Ho	MN 50233
Platyrinchus mystaceus Vieillot, 1818	White-throated Spadebill	R	X		C, V, Ho	MN 50232; MN 50312; MN 50297; MN 50248
Cnemotriccus fuscatus (Wied, 1831)	Fuscous Flycatcher	R	X		C, V, Ho	MN 49902
Fluvicola albiventer (Spix, 1825)	Black-backed Water-Tyrant	R	X		C	TERNA 1428
Colonia colonus (Vieillot, 1818)	Long-tailed Tyrant	R	X		V	
Machetornis rixosa (Vieillot, 1819)	Cattle Tyrant	R	X		V	
Legatus leucophaius (Vieillot, 1818)	Piratic Flycatcher	R	X		V, Ho	
Myiozetetes cayanensis (Linnaeus, 1766)	Rusty-margined Flycatcher	R	X		V, Ho	
Pitangus sulphuratus (Linnaeus, 1766)	Great Kiskadee	R	X		C, V, Ho	TERNA 519
Philohydor lictor (Lichtenstein, 1823)	Lesser Kiskadee	R		Guaraí-Araguacema Road	C	MN 49823
Myiodynastes maculatus (Statius Muller, 1776)	Streaked Flycatcher	R	X		C, V	MN 48852
Megarynchus pitangua (Linnaeus, 1766)	Boat-billed Flycatcher	R	X		C, V, Ho	TERNA 383

Taxon	English Name	Status in Brazil	Presidente Kennedy	Adjacent Localities	Register type	Ascension numbers
Griseotyrannus aurantioatrocristatus (d'Orbigny & Lafresnaye, 1837)	Crowned Slaty Flycatcher	R	X		C, V	MN 47628
Tyrannus savana Vieillot, 1808	Fork-tailed Flycatcher	R	X		V	
Rhytipterna simplex (Lichtenstein, 1823)	Grayish Mourner	R	X		C, V, Ho	MN 47643; MNA 6548; MNA 6552
Sirystes sibilator (Vieillot, 1818)	Sibilant Sirystes	R	X		C, Ho	MN 49159
Casiornis fuscus Sclater & Salvin, 1873	Ash-throated Casiornis	R, E	X		C, V	MN 50611
Myiarchus tuberculifer (d'Orbigny & Lafresnaye, 1837)	Dusky-capped Flycatcher	R	X		C	TERNA 1379
Myiarchus swainsoni Cabanis & Heine, 1859	Swainson's Flycatcher	R	X		C, V, Ho	TERNA 512; TERNA 368
Myiarchus ferox (Gmelin, 1789)	Short-crested Flycatcher	R	X		C, V, Ho	MN 49601; MN 49602; MN 47648; MN 47670
Ramphotrigon ruficauda (Spix, 1825)	Rufous-tailed Flatbill	R	X		C	MN 47663
Attila spadiceus (Gmelin, 1789)	Bright-rumped Attila	R	X		V, Ho	
Cotingidae						
Lipaugus vociferans (Wied, 1820)	Screaming Piha	R	X		C, V, Ho	MN 49828
Pipridae						
Neopelma pallescens (Lafresnaye, 1853)	Pale-bellied Tyrant-Manakin	R	X		C, V, Ho	MN 47633; MN 47634; MNA 6560; MN 50263
Manacus manacus (Linnaeus, 1766)	White-bearded Manakin	R	X		C, V, Ho	MNA 6554; MN 6563; MNA 7440
Chiroxiphia pareola (Linnaeus, 1766)	Blue-backed Manakin	R	X		C, V, Ho	MN 47638; MN 47640; MN 50225
Tityridae						
Schiffornis turdina (Wied, 1831)	Greenish Schiffornis	R, E	X		C, V, Ho	MN 49900
Iodopleura isabellae Parzudaki, 1847	White-browed Purpletuft	R	X		C, V	MN 47636; MN 49584
Pachyramphus polychopterus (Vieillot, 1818)	White-winged Becard	R	X		V	
Xenopsaris albinucha (Burmeister, 1869)	White-naped Xenopsaris	R	X		C, V	MN 47616
Vireonidae						
Cyclarhis gujanensis (Gmelin, 1789)	Rufous-browed Peppershrike	R	X		C, V, Ho	TERNA 534
Corvidae						
Cyanocorax cyanopogon (Wied, 1821)	White-naped Jay	R, E	X		C, V, Ho	TERNA 1437; TERNA 1438
Hirundinidae						
Pygochelidon cyanoleuca (Vieillot, 1817)	Blue-and-white Swallow	R	X		V	
Stelgidopteryx ruficollis (Vieillot, 1817)	Southern Rough-winged Swallow	R	X		V	
Progne tapera (Vieillot, 1817)	Brown-chested Martin	R	X		V	
Troglodytidae						
Pheugopedius genibarbis (Swainson, 1838)	Moustached Wren	R	X		C, V, Ho	MN 50305; MN 50258
Turdidae						
Catharus fuscescens (Stephens, 1817)	Veery	VN	X		C, V	MN 501072; MN 48850

Taxon	English Name	Status in Brazil	Presidente Kennedy	Adjacent Localities	Register type	Ascension numbers
Mimidae						
Mimus saturninus (Lichtenstein, 1823)	Chalk-browed Mockingbird	R	X		C, V	TERNA 482
Thraupidae						
Schistochlamys ruficapillus (Vieillot, 1817)	Cinnamon Tanager	R, E	X		C	TERNA 379
Nemosia pileata (Boddaert, 1783)	Hooded Tanager	R	X	Pium - TO	C	MN 50247
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	Orange-headed Tanager	R	X		V	
Tachyphonus cristatus (Linnaeus, 1766)	Flame-crested Tanager	R	X		C, V	MN 47671
Tachyphonus rufus (Boddaert, 1783)	White-lined Tanager	R	X		C, V	MN 49907
Ramphocelus carbo (Pallas, 1764)	Silver-beaked Tanager	R	X	Pium - TO	V	MN 50277; MN 49596
Tangara palmarum (Wied, 1823)	Palm Tanager	R	X		V, Ho	
Tangara cayana (Linnaeus, 1766)	Burnished-buff Tanager	R	X		C, V	MN 47631
Dacnis cayana (Linnaeus, 1766)	Blue Dacnis	R	X		V	
Conirostrum speciosum (Temminck, 1824)	Chestnut-vented Conebill	R	X		V	
Emberizidae						
Volatinia jacarina (Linnaeus, 1766)	Blue-black Grassquit	R	X		C, V, Ho	TERNA 1433
Tiaris fuliginosus (Wied, 1830)	Sooty Grassquit	R	X		C, V	MN 47662
Arremon taciturnus (Hermann, 1783)	Pectoral Sparrow	R	X		C, Ho	MN 47609; MN 47613; MN 50283; MN 50459
Charitospiza eucosma Oberholser, 1905	Coal-crested Finch	R	X		C, V	TERNA 517
Coryphospingus pileatus (Wied, 1821)	Pileated Finch	R	X		C, V	TERNA 371; TERNA 372
Cardinalidae						
Saltator maximus (Statius Muller, 1776)	Buff-throated Saltator	R	X		C, V, Ho	MN 49164
Parulidae						
Geothlypis aequinoctialis (Gmelin, 1789)	Masked Yellowthroat	R	X		V, Ho	
Basileuterus culicivorus (Deppe, 1830)	Golden-crowned Warbler	R	X		C	TERNA 1332
Basileuterus flaveolus (Baird, 1865)	Flavescent Warbler	R	X		C, V, Ho	MN 47642; MN 50026; MN 50275
Granatellus pelzelni Sclater, 1865	Rose-breasted Chat	R	X		C, V	TERNA 1357
Fringillidae						
Euphonia chlorotica (Linnaeus, 1766)	Purple-throated Euphonia	R	X		C, V, Ho	MN 49839
Euphonia violacea (Linnaeus, 1758)	Thick-billed Euphonia	R	X		C	MN 49821

In our study region, it is noteworthy that we found very few fragments of representative natural vegetation of the above-mentioned formations. Throughout the process of human settlement of Tocantins, the regional natural vegetation has been impacted variously, by the unbridled exploitation of forest resources, including direct deforestation (mainly using fire), or via the extensive introduction of cattle on well-managed pastures.

Also noteworthy is that the study site lacks more detailed surveys of its natural resources, beyond that made by Project RadamBrasil (1981), thus surveys of species richness and the occurrence of endemic taxa are not available.

As mentioned, wooded savanna, or typical Cerrado, represents the dominant physiognomy of the study site. The terrain is generally flat to slightly undulating, while quartzite sands with patches of latosols form the substrate. The predominantly sandy soils, associated with factors such as acidity, hydric supplement and fertility, act markedly on the vertical structure and spatial distribution of the arboreal community of the typical local Cerrado, characterized by larger species, with total height varying between 4 and 8 m. Such trees have generally level canopies, are poorly branched and present arboreal coverage of 20–30%. The distribution of arboreal species within the fragment is random, with obvious concentrations of individuals at specific points.

The fragment is representative of the contact between savanna and open ombrophylous forest, but is secondary, not primary forest, due to the process of selective commercial wood extraction. This fact is evidenced by the large number of artificial clearings, the presence of many vines and lianas, tracks for timber removal, and the overall low diversity and dominance of a very small number of species, *e.g. Callistene major* (Vochysiaceae).

Figure 2 illustrates the forest fragment. The vegetation presents well-defined strata. The herbaceous layer is very open, with low species diversity and *Olyria laxiflora* (Poaceae) is predominant. The sub-canopy is more closed, varies between 0.8 m and 1.8 m in height, and presents low species diversity, with representatives of Rubiaceae including species of the genus *Psychotria* and young *Astrocaryum aculeatum* and *Strychnus pseudoquina*, besides many individuals and species of lianas, *e.g. Doliocarpus* sp., *Tretacera* aff. *vollubilis*, *Serjania* sp., *Byrsonima* sp., *Abuta* sp. and *Pleonotoma jasminifolia*. The canopy layer is highly discontinuous, varying between 6 and 12 m in height, with the presence of some emergents of up to 16 m, and is again characterized by relatively low diversity with *Callistene major* the single most numerous species, besides *Martiodendrum mediterraneum* (Ceasalpinioideae) and others.

Adjacent localities

Three adjacent localities had punctual collections and are described and part listed here (Figure 1):

Rio dos Bois – TO (09°22'50.9''S; 48°33'48.8''W): this municipality lies 60 km south of the main study site, and comprises several forest fragments with very similar vegetation characteristics, albeit a greater number of bamboo thickets where one individual of Kaempfer's Woodpecker (*Celeus obrieni*) was seen and collected.

Pium – TO (10°24'10.3''S; 48°56'53.9''W): located 215 km south of the main fragment studied, this site consists of Cerrado *sensu strictu* with bamboo thickets where Kaempfer's Woodpeckers were also seen and collected.

Guaraí – Araguacema road – TO (08°48'35.77''S; 49°25'24.13''W): this is a road on the left bank of the Araguaia River. The surveyed locality was a very large marsh 15 km from the river itself. Several species associated with water were observed and collected (Table 1).

RESULTS AND DISCUSSION

We report the presence of 151 species at the study locality of Presidente Kennedy, Tocantins, and adjacent areas (Table 1). The avifaunal community of the site is characteristic of the open Cerrado grasslands, albeit with several important Amazonian elements, of which the most noteworthy records are detailed in the "Species accounts" that follow.

The study site is apparently the largest forest fragment of its type in central Tocantins and merits further investigation into its avifaunal community, given the potential for further discoveries including yet more new records for the state, and thus a better understanding of the avifaunal dynamics of this still poorly explored region. All specimen data in the following accounts are transcribed from the original field labels, while all measurements were taken by GMK. These were taken according to standard protocols using dial callipers and a wing-rule with a perpendicular stop at zero: wing length (from carpal joint to tip applying gentle pressure to the primary-coverts), tail length (from the distal end of the pygostyle to the tip), tail graduation (from tip of longest to tip of shortest rectrix), tarsus length (from the back of the intertarsal joint to the last complete scute before the toes diverge), and bill length (from the tip of the maxilla to skull).

Species accounts

Brazilian Tinamou *Crypturellus strigulosus* (Temminck, 1815): Not collected. Heard on 20 November 2010.

Pinto (1937) mentioned its occurrence as far east as Pará and south to northern Mato Grosso states, *e.g.* at the Guaporé River (11°54'S; 65°01''W). However, until recently, *C. strigulosus* does not appear to have been mentioned in the literature from Tocantins (see *e.g.*, Hidasi 1983, 1998, 2007, Sick 1997, Pinheiro & Dornas 2009), despite the map in Davies (2002). Nonetheless, E. Snethlage collected a female at Furo das Pedras (*c.* 10°28'S; 50°23'W), in the Ilha do Bananal, on 15 September 1927 (MN 4486), and there is also a female specimen from Barra do Garças (15°53'S; 52°15'W), Mato Grosso, at the border with Goiás, taken on 25 June 1973 (MN 33231) by O. Junqueira, while the species was also recorded in northern Tocantins by Olmos *et al.* (2004) and heard in tall forest south of Senhor do Bonfim in January 2009 (Kirwan *et al.* 2015). Dornas (2009) incorrectly listed the specimen as "MN 1876", but this is the same as MN 4486; 1876 is s the field collector's number.

Yellow-collared Macaw *Primolius auricollis* (Cassin, 1853): Not collected. Two individuals were observed by CPA, MAR and DHF at a *vereda* together with Blue-and-yellow Macaws, *Ara ararauna*. In Tocantins the species range is apparently confined to the Vale do Araguaia (Gwynne *et al.* 2010, Kirwan *et al.* 2015) and the present record therefore plausibly might pertain to escapees.

Pearly Parakeet "*Pyrrhura perlata-coerulescens*" complex and **Crimson-bellied Parakeet** *P. perlata* (Spix, 1824): MN 47649: male (gonads 7 × 3 mm), Presidente Kennedy, 11 August 2010; iris dark brown with white peri-ocular ring, bill and tarsus black; in moult (mantle feathers, while rectrices very worn); mass 66 g, wing 135 mm, tail 104 mm, bill 20 mm; MN 49580: one (sex unknown), Presidente Kennedy, 23 August 2011; iris chestnut-brown, with white peri-ocular ring, bill greyish brown, and tarsus dark grey; no moult; mass 80 g, wingspan 367 mm, total length 251 mm, wing 131 mm, tail 114 mm, bill 21.3 mm; MN 49581: one (sex unknown), Presidente Kennedy, 23 August 2011; iris chestnut-brown, with white peri-ocular ring, bill greyish brown, and tarsus dark grey; mass 75 g, wingspan 368 mm, total length 238 mm, wing 127 mm, tail 111 mm, bill 20.4 mm.

We ascribe our specimens to none of the geographically expected *Pyrrhura* species of the "*P. perlata-coerulescens*" complex. Following the recent study by Somenzari & Silveira (2015), our study site lies very close to the boundary between the ranges of two species within it, namely *anerythra* west of the Tocantins River and *coerulescens* east of the same river. The most diagnostic characters of *P. anerythra* are the presence of red on the belly and pure green and cobalt-blue underwing-coverts, whereas *P. coerulescens* has a green belly and characteristic red underwing-coverts. Our specimens appear to represent intermediates or hybrids between these two species, showing mixed characters, *i.e.* the characteristic dark red belly (with the extent of red varying individually) of *anerythra*, together with the red underwing-coverts (very pronounced on MN 47649, 49580, but much less obvious on MN 49581) associated with *coerulescens* (Figures 3 and 4). The species was common at our study site, and further work is required on this issue, because the supposedly hybrid zone described by Somenzari & Silveira (2015) is situated much farther north than our study site (750 km at the mouth of the Tocantins River), indicating that intermediate individuals can be expected throughout the potential contact zone. It also demonstrates that the unusual pattern of contact and mixing between two taxa in the lowest reaches of a major Amazonian river, reported by Somenzari & Silveira (2015), can clearly be expected to occur closer to the same river's headwaters. Barton & Hewitt (1985) attest that the size of a hybrid zone depends on the gene fitness and dispersal capabilities of the hybrids, but when both parameters are high the hybrid zone can consequently occupy many kilometres. Nevertheless, more data, including genetic, are clearly required to more fully understand the distributions and relationships of these forest-dwelling parakeets.

FIGURE 3. Collected specimens of hybrids or intermediates of the "*Pyrrhura lepida-coerulescens*" complex. (**A**) dorsal view; (**B**) ventral view; (**C**) right lateral view. In order MN 49581, MN 47649 and MN 49580.

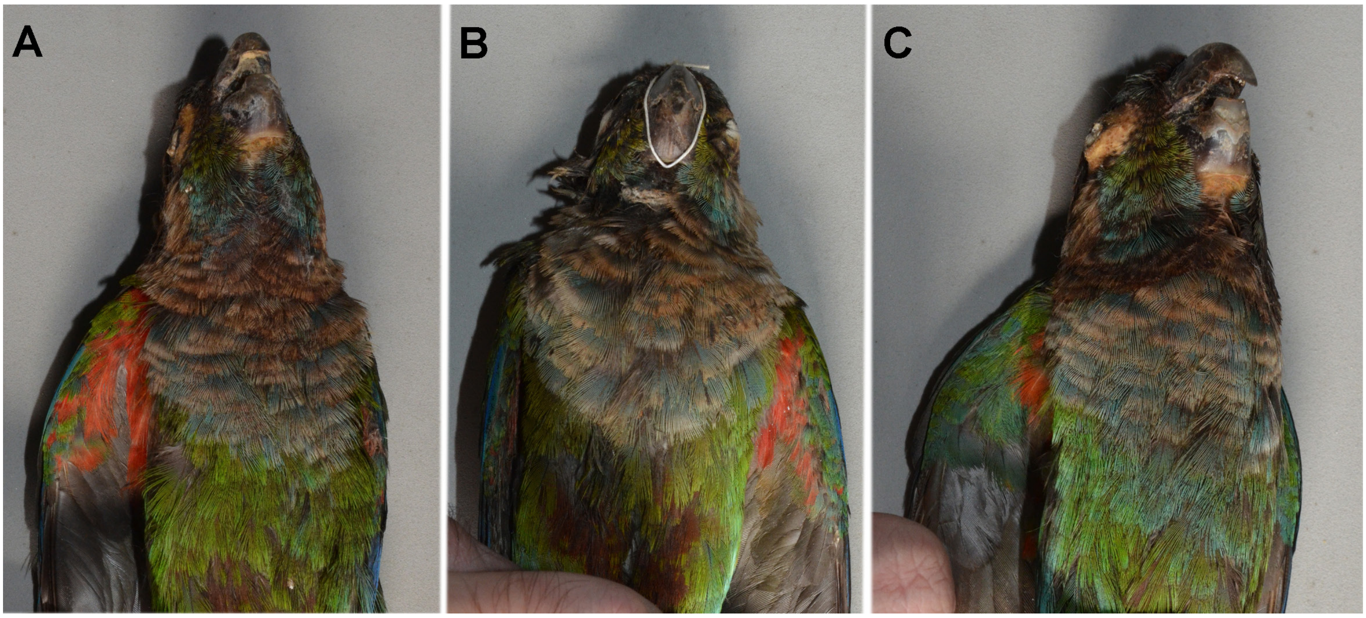

FIGURE 4. Details of the variation on the amount of red on underwing coverts of the collected specimens of the "*Pyrrhura lepida-coerulescens*" complex. (**A**) MN 49580; (**B**) MN47649; (**C**) MN49581.

Dornas (2009) mentioned sight records of this group of species from Tocantins, published by Olmos *et al.* (2005) and Oikos (2002), but the only previous specimen record that he knew of, MN 3632, collected by R. Pfrimer at the lower Palma River, south-east Tocantins (12°33'S; 47°52'W), sometime prior to 1919 (Paynter & Traylor 1991), is in fact a young Crimson-bellied Parakeet *P. perlata*. Pfrimer also collected an adult *perlata* at the same locality (MN 3633), also without details (Figure 5). Our three specimens pertaining to the *P. perlata-coerulescens* complex represent the first published documentation of this group of species for the same state. The two specimens of *P. perlata* represent the only evidence for this "vulnerable" species (at least formerly) in Tocantins. However, as already noted by Silva (1989), Sick (1997) and Pacheco (2004), there is no other evidence for the occurrence of this rare parrot outside the Madeira–Xingu interfluvium, neither historical nor recent, and the possibility exists that these specimens instead came from Rondônia state and were incorrectly curated by Dr. Alípio Miranda Ribeiro. Furthermore, other Pfrimer specimens present problematic localities, *e.g.* two specimens of Orange-cheeked Parrot *Pyrilia barrabandi* (Kuhl, 1820) said to be from Palma, Goiás (MN 3979, 3980), although the species is otherwise largely confined to western Amazonia, or are problematic because of the lack of locality information associated with them, or are labelled very inexactly, and generally lack even basic information like sex. For now, and without strong additional evidence, these specimens of *P. perlata* cannot be definitively evinced as being taken in Tocantins, especially from such an unlikely locality as the extreme southeast of the state, *i.e.* comparatively far from the region of Amazonian influence. Nevertheless, additional research into Pfrimer's specimens is still required.

FIGURE 5. Pfrimer's specimens of *Pyrrhura rhodogaster* putatively collected in Tocantins. Left adult MN3633; right juvenile MN 3632.

Pearly-breasted Cuckoo *Coccyzus euleri* Cabanis, 1873: MN 48847: female, Presidente Kennedy, 20 November 2010; iris brown, maxilla black with yellow base, mandible yellow, and tarsus lead grey; no moult; mass 47.5 g, wingspan 380 mm, total length 285 mm, wing 142.5 mm, tail 130 mm, bill 28.5 mm. The first specimen record for Tocantins (Dornas 2009); the species is not mentioned by Hidasi (1998), and no records are indicated on Wikiaves. Nevertheless, sight records were mentioned by Olmos *et al*. (2005) and Oikos (2002), as well as by Pinheiro *et al*. (2008) from the urban area of Palmas, the state's capital.

Yellow-billed Cuckoo *Coccyzus americanus* (Linnaeus, 1758): MN 49610: male, captured in a mist-net, Presidente Kennedy, 18 November 2010; iris brown, tarsus grey; in general moult; 55 g, wing 150.5 mm, tail 136 mm, bill 30.06 mm. Not previously listed for the state of Tocantins (Hidasi 1998, Dornas 2009), although a photographic record was recently published from December 2010 (D. Rodello; WA 255397) and one was seen just north of Couto de Magalhães, in November 2011 (Kirwan *et al*. 2015). Ours becomes the first record from Tocantins, pre-dating both others available to date.

Pavonine Cuckoo *Dromococcyx pavoninus* Pelzeln, 1870: MN 47661: male (gonads 3 × 2 mm) captured in a mist-net, Presidente Kennedy, 13 August 2010; iris amber, with cream-coloured peri-ocular ring, maxilla sepia, mandible pale grey, and tarsus reddish grey; no moult; mass 39 g, wingspan 375 mm, total length 294 mm, wing 127 mm, tail 151 mm, bill 25.5 mm. In Tocantins, it is known from a single specimen record, MN 4097, a female collected by E. Snethlage at Furo de Pedra (= Furo das Pedras, *c.* 10°28'S; 50°23'W), Ilha do Bananal, 22 September 1927, as well as records by Pacheco & Olmos (2006) in the Palmeiras Valley, in the southeast of the state, and T. Dornas (sound-recording) at an unstated locality (Dornas 2009), while photo-documented records are available on Wikiaves from Araguatins, Caseara, Palmas, Pium and Porto Nacional. Our new specimen record, only the second for Tocantins, augments the suspicion that the species is resident in suitable habitat throughout the Araguaia–Tocantins interfluvium (Kirwan *et al*. 2015).

Kaempfer's Woodpecker *Celeus obrieni* Short, 1973: MN 48828: male, Pium, 22 November 2010; iris grey, bill pearl-grey with paler grey base to mandible, and tarsus yellow; moulting wing- and tail-feathers; mass 105 g, wingspan 460 mm, wing 134 mm, tail 95 mm, bill removed; MN 48362: male, Pium, 16 November 2010; iris grey, bill pearl-grey with greenish-grey base to mandible, and tarsus yellowish green; moulting inner wing-coverts and some upperparts feathers; mass 94 g, wingspan 346 mm, total length 380 mm, wing 143 mm, tail 93 mm, bill 27.48 mm; MN 49065: male, Rio do Bois, 16 November 2010; iris grey, bill pearl-grey with greenish-grey base, and tarsus yellowish green; in general moult; mass 100 g, wingspan 275 mm, wing 148 mm, tail 90 mm, bill removed; MN 49286: female, Presidente Kennedy, 19 August 2011; iris chestnut-brown, bill horn-coloured, and tarsus greyish brown; mass 85 g, total length 270 mm, wing 142 mm, tail 101 mm, bill 25.13 mm. Rare in collections throughout the world, our specimens were preserved as two normal study skins and two "schmoo" type skins, with the aim of preserving complete skeletons.

Plain-brown Woodcreeper *Dendrocincla fuliginosa* (Vieillot, 1818): MN 49587: one (sex unknown), Presidente Kennedy, 23 August 2011; iris chestnut-brown, bill dark brown, and tarsus greyish brown; moulting the ventral feathers; mass 47 g, total length 250 mm, wing 114 mm, tail 94.5 mm, bill 34.5 mm. In Tocantins, known from the following specimens: COMB 1634, MN 13649–50, 13652 and 13659 (all collected by E. Snethlage at Furo das Pedras, Ilha do Bananal), and MZUSP 78737, while there are photo-documented records from Palmeirante, 13 January 2013 (W. Pascoal; WA 854431, WA 854623) and Tupirama, 15 September 2011 (T. Dornas; WA 1040124).

Spix's Woodcreeper *Xiphorhynchus spixii* (Lesson, 1830): MN 47664: one (sex unknown), Presidente Kennedy, 13 August 2010; mist-netted; iris dark brown, maxilla dark grey and mandible pale grey, tarsus greenish grey; no moult; mass 27.5 g; wingspan 305 mm; wing 84 mm; tail 87 mm; bill 29 mm. In Tocantins, the only previous specimens available are from Couto de Magalhães (MPEG 34749, 34762: Dornas 2009). Our specimen is the south-westernmost record of the species in the Brazilian territory to date and the first in the state away from the banks of the Araguaia.

Amazonian Antshrike *Thamnophilus amazonicus* Sclater, 1858: MN 48843: male, Presidente Kennedy, 20 November 2010; iris brown, bill black, and tarsus grey; in moult; mass 19.5 g, wingspan 210 mm; wing 69 mm, tail 58 mm, bill 19.96 mm; MN 49607: female, Presidente Kennedy, 19 November 2010; iris reddish brown, and tarsus grey; no moult; mass 20 g, wingspan 221 mm, total length 166 mm, wing 66 mm, tail 54 mm, bill 21.2 mm. In Tocantins, specimens are available from Araguatins (MZUSP 52686), Couto de Magalhães (MPEG 34750) and Santo Antonio (FMNH 63429–430), with photo- or sound-documented records from the following additional localities available on Wikiaves: Ananás (WA 587580: T. Dornas), Caseara (WA 1081425, WA 1081426 and WA 1764420: M. Barbosa, M. Martins), Miracema do Tocantins (WA 1757325, WA 1757326: C. Cruvinel), Palmeirante (WA 725048: W. Pascoal), Pau d'Arco (WA 729124: M. Paula) and Pium (WA 9641: G. Leite, plus others). Our specimens can be referred to the subspecies *T. a. obscurus* based on the very dark underparts of the male, and the greyish ventral underparts, lack of reddish tones in the uppertail and absence of white spots on tips of central rectrices of the female (compared to long series of *T. a. paraensis* in MN). Zimmer & Isler (2003) considered that the range of *obscurus* occupies forests between the Tapajós and Araguaia Rivers, in southern Pará, whereas *paraensis* occurs east of the Tocantins River in eastern Pará, western Maranhão and northern

Tocantins. Our specimens and the many photographs on Wikiaves indicate that *obscurus* also occurs in Tocantins (*e.g.* WA 1520682, WA 1081425).

White-flanked Antwren *Myrmotherula axillaris* (Vieillot, 1817): MN 49608: male, Presidente Kennedy, 19 November 2010; iris brown, bill black and tarsus grey; in moult; mass 8.5 g, wingspan 165 mm, total length 111 mm, wing 47 mm, tail 35.5 mm, bill 15.05 mm. In Tocantins, previous specimen records are from Araguatins (MPEG 21982, MZUSP 52688), Tocantinópolis (MOG 7976) and Xamboiá (MPEG 34756) (Dornas & Pinheiro 2011), while photo- or sound-documented records, archived on Wikiaves, are from Ananás (WA 69634: G. Leite), Caseara (WA 409220, WA 409221: C. Martins, plus others), Palmeirante (WA 725049: W. Pascoal) and Pium (WA 6693, WA 657030: G. Leite, W. Pascoal), with an unpublished sight record from Senhor do Bonfim, in January 2009 (GMK, pers. obs.).

Bananal Antbird *Cercomacra ferdinandi* Snethlage, 1928: Not collected, but seen and heard on 21 August of 2011 in a narrow gallery forest at the northwest corner of the main forest fragment, when at least two pairs responded to playback of Manu Antbird *C. manu,* with the identification being confirmed as the present species based on the males overall darker and females bein gray above rather than brown, as well as the voice, which was clearly that of *C. ferdinandi*. Species largely restricted to the Ilha do Bananal and adjacent downstream sections of the Araguaia River, as well as the Tocantins River in both Tocantins and adjacent Maranhão (Zimmer & Isler 2003, Olmos *et al.* 2005, Vasconcelos & Souza-Werneck 2008, BirdLife International 2014, WA 1282167, WA 581658 and WA 587556), although there are a few records from further upstream, in adjacent northeastern Mato Grosso and north-western Goiás (see Wikiaves). There are comparatively few records away from larger rivers with seasonally flooded forests.

Xingu Scale-backed Antbird *Willisornis vidua* (Cabanis, 1847): MN 47608: female captured in a mist-net, Presidente Kennedy, 9 August 2010; iris brown, bill black and tarsus lead grey; no moult; mass 17.5 g, wing 74.5 mm, tail 55 mm, bill 17.2 mm; MN 47611: male captured in a mist-net, Presidente Kennedy, 9 August 2010; iris brown, bill black and tarsus grey; no moult; mass 17.5 g, wingspan 220 mm, total length 140 mm, wing 70 mm, tail 42 mm, bill 18.32 mm; MN 47612: male captured in a mist-net, Presidente Kennedy, 9 August 2010; iris brown, bill black and tarsus grey; no moult; mass 16 g, wingspan 215 mm, total length 130 mm, wing 67.5 mm, tail 40.5 mm, bill 18.32 mm; MN 47641 captured in a mist-net, Presidente Kennedy, 10 August 2010; iris brown, bill black and tarsus grey; no moult; mass 17 g, wingspan 208 mm, total length 133 mm, wing 70 mm, tail 41 mm, bill 18.36 mm. In Tocantins, Dornas & Pinheiro (2011) listed single specimens from three localities: Ananás (MPEG 34741), Xamboiá (MPEG 34754) and Couto de Magalhães (MPEG 34752), all of them along the right bank of the Araguaia, while there is a sound-recording from Babaçulândia, in the far north of the state, at the border with Maranhão (J. F. Pacheco; WA 1249671). Our specimens represent the southernmost locality in Tocantins for this recently recognized species, and is apparently only the second in the state away from the banks of the Araguaia.

Rufous-capped Antthrush *Formicarius colma* Boddaert, 1783: MN 47637: one (sex unknown), captured in a mist-net, Presidente Kennedy, 10 August 2010; iris brown, bill black, and tarsus greyish purple; moulting thigh-feathers; mass 42 g, wingspan 265 mm, total length 168 mm, wing 55.5 mm, tail 48 mm, bill 20.75 mm. In Tocantins, previously available specimens all emanated from two localities, Araguatins (n = 12) and Fazenda Farol dos Trópicos, Couto de Magalhães (n = 1), both on the right bank of the Araguaia River (Dornas & Pinheiro 2011), with photo-documented records also from the first-named locality (C. Silva; WA 281267, WA 281806), a sound-recording from Ananás (G. Leite; WA 69617) and sight records from the extreme north of the state (Olmos *et al.* 2004) and from Senhor do Bonfim (Kirwan *et al.* 2015). Ours is apparently the first record from the interior of the state, albeit still within the zone of Amazonian influence (Dornas & Pinheiro 2011), and represents only the third specimen locality.

Greyish Mourner *Rhytipterna simplex* (Lichtenstein, 1823): MN 47643: male captured in a mist-net, Presidente Kennedy, 10 August 2010; iris pale brown, bill black with reddish base to mandible, and tarsus grey; no moult; mass 28 g, total length 205 mm, wing 91 mm, tail 90 mm, bill 22.2 mm. In Tocantins, previously known from three specimen records (Dornas 2009), including MN 6060 (not 6061 as stated in Dornas 2009), collected at Furo de Pedra (= Furo das Pedras, *c.* 10°28'S; 50°23'W), Ilha do Bananal, 26 September 1927, while the species is also known from two photo-documented records, both from Pium, 7 July 2010 (M. Barbosa; WA 191815) and 15 March 2012 (A. Corrêa; WA 678443), as well as sight records from Cantão State Park, where the species is common (Pinheiro & Dornas 2009) and the far north of the state (Olmos *et al.* 2004). Our record represents the easternmost to date for the state of Tocantins.

Rufous-tailed Flatbill *Ramphotrigon ruficauda* (Spix, 1825): MN 47663: male (gonads 2 × 1 mm) captured in a mist-net, Presidente Kennedy, 13 August 2010; iris brown, bill black and tarsus black; no moult; mass 14 g, wingspan 242 mm, total length 170 mm, wing 74.5 mm, tail 55 mm, bill 17.2 mm. In Tocantins, previously known from two photo-documented records: Pium, 23 February 2009 (M. Crozariol; WA 9715) and

Lagoa da Confusão, 12 October 2011 (WA 480844), with several sight records from Cantão State Park (Buzzetti 2004, Dornas 2009). Presidente Kennedy would appear to represent the easternmost locality for the species in Tocantins. Ours is the first specimen record for the state.

White-naped Xenopsaris *Xenopsaris albinucha* (Burmeister, 1869): MN 47616: one (not sexed during taxidermy, but some brownish elements in crown suggest a female), Presidente Kennedy, 9 August 2013, from among a mixed-species flock; iris black, maxilla black, mandible pearl grey, and tarsus very dark grey; no moult; mass 9 g, wingspan 203 mm, total length 140 mm, wing 66 mm, tail 51 mm, bill 12.52 mm. In Tocantins, two previous specimen records, MOG 7273 and MZJH 1295 (Dornas 2009), two photo-documented records, from Palmas, 13 July 2014 (M. Barbosa; WA 1384653–654) and Palmeirante, 29 July 2009 (W. Pascoal; WA 79557, WA 80861 and WA 82872), while Kirwan *et al*. (2015) listed a series of sight records in the state, both from wooded Cerrados and river islands in the Araguaia.

White-bearded Manakin *Manacus manacus* (Linnaeus, 1766): MN 49609: male, Presidente Kennedy, 19 November 2010; iris brown, maxilla dark grey, mandible lead-coloured, and tarsus orange; no moult; mass 16 g, wingspan 190 mm, total length 115 mm, wing 56 mm, tail 25 mm, bill 11.33 mm. Kirwan & Green (2011) noted the difficulties in defining the eastern and western limits, respectively, of *M. m. longibarbatus* and *M. m. purissimus*, and speculated that the former might well prove synonymous with the latter. We compared our specimen with other relevant material at MN and consider that Zimmer's (1936) delimitation of *longibarbatus* cannot be upheld, given much overlap and variation, even in birds from the same locality in the amount of white feathering on the upper mantle and neck, the breadth of the grey rump patch and amount of grey on thighs and belly. In addition, the long throat-feathering in MN 49609 contrasts with the shorter feathering in MN 11060, a male from Furo das Pedras, Ilha do Bananal, and is only marginally shorter than that of MN 11059, a male from Cametá, Tocantins River, despite that the first two are both from the range of *longibarbatus* as delimited by Zimmer, and the last from that of *purissimus*, while MN 49609 has the width of the outermost primary distinctly broader (2.48 mm) than that of MN 11059 (1.32 mm), but similar to that of MN 11060 (2.52 mm), whereas according to Zimmer (1936), it should be *purissimus* that has the broadest outermost primary. All three have the wing length (55–56 mm) very similar. Our data do not support *longibarbatus* although it is clear that a serious range-wide revision of the species is needed, to determine the number of taxa that might comfortably be maintained.

White-browed Purpletuft *Iodopleura isabellae* Parzudaki, 1847: MN 47636: male, Presidente Kennedy, August 2010; wing 75 mm, tail 27 mm, bill 9.35 mm; MN 49584: female, Presidente Kennedy, August 2010; iris dark chestnut, maxilla dark brown, mandible grey, and tarsus dark grey; in moult (contour feathers); mass 18.5 g, wingspan 240 mm, total length 127 mm, wing 76 mm, tail 34 mm, bill 10.02 mm. In Tocantins, Dornas (2009) and Dornas & Pinheiro (2011) listed a total of seven specimens, all of them from Araguatins in the extreme north of the state, while there are photo- and/or sound-documented records from Ananás, 18 April 2009 (M. Crozariol; WA 115960, G. Leite; WA 69608), also in the far north of Tocantins, and Fortaleza do Tabocão, 19 March 2014 (T. A. Bichinski; WA 1379917) and Dois Irmãos do Tocantins, 2 and 4 October 2014 (A. Correa; WA 1524063, WA 1524064), which extend the species range further south in the Araguaia–Tocantins interfluvium. Our material apparently represents the second specimen-documented locality for the state and the fourth overall.

Veery *Catharus fuscescens* (Stephens, 1817): MN 48850: female, Presidente Kennedy, 21 November 2010; iris brown, maxilla blackish brown, mandible mainly yellowish with darker tip, and tarsus pearl grey; no moult; mass 32.5 g, wingspan 310 mm, total length 195 mm, wing 103 mm, tail 76 mm, bill 17.54 mm; MN 49595: male, Presidente Kennedy, 18 November 2010; iris brown, maxilla blackish brown, mandible mainly yellowish with blackish-brown tip, and tarsus pale pink; moulting tail-feathers; mass 31.5 g, wingspan 310 mm, wing 105 mm, tail 72 mm, bill 18.32 mm. In Tocantins, two previous specimen records: MOG 604 was collected at Araguatins in November 1968 (Dornas & Pinheiro 2011) and COCEULP/ULBRA 124 (Dornas 2009), while the species was also recorded during Oikos (2006) surveys, by Dornas & Crozariol (2012) at the Estação Ecológica Serra Geral do Tocantins, in Jalapão, in mid-November 2010, and there is a photo-documented record from Palmas, on 22 April 2013 (F. Af; WA 943762–763). Our records could reflect migration rather than overwintering (*sensu* Remsen 2001). The species is probably overlooked in Tocantins due to the lack of surveys using mist-nets.

Sooty Grassquit *Tiaris fuliginosus* (Wied, 1830) MN 47662: male, captured in a mist-net, Presidente Kennedy, 13 August 2010; iris dark brown, bill brown with beige tip to mandible, and tarsus purple; no moult; mass 9 g, wingspan 185 mm, total length 125 mm, wing 57 mm, tail 31 mm, bill 12.5 mm. In Tocantins, recorded during various environmental surveys (Oikos 2002, Direção 2006), with a single photo-documented record from the extreme north of the state, at Sítio Novo do Tocantins, 15 March 2012 (C. Silva; WA 597351). Ours is the first specimen and first documented record for the state (pre-dating the photo mentioned above).

ACKNOWLEDGEMENTS

We are grateful to the *Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro* (FAPERJ) for grant support to M. A. Raposo (Proc. No. E-26/101.489/2010) and to G. R. R. Brito (Proc. No. E-26/102.506/2010); *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) for grant support to M. A. Raposo (Procs No. 479049/2006-8, 476861/2009-8 and 301350/2008-6); *Fundação de Amparo à Pesquisa do Estado de São Paulo* (FAPESP) for grant support to Claydson Assis (Proc. No. 2014/10914-2) and Proc. No. 2012/00614-6 for doctoral fellowship to D. H. Firme; *Coordenação de Aperfeiçoamento de Pessoal de Nivel Superior* (CAPES) for felowships to G. R. R. Brito and N. Buainain Neto; and F. R. Amaral for information concerning hybrid zones. TAESA, P&D Aneel, ETAU Transmissão and Ecology Brasil provided logistics and field support. We are extremely grateful to an anonymous referee for invaluable comments and corrections to the submitted manuscript.

REFERENCES

Barton, N. H. & Hewitt, G. M. 1985. Analysis of hybrid zones. *Annual Review of Ecology and Systematics*, 16: 113–148.

BirdLife International. 2014. Species factsheet: *Cercomacra ferdinandi*. http://www.birdlife.org/datazone/species/factsheet/22701677 (accessed October 2014).

Blondel, J.; Ferry, C. & Frochot, B. 1970. La méthode des indices ponctuels d'abondance (I.P.A.) ou des relevés d'avifaune par "stations d'écoute". *Alauda*, 38: 55–71.

Buzzetti, D. 2004. Avifauna do Parque Estadual do Cantão, p. 74–102. *In*: *Avaliação Ecológica Rápida do Parque Estadual do Cantão*. Palmas: Secretaria do Planejamento e Meio Ambiente do Estado do Tocantins, SEPLAN.

Davies, S. J. J. F. 2002. *Ratites and tinamous*. New York: Oxford University Press.

De Luca, A. C.; Develey, P. F.; Bencke, G. A. & Goerck, J. M. 2009. *Áreas importantes para a conservação das aves no Brasil. Part II – Amazônia, Cerrado e Pantanal*. São Paulo: SAVE Brasil.

Direção. 2006. *Pesquisa de fauna e flora e elaboração dos estudos das alterações da cobertura vegetal e da ocupação antrópica Regiões Central e Leste do Estado do Tocantins*. Belo Horizonte: Direção Consultoria e Engenharia Ltda., v. 1 & 2.

Dornas, T. 2009. *Compilação dos registros de quelônios, crocodilianos e aves do Estado do Tocantins: biodiversidade e lacunas de conhecimento*. M.Sc. Dissertation. Palmas: Universidade Federal do Tocantins.

Dornas, T. & Crozariol, M. A. 2012. Aves associadas a ambiente de veredas na Estação Ecológica Serra Geral do Tocantins com novos registros para a região e nota sobre população local de *Culicivora caudacuta*. *Atualidades Ornitológicas*, 169: 54–65.

Dornas, T. & Pinheiro, R. T. 2011. Aves coligidas por José Hidasi e Manoel Santa-Brigida na Amazônia Tocantinense: implicações para a distribuição geográfica das aves amazônicas brasileiras. *Revista Brasileira de Ornitologia*, 19: 276–301.

Gwynne, J. E.; Ridgely, R. S.; Tudor, G. & Argel, M. 2010. *Aves do Brasil, v. 1, Pantanal & Cerrado*. São Paulo: Editora Horizonte.

Haidar, R. F.; Fagg, J. M. F.; Pinto, J. R. R.; Dias, R. R.; Damasco, G.; Silva, L. C. R. & Fagg, C. W. 2013. Florestas estacionais e áreas de ecótono no estado do Tocantins, Brasil: parâmetros estruturais, classificação das fitofisionomias florestais e subsídios para conservação. *Acta Amazonica*, 43: 261–290.

Hellmayr, C. E. 1929. A contribution to the ornithology of northeastern Brazil. *Field Museum of Natural History (Zoological Series)*, 12: 235–501.

Hidasi, J. 1983. *Lista preliminar das aves do Estado de Goiás*. Goiânia: Gráfica Palmares.

Hidasi, J. 1998. *Lista preliminar das aves do Tocantins*. Palmas: Editora UNITINS.

Hidasi, J. 2007. *Aves de Goiás*. Goiânia: Editora UCG & Editora Kelps.

Kirwan, G. M. & Green, G. 2011. *Cotingas and manakins*. London: Christopher Helm.

Kirwan, G. M.; Whittaker, A. & Zimmer, K. J. 2015. Interesting bird records from the Araguaia River Valley, central Brazil, with comments on conservation, distribution and taxonomy. *Bulletin of the British Ornithologists' Club*, 135: 21–60.

Lees, A. C.; Naka, L. N.; Aleixo, A.; Cohn-Haft, M.; Piacentini, V. Q.; Santos, M. P. D. & Silveira, L. F. 2014. Conducting rigorous avian inventories: Amazonian case studies and a roadmap for improvement. *Revista Brasileira de Ornitologia*, 22: 107–120.

Oikos. 2002. *Estudos ambientais complementares ao EIA/RIMA da Ferrovia Norte-sul nos Estados de Tocantins e Goiás*. Rio de Janeiro: Oikos Pesquisa Aplicada.

Oikos. 2006. *Estudos para a seleção das áreas de maior potencial para a conversão em unidades de conservação na região centro-oeste do Tocantins*. Palmas: Oikos. Pesquisa Aplicada Ltda., Unpub. Report.

Olmos, F.; Arbocz, G.; Pacheco, J. F. & Dias, R. 2004. Estudo de flora e fauna do norte do estado do Tocantins, p. 1–154. *In*: Dias, R. (org.). *Projeto de gestão ambiental integrada Bico do Papagaio, zoneamento ecológico-econômico*. Palmas: Secretaria do Planejamento e Meio Ambiente (Seplan) e Diretoria de Zoneamento Ecológico-Econômico (DZE).

Olmos, F.; Silva e Silva, R. & Pacheco, J. F. 2005. The range of the Bananal Antbird *Cercomacra ferdinandi*. *Cotinga*, 25: 21–23.

Pacheco, J. F. 2004. As aves da Caatinga: uma análise histórica do conhecimento. *In*: Silva, J. M. C.; Tabarelli, M.; Fonseca, M. T. & Lins, L. V. (eds.). *Biodiversidade da caatinga: áreas e ações prioritárias para conservação*. Brasília: Ministério do Meio Ambiente.

Pacheco, J. F. & Olmos, F. 2006. As aves do Tocantins 1: região sudeste. *Revista Brasileira de Ornitologia*, 14: 55–71.

Paynter, R. A. & Traylor, M. A. 1991. *Ornithological gazetteer of Brazil*. Cambridge: Museum of Comparative Zoology, Harvard University.

Perotti, R. T. 2005. *José Hidasi e os naturalistas no "coração bárbaro" do Brasil*. M.Sc. Dissertation. Goiânia: Gestão do Patrimônio Cultural, Área de Concentração Antropologia, Universidade Católica de Goiás.

Piacentini, V. Q.; Aleixo, A.; Agne, C. E.; Mauricio, G. N.; Pacheco, J. F.; Bravo, G. A.; Brito, G. R. R.; Naka, L. N.; Olmos, F.; Posso, S.; Silveira, L. F.; Betini, G. N.; Carrano, E.; Franz, I.; Lees, A. C.; Lima, L. M.; Pioli, D.; Schunck, F.; Amaral, F. R.; Bencke, G. A.; Cohn-Haft, M.; Figueiredo, L. F. A.; Straube, F. C. & Cesari, E. 2015. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committe. *Revista Brasileira de Ornitologia*, 23: 91–298.

Pinheiro, R. T. & Dornas, T. 2009. Distribuição e conservação das aves na região do Cantão, Tocantins: ecótono Amazônia/Cerrado. *Biota Neotropica*, 9: 187–205.

Pinheiro, R. T.; Dornas, T.; Reis, E. S; Barbosa, M. O. & Rodello, D. 2008. Birds of the urban area of Palmas-TO: composition and conservation. *Revista Brasileira de Ornitologia*, 16: 339–347.

Pinto, O. M. O. 1937. Catálogo das aves do Brazil. 1ª parte. *Revista Museu Paulista*, 22: 1–566.

Radambrasil. 1981. *SD.22 Goiás: geologia, geomorfologia, pedologia, vegetação e uso potencial da terra.* Rio de Janeiro: Ministério das Minas e Energia. Levantamento de Recursos Naturais.

Raposo, M. A.; Assis, C. P.; Figueira, D.; Demari, E.; Frickes, G. R.; Araújo, G.; Firme, D. H.; Neto, N. B.; Straker, L. C.; Russo, R. M.; Cid, F. C.; Lima, G.; Brito, G. R. R.; Alves, L. P. & Formozo, P. 2013. *Aves e linhas de transmissão: um estudo de caso*. São Paulo: Editora Arte Ensaio.

Remsen, J. V. 2001. True winter range of the Veery (*Catharus fuscescens*): lessons for determining winter ranges of species that winter in the tropics. *Auk*, 118: 838–848.

Sick, H. 1997. *Ornitologia brasileira*. Rio de Janeiro: Editora Nova Fronteira.

Silva, J. M. C. 1989. *Análise biogeográfica da avifauna de florestas do interflúvio Araguaia–São Francisco*. M.Sc. Dissertation. Brasília: Universidade de Brasília.

Silva, J. M. C. 1990. A reavaluation [*sic*] of *Serpophaga araguayae* Snethlage 1928 (Aves: Tyrannidae). *Goeldiana, Zoologia*, 1: 1–6.

Somenzari, M. & Silveira, L. F. 2015. Taxonomy of the *Pyrrhura perlata-coerulescens* complex (Psittaciformes: Psittacidae) with description of a hybrid zone. *Journal of Ornithology*, 156: 1049–1060.

Teixeira, D. M. 1990. Notas sobre algumas aves descritas por Emilie Snethlage. *Boletim do Museu Nacional*, 337: 1–6.

Vasconcelos, M. F. & Souza-Werneck, M. 2008. Northern record for Bananal Antbird *Cercomacra ferdinandi*. *Cotinga*, 29: 177–178.

Veloso, R. B.; Rangel-Filho, A. L. R. & Lima, J. C. A. 1991. *Classificação da vegetação brasileira, adaptada a um sistema universal*. Rio de Janeiro: IBGE.

Zimmer, J. T. 1936. Studies of Peruvian birds, No. XXII. Notes on the Pipridae. *American Museum Novitates*, 889: 1–29.

Zimmer, K. J. & Isler, M. L. 2003. Family Thamnophilidae (typical antbirds), p. 448–681. *In*: del Hoyo, J.; Elliott, A. & Christie, D. A. (eds.). *Handbook of the birds of the world*, v. 8. Barcelona: Lynx Edicions.

Associate Editor: Alexandre Aleixo.

Revista Brasileira de Ornitologia, 24(2), 185-190
June 2016

SHORT-COMMUNICATION

Confirmation of the hybridization of *Chiroxiphia* Cabanis, 1847 and *Antilophia* Reichenbach, 1850 (Passeriformes: Pipridae) using molecular markers

Wagner Brito Alves[1], Ciro Albano[2], Weber Andrade de Girão e Silva[2], Juliana Araripe[3] and Péricles Sena do Rêgo[3,4]

[1] Laboratório de Genética e Conservação, Instituto de Estudos Costeiros, Universidade Federal do Pará, CEP 68600-000, Bragança, PA, Brazil.
[2] Associação de Pesquisa e Preservação de Ecossistemas Aquáticos, CEP 61627-610, Caucaia, CE, Brazil.
[3] Laboratório de Genética e Conservação, Instituto de Estudos Costeiros, Universidade Federal do Pará, CEP 68600-000, Bragança, PA, Brazil.
[4] Corresponding author: periclessena@yahoo.com.br

Received on 06 August 2015. Accepted on 21 June 2016.

ABSTRACT: Events of hybridization between species of different manakin genera are well documented, although the relative contribution of the species remains unclear, as well as the factors determining the occurrence of these events. In this context, the use of molecular markers has become increasingly important for the reliable diagnosis of the species involved and the understanding of the process. In 2008 two unusual manakins were observed in the Ibiapaba Highlands of the Brazilian state of Ceará (municipality of Tianguá). Their morphological traits indicated that they were male hybrids of *Chiroxiphia* and an *Antilophia* species, despite the fact that neither of the two species of *Antilophia* had been found in the Ibiapaba region. In order to confirm the hybridization and identify the species involved, the present study was based on the analysis of samples taken from a supposed hybrid and a specimen of *C. pareola* collected in the Ibiapaba Highlands, together with two samples of the two species of the genus *Antilophia* (*A. bokermanni* and *A. galeata*) provided by research collections. Partial sequences of three mitochondrial markers (ND2/COI/16S) and a nuclear intron (I7BF) were obtained to confirm hybridization and identify the contribution of each parent species. Results confirmed that the specimen was a hybrid produced by the crossing of a male *Chiroxiphia* (*C. pareola* as most likely species) with a female *Antilophia*, although it was not possible to identify which species were involved. The confirmation that this hybridization event in the Ibiapaba Highlands involved *Antilophia* indicates that one of the two species of this genus occurs in this region, which may thus constitute a previously unknown hybrid zone between two manakin species.

KEY-WORDS: hybrid, Ibiapaba Highlands, intergeneric mating, manakin.

The hybridization of different manakin species (family Pipridae) is a phenomenon that has been well documented by ornithologists, with a multitude of cases being scientifically confirmed (Parkes 1961, Stotz 1993, Pacheco & Parrini 1995, Sick 1997, Brumfield *et al.* 2001, Marini & Hackett 2002). A special case of hybridization in this bird family involves species of the genera *Chiroxiphia* Cabanis, 1847 and *Antilophia* Reichenbach, 1850, with the hybrid being known as "King-of-the-manakins" (Sick 1979, Rezende *et al.* 2013). These two genera, while closely-related phylogenetically as sister groups (Tello *et al.* 2009, McKay *et al.* 2010, Ohlson *et al.* 2013), have very distinct reproductive behavior. *Antilophia* males do not engage in a mating dance during the breeding season, and only display flights have been observed (Marini & Cavalcanti 1992, Aquasis *et al.* 2006). By contrast, *Chiroxiphia* males form leks during the breeding season, in which they present display behavior (Foster 1981, Sick 1997). Despite these differences, a number of hybrids of these genera have been observed in the wild, especially between *Chiroxiphia caudata* (Shaw & Nodder, 1793) and *Antilophia galeata* (Lichtenstein, 1823). This hybridization occurs in the transition zone between the Atlantic Forest and the central Brazilian Cerrado savanna (Pacheco & Parrini 1995, Sick 1997, Vasconcelos *et al.* 2005, Rezende *et al.* 2013), where the geographic distributions of the two species overlap.

The pattern of hybridization observed in *C. caudata* and *A. galeata* is restricted to the marginal transition zone between the preferred biome of each species (Vasconcelos *et al.* 2005). These authors concluded that biogeographic factors may also influence the hybridization of these two species, reflecting differences in their abundance, given that the forest formations in which the hybrid was found are more characteristic of the natural habitat of *Chiroxiphia*, which is more common in this type of environment. In addition, it is possible that *Chiroxiphia* males not selected by females of this species during the mating display may remain aroused by this behavior and try to copulate with females of other species, in particular *Antilophia* (Rezende *et al.* 2013).

In 2008, in a fragment of rainforest in the Ibiapaba Highlands of the Brazilian state of Ceará (municipality of Tianguá), two birds with unusual morphological characteristics (in the plumage and body size) were observed. One specimen was captured, and an analysis of its morphology indicated that it was an adult male produced by an intergeneric cross between *Chiroxiphia pareola* and an *Antilophia* species, either *A. bokermanni* or *A. galeata* (Silva *et al.* 2011, Kirwan & Green 2011). This finding was somewhat enigmatic, given that the only *C. pareola* had been recorded previously in the Ibiapaba Highlands, while the nearest record of *A. galeata* is from a site approximately 550 km away, and that of *A. bokermanni* is more than 400 km distant (Silva *et al.* 2011) (Figure 1). The determination of the parental contribution of the two species involved in this hybridization event provides important insights into the reproductive patterns of the species involved and the ways in which they interact with one another in the sympatric zone. Given this, the principal objective of the present study was the confirmation of the hybrid status of the specimen captured in the Ibiapaba Highlands, and the identification of the two species that contributed genetically to this hybrid.

Samples of muscle tissue were obtained from specimens of *Antilophia bokermanni* (n = 2), *Antilophia galeata* (n = 2), and *Chiroxiphia pareola* (n = 2), as well as of a single hybrid. One of the *C. pareola* specimens (specimen 01) and the hybrid were captured by mist-netting in the municipality of Tianguá, in the Ibiapaba Highlands of Ceará (Brazil). The tissue samples of *Antilophia* species and the second *C. pareola* (specimen 02) were obtained from the collection of the Genetics and Conservation Laboratory of the Federal University of Pará (UFPA). Samples were stored in a freezer in 95% ethanol.

Total DNA was extracted using the standard phenol-chloroform method, followed by precipitation with sodium acetate and alcohol (Sambrook *et al.* 1989). The DNA was electrophoresed horizontally in 1%

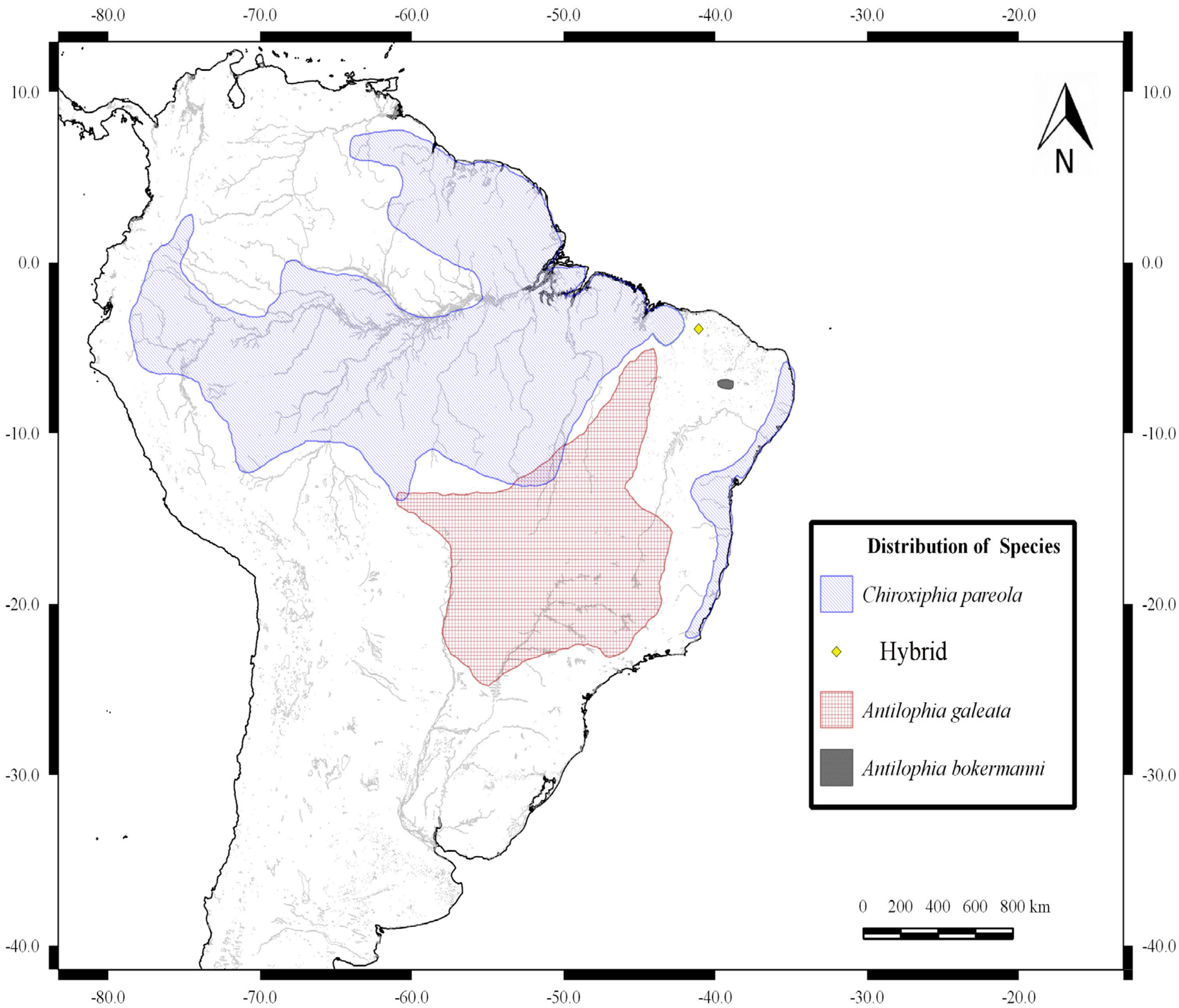

FIGURE 1. Geographic distribution of the three manakin species analyzed in the present study. The yellow dot shows the locality at which the hybrid and one specimen of *Chiroxiphia pareola* (specimen 01) were captured in the Ibiapaba Highlands of Ceará state, Brazil.

agarose gel and stained with GelRed (Uniscience) for visualization in an ultraviolet transilluminator, where the efficiency of the isolation process was evaluated. The Polymerase Chain Reaction (PCR) was used to amplify fragments of three mitochondrial genes, using available primers and reaction conditions. The genes were NADH dehydrogenase subunit 2, or ND2 (Sorenson *et al.* 1999), Cytochrome Oxidase subunit I, COI (Ward *et al.* 2005), and rDNA 16S (Palumbi *et al.* 1991). In addition to these mitochondrial markers, a fragment of the nuclear intron 7 of the β-fibrinogen gene (I7BF) was also sequenced. This fragment was chosen because it contains specific sites that can distinguish the two study genera (Prychitko & Moore 1997). Each reaction was conducted in a final volume of 25 µL, containing 4 µL of dNTP (1.25 mM), 2.5 µL of buffer (10 ×), 1 µL of $MgCl_2$ (25 mM), 0.3 µL of each primer (200 ng/µL), 1µL of the total DNA, 0.25 µL of Taq polymerase (5 U/µL - Invitrogen) and ultrapure water to complete the reaction volume. The PCR products were purified with a PEG 8000, using the protocol described by Dunn & Blattner (1987). The positive reactions were sequenced by the dideoxy-terminal method of Sanger *et al*. (1977) using the Big Dye kit (Applied Biosystems) and run in an ABI 3500XL automatic sequencer, according to standard protocol from the supplier.

The sequences were aligned and edited manually using BioEdit, version 7.1.3.0 (Hall 1999). The differences among the variable sites found in the sequences were verified using MEGA, version 5.0.5 (Tamura *et al.* 2011). This analysis consisted of comparisons between the variable points that differentiate each species and the supposed hybrid. The mitochondrial markers allowed the identification of species that contributed to the maternal lineage, given that the mitochondrial DNA is inherited matrilineally. The nuclear marker should confirm the hybridization process through the observation of species-specific sites with a double signal in the supposed hybrid.

All target sequences selected for the present study were successfully sequenced in the six specimens, resulting in a total of 2630 base pairs (bps). A total of 1900 bps were obtained for the mitochondrial sequences, with 121 sites varying among the species (Table 1). The nuclear fragment (I7BF) rendered 730 bps, with nine variable sites (Table 1). GenBank accession numbers for the sequences of the different molecular markers analyzed: ND2 (KX394495–KX394501), COI (KX394509–KX394515), 16S (KX394516–KX394522) and I7BF (KX394502–KX394508).

The same mitochondrial sequences were observed in *Antilophia* (*A. galeata* and *A. bokermanni*) and the hybrid, whereas the *Chiroxiphia* (*C. pareola*) samples had 106 different sites in the three fragments (Table 1). This evidence confirms conclusively that the hybrid was produced by a female *Antilophia*.

In the electropherogram of the nuclear sequences of the hybrid, it was possible to observe double peaks at nine sites. These heterozygous signals coincided with the sites of the I7BF marker that distinguish the genera *Antilophia* and *Chiroxiphia*, confirming the contribution of species of both genera to the production of the hybrid. The degenerated bases found in the nuclear markers obtained from the hybrid coincide with the nucleotides that differentiate the two genera, confirming its hybrid status (Table 1).

However, it was not possible to determine precisely which *Antilophia* species was involved in the hybridization, given that the molecular markers used in the present study were unable to differentiate between the two species. This lack of differentiation was observed in all four molecular markers, with only a single haplotype found in each mitochondrial sequence for the two *Antilophia* species, and a single genotype for the nuclear sequence. Based in the geographic distribution, *C. pareola* is the most likely second parental.

Most reports of hybrids between *Chiroxiphia* and *Antilophia* refer to *C. caudata* and *A. galeata* in southeastern Brazil, in the states of Minas Gerais (Pacheco & Parrini 1995, Vasconcelos 2005, Rezende *et al.* 2013) and São Paulo (Gussoni *et al.* 2005). In all these cases, hybridization was confirmed on the basis of morphological characteristics and field observations. Prior to the present study, the only molecular confirmation of intergeneric hybridization in manakins was that of Marini & Hackett (2002) for *Ilicura militaris* and *Chiroxiphia caudata*. Results of the present study provide the first evidence of hybridization between *Chiroxiphia*, most likely *C. pareola*, and a member of the genus *Antilophia* in northeastern Brazil, confirmed by the genetic evidence.

No *Antilophia* manakin have been recorded in the Ibiapaba Highlands, where the hybrid analyzed in the present study was captured, while a number of records of *C. pareola* have now been confirmed for the region. Nascimento *et al.* (2005) conducted an extensive bird survey in the region, and found no evidence of the occurrence of either *A. galeata* or *A. bokermanni*. The majority of manakin species – including those of the genera *Chiroxiphia* and *Antilophia* – the plumage of the female is predominantly olive green, making them difficult to distinguish. This may account for the difficulty of recording *Antilophia* in the region, given that the molecular data confirmed that the hybrid was generated by a female *Antilophia*. The greater abundance of female *Antilophia* may be related to differences between males and females in the use of habitats and movements among areas, as observed in many piprids, in which the females tend to occupy larger ranges than males (Théry 1992, Durães *et al.* 2007).

TABLE 1. Variable sites observed in the mitochondrial (**A**) ND2, (**B**) COI, and (**C**) 16S fragments, and the nuclear (**D**) I7BF fragment. The letters R, Y, and K represent the degenerated bases for the pairs of nucleotides, A/B, C/T, and G/T, respectively, found in the nuclear fragment. The fragment length of each marker is shown between parentheses next to its acronym.

(A)

Species	ND2 (750 bps)																																																				
								1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	7	7	7	7	7
	1	2	2	3	5	9	9	0	1	4	5	8	9	9	3	5	6	6	6	8	9	1	6	7	1	2	2	3	4	6	6	7	8	8	0	4	4	5	5	8	8	8	9	9	0	4	4	5	6	1	1	1	2	4
	2	3	9	5	6	2	5	1	5	0	2	2	1	7	4	2	0	4	7	1	0	1	8	2	3	2	9	4	9	4	7	3	2	5	7	5	6	1	4	4	5	7	1	9	0	4	8	7	5	3	4	6	8	4
A. galeata 01	T	A	C	A	A	A	C	C	C	C	C	A	T	C	A	G	T	C	C	C	A	C	T	A	C	T	G	G	T	A	G	T	A	G	G	G	A	T	C	T	G	T	T	C	G	T	T	T	A	C	A	G	T	C
A. galeata 02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. bokermanni 01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. bokermanni 02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
HIB-01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C. pareola 01	C	G	T	G	T	G	T	T	G	T	T	T	C	T	T	A	C	T	T	T	G	T	C	G	T	C	A	A	A	C	A	C	G	A	A	A	G	C	T	C	A	A	C	T	T	C	C	C	T	T	G	T	C	T
C. pareola 02	C	G	T	G	T	G	T	T	G	T	T	T	C	T	T	A	C	T	T	T	G	T	C	G	T	C	A	A	A	C	A	C	G	A	A	A	G	C	T	C	A	A	C	T	T	C	C	C	T	T	G	T	C	T

(B)

Species	COI (627 bps)																																					
								1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6
			1	2	3	5	8	1	1	1	7	8	0	0	2	2	5	5	6	6	1	2	4	7	0	0	2	3	9	1	2	2	4	6	7	7	8	9	2
	2	5	7	6	5	3	3	0	3	6	0	0	0	9	1	4	1	8	0	3	1	6	7	4	4	7	5	7	4	5	1	4	5	6	2	5	1	3	7
A. galeata 01	A	T	T	G	C	G	G	T	C	C	G	T	C	T	C	C	C	C	T	C	A	T	G	T	C	G	T	T	A	A	C	T	T	T	A	T	A	T	T
A. galeata 02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. bokermanni 01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A. bokermanni 02	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
HIB-01	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C. pareola 01	G	C	C	A	T	A	A	C	T	T	A	C	T	C	T	T	T	T	A	T	G	C	A	C	T	A	C	C	G	T	A	C	C	A	G	C	C	C	C
C. pareola 02	G	C	C	A	T	A	A	C	T	T	A	C	T	C	T	T	T	T	A	T	G	C	A	C	T	A	C	C	G	T	A	C	C	A	G	C	C	C	C

Species	16S (510 bps)													(C)	I7BF (730 bps)									(D)
		1	1	2	2	2	2	2	2	2	3	3	4			1	2	3	3	3	3	4	5	
	1	6	7	0	2	3	4	5	6	6	2	4	2			5	7	6	6	7	8	3	4	
	5	8	0	6	9	5	3	7	2	7	2	7	9		2	8	1	4	5	3	4	2	3	
A. galeata 01	T	C	A	T	C	C	C	T	T	T	C	C	C		A	C	T	C	T	G	T	C	C	
A. galeata 02	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	
A. bokermanni 01	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	
A. bokermanni 02	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	
HIB-01	.	.	.	.	.	.	.	.	.	.	.	.	.		R	Y	K	Y	K	R	Y	Y	Y	
C. pareola 01	A	T	C	C	T	T	T	C	C	C	T	T	T		G	T	G	T	G	A	C	T	T	
C. pareola 02	A	T	C	C	T	T	T	C	C	C	T	T	T		G	T	G	T	G	A	C	T	T	

Understanding the geographic distribution of the species is a crucial aspect of the study of hybridization events in birds (Marini & Hackett 2002). Vasconcelos *et al.* (2005) concluded that forests in the area where the hybrid was found are more characteristic of the habitats occupied by *Chiroxiphia*, supporting the conclusion that manakins of the genus *Antilophia* are colonizing areas outside their natural range. Gallery forests of the tributaries of the Parnaíba River, located less than 125 km west of the area in which the hybrid was found, may contain small populations of *A. galeata* (Silva *et al.* 2011), which would increase the likelihood of this species being involved in the production of the hybrid. The Araripe Plateau, also in Ceará state, where the Araripe Manakin (*A. bokermanni*) is found, is located approximately 400 km east of the southern portion of the Ibiapaba Highlands. The westernmost portion of the Araripe Plateau has similar climatic conditions and vegetation to those found in the Ibiapaba Highlands, although no continuous forest connects the areas (Silva *et al.* 2011).

It was not possible to determine which *Antilophia* species was involved in this hybridization, due to the considerable genetic similarities between species, given that no species-specific sites were found in their nucleotide sequences. A shared haplotype in a mitochondrial marker had already been reported by Rêgo *et al.* (2010), precluding the discrimination among the two species. The absence of reciprocal monophyletism in these two *Antilophia* species has been attributed to a relatively recent speciation process, despite the existence of phenotypic features that clearly distinguish both species, such as the color of the plumage in adult males. The uncertainty regarding the identification of which *Antilophia* species was involved in the hybridization event will continue, either until a species-specific marker can be identified or an adult male is observed in the Ibiapaba region. Despite this limitation, the fact that an *Antilophia* species does occur in the Ibiapaba Highlands reinforces the need for further studies to evaluate the exact geographic distribution and dispersal patterns of the species of this genus. Newly matured individuals usually seek new areas for establishment of their territories. This may result in the constant dispersal of young adults into new areas, at least where appropriate habitats exist (Silva *et al.* 2011).

A second factor that may have also contributed to the hybridization process is the mating behavior of *Chiroxiphia*. Rezende *et al.* (2013) reported that male *Chiroxiphia* involved in the lek display, which were not selected by females, would remain in a state of arousal for a time afterwards, and would try to copulate with females of other species, in the present case, *Antilophia*. However, this conclusion is contradicted by the predictions of intersexual selection, which is determined by female choices (Freeman & Herron 2009). Previous studies on manakins have shown that the females discriminate males actively (Brumfield *et al.* 2001, Anciães *et al.* 2009), and the presence of a female *Antilophia* in a display area used exclusively by male *Chiroxiphia* may favor mating due to the sensory predisposition of females.

Natural hybridization events require systematic monitoring in order to identify their key factors, especially where the influence of anthropogenic disturbances is suspected. The persistence of first generation hybrids that continue to breed with one of the paternal species may result in secondary introgression, which may be especially deleterious when combined with a tendency for only one of the sexes of each species to contribute to the reproductive process. This progressive introgression may result in individuals with phenotypes very similar to the parental species, but with the exclusion of the haplotype of the paternal lineage following the second generation, where the hybrid is female. In the present case, it would be important to determine whether female hybrids exist, and whether they are able to produce viable offspring. In this case, continuing unidirectional introgression would lead to the existence of a population with a phenotype similar to that of *Chiroxiphia*, but with the mitochondrial DNA of *Antilophia*. Brumfield *et al.* (2001) evaluated the effects of hybridization events involving manakins of the genus *Manacus*, and emphasized the role of sexual selection in the asymmetrical introgression of plumage coloration. Given this, female choice may be the main factor determining the existence of hybridization zones in manakins, given that females may either prefer "novel" males (when males of both species are present) or be flexible enough to accept "novel" males in the absence of males of its own species.

Rezende *et al.* (2013) described the morphology of a female hybrid of *A. galeata* and *C. caudata*, which is denominated "queen-of-the-manakins". These authors emphasized the need for additional molecular studies in areas where hybridization events occur, in order to support the effective monitoring and conservation of these species. Results of the present study indicate that a hybrid zone between *Chiroxiphia* (most likely *C. pareola*) and an as yet unspecified *Antilophia* species exists in the region of the Ibiapaba Highlands, in the Brazilian state of Ceará, with a pattern of parental contribution that requires further investigation.

ACKNOWLEDGEMENTS

This study was supported by Universidade Federal do Pará (UFPA) and *Associação de Pesquisa e Preservação de Ecossistema Aquáticos (AQUASIS)*. We also thank S. Ferrari for revision of the manuscript. Samples were collected with permit from *Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis (IBAMA)* (License No. 027/2005).

REFERENCES

Anciães, M.; Durães, R. R.; Cerqueira, M. C.; Fortuna, J. R.; Sohn, N.; Cohn-Half, M. & Farias, I. P. 2009. Diversidade de piprídeos (Aves: Pipridae) amazônicos: seleção sexual, ecologia e evolução. *Oecologia Brasiliensis*, 13: 165–182.

Aquasis (Associação de Pesquisa e Preservação de Ecossistemas Aquáticos), OAP (Associação de Observadores de Aves de Pernambuco), UFPA (Universidade Federal do Pará), Save Brasil, IBAMA. 2006. *Plano de conservação do Soldadinho-do-araripe* (*Antilophia bokermanni*). Fortaleza: Pouchain Ramos.

Brumfield, R. T.; Jernigan, R. W.; McDonald, D. B. & J. M. Braun 2001. Evolutionary implications of divergent clines in an avian (*Manacus*: Aves) hybrid zone. *Evolution*, 55: 2070–2087.

Dunn, I. S. & Blattner, F. R. 1987. Charon-36 to charon-40 multi enzyme, high-capacity recombination deficient replacement vectors with polylinkers and polystuffers. *Nucleic Acids Research*, 15: 2677–2698.

Durães, R.; Loiselle, B. A. & Blake, J. G. 2007. Intersexual spacial relationships in a lekking species: Blue-crowned Manakins and female hot spots. *Behavioral Ecology*, 18: 1029–1039.

Foster, M. S. 1981. Cooperative behavior and social organization of the Swallow-tailed Manakin (*Chiroxiphia caudata*). *Behavioral Ecology and Sociobiology*, 9: 167–177.

Freeman, S. & Herron, J. C. 2009. *Análise evolutiva*. 4th. Ed.. Porto Alegre: Artmed.

Gussoni, C. O. A.; Lima, G.; Guaraldo, A. C.; Costa, J. C.; Guedes, J.; Alves, J. R.; Pedrassoli, S.; Figueiredo, L. F. A. & Brown, T. E. 2005. Nova ocorrência do 'rei-dos-tangarás', em Corumbataí, estado de São Paulo, Brasil. *Atualidades Ornitológicas*, 128: 8–9.

Hall, T. A. 1999. Bioedit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series*, 41: 95–98.

Kirwan, G. M. & Green, G. 2001. *Cotingas and manakins*. London: Christopher Helm.

Marini, M. Â. & Cavalcanti, R. B. 1992. Mating system of the Helmeted Manakin (*Antilophia galeata*) in central Brazil. *Auk*, 109: 911–913.

Marini, M. Â. & Hackett, S. J. A. 2002. Multifaceted approach to the characterization of an intergeneric hybrid manakin (Pipridae) from Brazil. *Auk*, 119: 1114–1120.

McKay, B. D.; Barker, F. K.; Mays, H. L.; Doucet, S. M. & Hill, G. E. 2010. A molecular phylogenetic hypothesis for the manakins (Aves: Pipridae). *Molecular Phylogenetics and Evolution*, 55: 733–737.

Nascimento, J. L. X.; Júnior, L. G. S.; Sousa, A. E. B. A. & Minns, J. 2005. Avaliação rápida das potencialidades ecológicas e econômicas do Parque Nacional de Ubajara, Ceará, usando aves como indicadores. *Ornithologia*, 1: 33–42.

Ohlson, J. I; Irestedt, M.; Ericson, P. G. P. & Fjeldså, J. 2013. Phylogeny and classification of the New World suboscines (Aves, Passeriformes). *Zootaxa,* 3613: 1–35.

Pacheco, J. F. & Parrini, R. 1995. O "rei-dos-tangarás" (*Chiroxiphia caudata* X *Antilophia galeata*) no sul de Minas Gerais. *Atualidades Ornitológicas*, 66: 14.

Palumbi, S.; Martin, A.; Romano, S.; Mcmillian, W. O.; Stice, L. & Grabowski, G. 1991. *The simple fool's guide to PCR*. Honolulu: University of Hawaii Press.

Parkes, K. C. 1961. Intergeneric hybrids in the Family Pipridae. *Condor*, 63: 345–350.

Prychitko, T. M. & Moore, W. S. 1997. The utility of DNA sequences of an intron the b fibrinogen gene in phylogenetics analysis of woodpeckers (Aves: Picidae). *Molecular Phylogenetics and Evolution*, 8: 193–204.

Rêgo, P. S.; Araripe, J.; Silva, W. A. G.; Albano, C.; Pinto, T.; Campos, A.; Vallinoto, M.; Sampaio, I. & Schneider, H. 2010. Population genetic studies of mitochondrial pseudo-control region in the endangered Araripe Manakin (*Antilophia bokermanni*). *Auk*, 127: 335–342.

Rezende, M. A.; Vasconcelos, M. F.; Nogueira, W.; Silva, J. C.; Becho, D. P.; Silva, L. F. & Souza, T. O. 2013. Novas ocorrências de híbridos entre *Chiroxiphia caudata* e *Antilophia galeata* em Minas Gerais, Brasil, com a primeira descrição de uma fêmea híbrida e comentários sobre os riscos da hibridação. *Atualidades Ornitológicas*, 174: 33–39.

Sambrook, J.; Fritsch, E. F. & Maniatis, T. 1989. *Molecular cloning: a laboratory manual*. New York: Cold Spring Harbor Laboratory Press.

Sanger, F.; Nichlen, S. & Coulson, A. R. 1977. DNA sequencing with chain termination inhibitors. *Proceeding of the National Academy of Science of the United States of America*, 74: 5463–5468.

Sick, H. 1979. Notes on some Brazilian birds. *Bulletin of the British Ornithologists' Club*, 99: 115–120.

Sick, H. 1997. *Ornitologia brasileira.* Rio de Janeiro: Nova Fronteira.

Silva, W. A. G.; Linhares, K. V. & Campos, A. A. (eds.). 2011. *Plano de Ação Nacional para a Conservação do Soldadinho-do-Araripe*. Brasília: ICMBio.

Sorenson, M. D.; Ast, J. C.; Dimcheff, D. E.; Yuri, T. & Mindell, D. P. 1999. Primers for a PCR-based approach to mitochondrial genome sequencing in birds and other vertebrates. *Molecular Phylogenetics and Evolution*, 12: 105–114.

Stotz, D. F. 1993. A hybrid Manakin (*Pipra*) from Roraima, Brazil, and a phylogenetic perspective on hybridization in the Pipridae. *Wilson Bulletin*, 105: 348–335.

Tamura, K.; Peterson, D.; Peterson, N.; Stercher, G.; Nei, M. & Kumar, S. 2011. Mega 5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum, parsimony methods. *Molecular Biology and Evolution*, 28: 2731–2739.

Tello, J. G.; Moyle, R. G.; Marchesea, D. J. & Cracraft, J. 2009. Phylogeny and phylogenetic classification of the tyrant flycatchers, cotingas, manakins, and their allies (Aves: Tyrannides). *Cladistics*, 25: 429–467.

Théry, M. 1992. The evolution of leks through female choice: differential clustering and space utilization in six sympatric manakins. *Behavioral Ecology and Sociobiology*, 30: 227–237.

Vasconcelos, M. F.; D'Angelo Neto, S. & Nemésio, A. 2005. Observações sobre o rei-dos-tangarás *Chiroxiphia caudata* X *Antilophia galeata* em Minas Gerais, Brasil. *Cotinga*, 23: 65–69.

Ward, R. D.; Zemlak, T. S.; Innes, B. H.; Last, P. R. & Hebert, P. D. N. 2005. DNA barcoding Australia's fish species. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 360: 1847–1857.

Associate Editor: Gustavo S. Cabanne.

Revista Brasileira de Ornitologia, 24(2), 191-195
June 2016

How many genera of Stercorariidae are there?

Caio J. Carlos[1]

[1] Laboratório de Sistemática e Ecologia de Aves e Mamíferos Marinhos, Instituto de Biociências, Universidade Federal do Rio Grande do Sul. Av. Bento Gonçalves 9500, Agronomia, CEP 91501-970, Porto Alegre, RS, Brasil.
[1] Corresponding author: macronectes1@yahoo.co.uk

Received on 29 June 2015. Accepted on 17 July 2016.

ABSTRACT: In this contribution I comment on the generic taxonomy of skuas, Stercorariidae, based on the currently available hypotheses of phylogenetic relationships for the group – *i.e.*, the cladograms. Specifically, the different cladograms were examined following Hennig's principle of reciprocal illumination, in which a given hypothesis is evaluated by the extent to which it agrees with competing hypotheses. Currently, all species are often assigned to genus *Stercorarius.* However, chewing lice- (Insecta, Phthiraptera), behaviour- (territorial display and calls) and molecular-based (mitochondrial DNA) hypotheses of phylogenetic relationships all indicate that Pomarine Skua *Stercorarius pomarinus* and the species formerly placed in genus *Catharacta* are monophyletic and sister to a clade comprising Long-tailed *S. longicaudus* and Parasitic *S. parasiticus* Skuas. Therefore, contrary to the prevailing view that all species within the family should be placed in a single genus, I argue herein that in a cladistic-based classification by sequencing, both *S. parasiticus* and *S. longicaudus* should retain their generic name, whereas *S. pomarinus* should be transferred to *Catharacta*, as *C. pomarina*.

KEY-WORDS: cladistics, cladograms, classification, nomenclature, seabird.

Recently, Vogt (2008, 2014; see also Rieppel 2008) argued that Karl Popper's hypothetico-deductive method and falsificationism are not applicable to cladistics (for a contrary view *cf*. Farris 2014). According to Popper (2001 [1959]), a hypothesis is falsifiable if it prohibits at least one event that is not prohibited by the background knowledge. However, as observed by Vogt (2008: 65) "[n]either such background knowledge as for instance 'descent with modification', nor any specific tree hypothesis prohibits the occurrence of convergent evolution. This allows for both apomorphy ... and homoplasy as possible explanations ... A given tree hypothesis is logically congruent with any specific evidence of character state distribution ... [and] *does not prohibit* any specific character state distribution." In other words, in the analysis of a taxon/character matrix, when a hypothesis of primary homology is not congruent with the others, it is not refuted in a Popperian way, but parsimoniously explained as homoplasy. Naturally, a similar reasoning can be applied to the analysis of a multiple sequence alignment.

Cladistic hypotheses are statements about the phylogenetic relationships represented by the best option given the data available, but subject to confrontation with additional evidence, particularly those drawn from different sources. Therefore, as pointed out by Santos & Capellari (2009), cladograms can be compared against each other to find congruencies among them. The idea behind such a comparison is similar to Hennig's (1968 [1955]) method of "reciprocal illumination", in which two sorts of data are complementary to each other, and has the potential to enlighten one another. If, for example, two (or more) cladograms are congruent, in the sense of depicting the same or almost the same relationships, they have a better explanatory value when compared to other contradictory cladograms. On the other hand, in case of no or little congruence, then the differences should be reconciled through reanalysis of existing data and/or the analysis of new characters (Santos & Capellari 2009, Santos & Klassa 2012).

That said, in the present contribution I comment on the generic taxonomy of Stercorariidae (skuas) in light of the available hypotheses of phylogenetic relationships for the family. Specifically, I focus on detecting congruencies among the different cladograms, as outlined in the preceding paragraph. For convenience, I also provide readers with measures of support of unrefuted clades (*sensu* Grant & Kluge 2008a) obtained for each cladogram examined. The details regarding characters descriptions and character/taxon and pairwise genetic distances matrices should be consulted at the respective papers cited herein.

Stercorariidae forms a group of eight to ten species (depending on the authority) of medium- to large-sized predatory/scavenger seabirds. Traditional, pre-cladistic classifications often divided the family into two genera: *Catharacta* for the larger and, except for Great Skua *Catharacta skua*, southern hemisphere-breeding species, and *Stercorarius* for the smaller, northern hemisphere-breeding species (Peters 1934, Furness 1996, Malling-Olsen & Larsson 1997, Christidis & Boles 2008). The two genera of Stercorariidae have been accepted until the end of 1990s, when the systematics of the family was revised from a cladistic perspective.

Cohen *et al.* (1997) presented a phylogeny for Stercorariidae, based on concatenated mitochondrial (mtDNA) cytochrome *b* and 12S rRNA sequences. In their single most-parsimonious cladogram, the species were divided into two clades; the first consisting of Parasitic *S. parasiticus* and Long-tailed *S. longicaudus* Skuas, and the second, which is the sister-group to the first, of Pomarine Skua *S. pomarinus*, and the other five *Catharacta* species. Particularly in this latter group, *S. pomarinus* and *C. skua* were monophyletic and sister to a clade comprising South Polar Skua *C. maccormicki* and an apparent polytomy formed by Chilean *C. chilensis*, Brown *C. antarctica*, Tristan *C. hamiltoni*, and Subantarctic *C. lonnbergi* Skuas (Figure 1A). Furthermore, according to Cohen *et al.* (1997: 184), both their maximum-likelihood and neighbour-joining analyses resulted in the same topology.

A year later, Braun & Brumfield (1998) reanalysed the Cohen *et al.*'s (1997) data using a maximum-likelihood approach and cladogram searches constrained for the monophyly of *Catharacta*. They recovered a cladogram similar to that of Cohen *et al.* (1997), the difference being the position of *S. pomarinus* as sister-taxon to a clade comprising the *Catharacta* species (Figure 1B). However, as the authors themselves point out (p. 997), unconstrained analysis by both maximum parsimony and maximum likelihood approaches resulted in a cladogram topologically identical to that obtained by Cohen *et al.* (1997; *cf.* Figures 1A and 1C). Braun & Brumfield (1998) defended their findings by arguing that they were more consistent with pre-cladistic, plumage-, body mass-, and behaviour-based hypotheses of a "natural" *Catharacta*. They furthermore suggested that, if their cladogram (Figure 1B) proves "correct", it would be reasonable to place *S. pomarinus* in its own genus, for which *Coprotheres* would be available.

Andersson (1999a) proposed two additional hypotheses of phylogenetic relationships within Stercorariidae: one based on body-mass and plumage characters (phenotype), the other based on presence or absence of ectoparasite chewing lice taxa (Insecta, Phthiraptera). In the phenotype-based cladogram, the species were divided in two clades; a "traditional", monophyletic *Stercorarius* sister to a trichotomy of

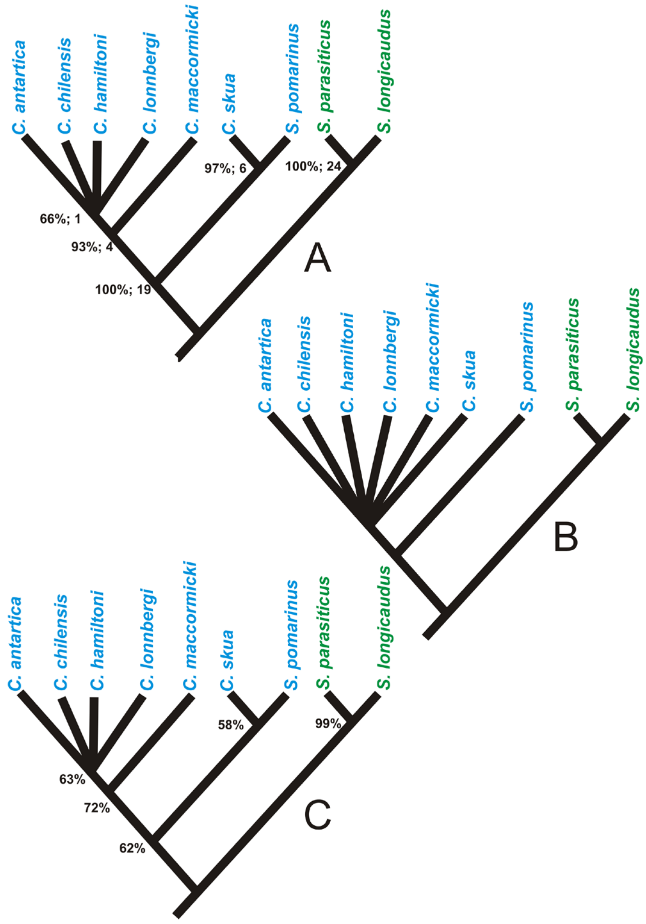

FIGURE 1. Clockwise, from top to bottom: Hypotheses of phylogenetic relationships within Stercorariidae, as recovered in the analyses by Cohen *et al.* (1997; (**A**) and Braun & Brumfield (1998; both constrained (**B**) and unconstrained (**C**) for the monophyly of *Catharacta*). Numbers refer to percentage bootstrap (100 replicates) and Goodman-Bremer support (Grant & Kluge 2008b). Note that Braun & Brumfield (1998) did not provide support values for their constrained cladogram.

C. antarctica, *C. chilensis*, and *C. maccormicki* (Figure 2A). In the cladogram derived from chewing lice data, *S. pomarinus* and *C. skua* were monophyletic and sister to a polytomy containing the other *Catharacta* species (Figure 2B). Andersson (1999b) also published a further hypothesis, this time based on behavioural characters (*i.e.*, territorial displays and calls). Although his analysis included only four out of seven–ten species of the family, *S. pomarinus* and *C. skua* were recovered as monophyletic, and placed sister to *S. parasiticus* plus *S. longicaudus* (Figure 2C). Andersson (1999b: 212) noted that "the traditional placement of the Pomarine Skua in the same genus as the two smaller *Stercorarius* forms, and not together with the larger *Catharacta* species to which *[S.] pomarinus* is clearly much more closely related, ignores the cladistic evidence and makes *Stercorarius* a paraphyletic genus." Nevertheless, his main recommendation was to merge all species into a single genus, the older *Stercorarius*. Andersson (1999b: 212) further commented that "if *Catharacta* is retained ... the generic name of *[S.] pomarinus* should be changed to *Catharacta*, as there is now massive evidence for closer relatedness of the Pomarine to the larger *Catharacta* skuas than to the two smaller *Stercorarius* species."

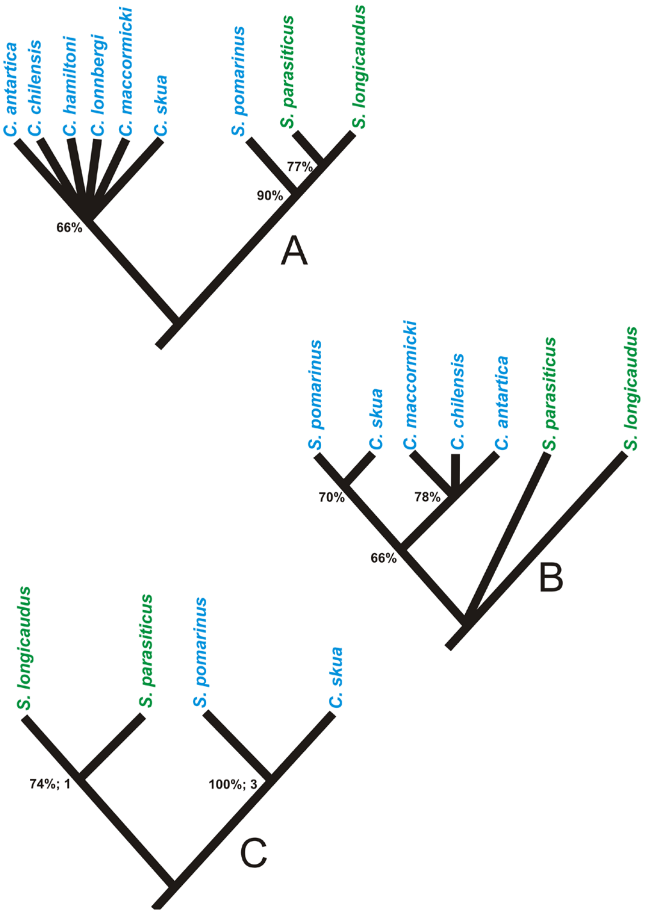

FIGURE 2. Clockwise, from top to bottom: Hypotheses of phylogenetic relationships within Stercorariidae, as recovered in the analyses by Andersson (1999a; body mass and plumage characters (**A**) and presence or absence of ectoparasite chewing lice taxa (**B**)), and Andersson (1999b; territorial display and calls (**C**)). Numbers refer to percentage bootstrap (100 replicates) and Goodman-Bremer support (Grant & Kluge 2008b).

More recently, Chu *et al.* (2009) performed a cladistic analysis of Stercorariidae on the basis of 141 osteological characters. They found a single most parsimonious tree in which the relationships among Stercorariidae fit a comb-shaped or pectinate topology (*i.e.*, that topology wherein every bifurcation leads to one terminal taxon). This can be parenthetically expressed as follows: (*S. longicaudus* + (*S. parasiticus* + (*S. pomarinus* + (*C. maccormicki* + (*C. skua* + (*C. antarctica* + (*C. chilensis* + *C. lonnbergi*))))))).

In the early 2000s, ornithologists in general, and technical committees responsible for developing and maintaining checklists of birds for countries or other political units in particular, all embraced the idea of having a single genus of Stercorariidae (*e.g.*, American Ornithologists' Union 2000, Sangster *et al.* 2004, Christidis & Boles 2008, Gill & Donsker 2015, Remsen *et al.* 2015). Apparently, the only exception to this general agreement was by the Checklist Committee Ornithological Society of New Zealand (2010: 223), which retained both *Catharacta* and *Stercorarius*, but placed *S. pomarinus* in *Coprotheres*.

Two methods for transposing information from cladograms to hierarchical Linnaean classifications have been proposed so far. The first, put forward by Hennig (1968 [1955]), is called "subordination". In this approach, each branching level in a cladogram receives a designation; furthermore, and importantly, sister-taxa are always given the same taxonomic rank. In the second approach, called "sequencing", progressively nested sister-group relationships are given the same taxonomic rank, with the first taxon in a sequence being sister to the subsequent taxa (Nelson 1973). Naturally, these approaches have their arguments for and against; nevertheless, they, alone or in combination, are objective and instrumental tools for the purpose they were devised for (Amorim 2002, Schuh & Brower 2009).

Now, taking into account the congruencies among those cladograms in Figures 1A, B and 2B, C, one can conclude that, regardless of intragroup resolution, *S. pomarinus* does belong to a clade with *Catharacta.* As seen above, this is just the conclusion that authors have come to (Cohen *et al.* 1997, Braun & Brumfield, 1998, Andersson, 1999a, b). Assuming the most inclusive nodes (*i.e.*, those including the common ancestor of all terminal taxa) of Figures 1A, B and 2C (the most inclusive node of Figure 2B is unresolved, but note that *S. pomarinus* is monophyletic with *C. skua*) to be ranked at the family level, as a wealth of evidence indicates (*e.g.*, Furness 1996, Chu *et al.* 2009, Ericson *et al.* 2003), then in a cladistic-based classification by sequencing, the two lineages branching from those nodes should be assigned to different genera, *contra* Andersson's (1999b) proposal of a single genus, but concurrent with his "alternative" suggestion to transfer *S. pomarinus* to *Catharacta*. Indeed, the only topology in which all terminal taxa would be given the same genus is that recovered by Chu *et al.* (2009: 616).

Stercorarius was introduced by Brisson (1760, 1: 56; 6: 149), with type species *Stercorarius* (Le Stercoraire) Brisson = *Larus parasiticus* Linnaeus, 1758, by tautonomy (*fide* Peters 1934, Hellmayr & Conover 1948). Therefore, both *S. parasiticus* and *S. longicaudus* can retain their generic name. The oldest name on genus level for the other clade, containing *S. pomarinus* and the *Catharacta* species, is *Catharacta* Brünnich (1764: 32) – type-species: *C. skua* Brünnich, by subsequent designation of Reichenbach (1852: v). Accordingly, *S. pomarinus* should be transferred to *Catharacta* as *C. pomarina*, a combination used previously by Mathews (1912: 182). The specific epithet was changed to "*pomarina*" to agree with the gender of the genus, as required by article 34.2

of the International Code of Zoological Nomenclature ("The Code"; ICZN 1999).

As mentioned above, Braun & Brumfield (1998) recommended to place *C. pomarina (= S. pamarinus)* in *Coprotheres*. According to them (p. 998), "[t]his treatment would have the advantage of recognizing the morphological distinctiveness that separates *[S.] pomarinus* from *Catharacta*". However, emphasizing the "distinctiveness" of a given taxa from, rather than its "similarities" with, its closest-related taxon/taxa is not strictly consistent with the cladistic principles, as proposed by Hennig (1968 [1955]). Instead, this is a way of thinking that recalls that of the gradistic school of systematic, which, in classifying taxa above the species-group level, also attempts to express the so-called degree of divergence among organisms (*e.g.*, Mayr 1969).

A few words are pertinent here in order to explain why the sequencing method was chosen in place of that by subordination. The subordination approach, though more precise from a nomenclatural standpoint, has two main disadvantages. Firstly, it often requires the use of too many Linnaean categories to represent every branching in a cladogram; and secondly, it often results in many redundant taxa (*i.e.*, a monotypic taxon at several levels). Because the sequencing approach requires a lower number of Linnaean categories, and also results in much less redundancy of names (Amorim 2002, Schuh & Brower 2009), it is better suited for classifying taxa in the family, genus, and species groups, whose nomenclature is governed by "The Code" (ICZN 1999). In zoology, the number of categories at these levels is extremely restricted (a total of eight from superfamily to species); therefore, depending on the quantity of taxa included in an analysis, the subordination method alone is simply not feasible (Amorim 2002, Schuh & Brower 2009).

A cladistic-based classification by sequencing of Stercorariidae derived from Braun & Brumfield's (1998) hypothesis, which is congruent with results of Andersson (1999a, b), would be as follows:

Stercorariidae Gray, 1871
- *Stercorarius* Brisson, 1760
  - *S. parasiticus* (Linnaeus, 1758)
  - *S. longicaudus* Vieillot, 1819
- *Catharacta* Brünnich, 1764
  - *C. pomarina* (Temminck, 1815)
  - *C. skua* Brünnich, 1764, *sedis mutabilis*
  - *C. maccormicki* (Saunders, 1893), *sedis mutabilis*
  - *C. lonnbergi* Mathews, 1912, *sedis mutabilis*
  - *C. hamiltoni* (Hagen, 1952), *sedis mutabilis*
  - *C. chilensis* (Bonaparte, 1857), *sedis mutabilis*
  - *C. antarctica* (Lesson, 1831), *sedis mutabilis*

Note that taxa are arranged in a sequence that reflects their postulated sister-group relationships. Thus, in the classification above, *C. pomarina* is the sister taxon to an unresolved clade containing the other six species in *Catharacta* (*cf.* Figure 1B). Wiley (1981) proposed the term "*sedis mutabilis*" ("of changeable seating") to indicate when a taxon are part of a politomy.

ACKNOWLEDGEMENTS

Several of the ideas presented herein were discussed with Jean-François Voisin, for which I am grateful. Nevertheless, all ideas expressed are strictly my own. I also thank Fábio Olmos for reading and constructively criticizing the manuscript and F. R. Amaral and L. Bugoni for editorial advice. My studies were supported by *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES), Brazil.

REFERENCES

American Ornithologists' Union. 2000. Forty-second supplement to the American Ornithologists' Union Checklist of North American Birds. *Auk*, 117: 847–858.

Amorim, D. S. 2002. *Fundamentos de sistemática filogenética*. Ribeirão Preto: Holos.

Andersson, M. 1999a. Hybridization and skua phylogeny. *Proceedings of the Royal Society of London Series B-Biological Sciences*, 266: 1579–1585.

Andersson, M. 1999b. Behaviour, plumage evolution and neoteny in skuas Stercorariidae. *Journal of Avian Biology*, 30: 205–215.

Braun, M. J. & Brumfield, R. T. 1998. Enigmatic phylogeny of skuas: an alternative hypothesis. *Proceedings of the Royal Society of London Series B-Biological Sciences*, 265: 995–999.

Brisson, M. J. 1760. *Ornithologia, sive Synopsis methodica sistens avium divisionem in ordines, sectiones, genera, species, ipsarumque varietates*, v. 1 and 6. Lugdunum Batavorum [Leiden]: T. Haak.

Brünnich, M. T. 1764. *Ornithologia borealis, sistens collectionem, avium ex omnibus, imperio Danico subjectis, provinciis insulisque borealibus Hafniae factam, cum descriptionibus novarum, nominibus incolarum, locis natalium et icone*. Hafniae [Copenhagen]: J. C. Kallius.

Checklist Committee Ornithological Society of New Zealand. 2010. *Checklist of the birds of New Zealand, Norfolk and Macquarie Islands, and the Ross Dependency, Antarctica*, 4th edn. Wellington: Te Papa Press.

Christidis, L. & Boles, W. 2008. *Systematics and taxonomy of Australian birds*. Collingwood: CSIRO Publishing.

Chu, P. C.; Eisenschenk, S. K. & Zhu, S.-T. 2009. Skeletal morphology and the phylogeny of skuas (Aves: Charadriiformes, Stercorariidae). *Zoological Journal of the Linnean Society*, 157: 612–621.

Cohen, B. L.; Baker, A. J.; Blechschmidt, K.; Dittmann, D. L.; Furness, R. W.; Gerwin, J. A.; Helbig, A. J.; de Korte, J.; Marshall, H. D.; Palma, R. L.; Peter, H. U.; Ramli, R.; Siebold, I.; Willcox, M. S.; Wilson, R. H. & Zink, R. M. 1997. Enigmatic phylogeny of skuas (Aves: Stercorariidae). *Proceedings of the Royal Society of London Series B-Biological Sciences*, 264: 181–190.

Ericson, P. G. P.; Envall, I.; Irestedt, M. & Norman, J. A. 2003. Inter-familial relationships of the shorebirds (Aves:

Charadriiformes) based on nuclear DNA sequence data. *BMC Evolutionary Biology*, 3: 16.

Farris, J. 2014. Popper with probability. *Cladistics*, 30: 5–7.

Furness, R. W. 1996. Family Stercorariidae (skuas), p. 556–571. *In*: del Hoyo, J.; Elliott, A. & Sargatal, J. (eds.) *Handbook of the birds of the world, v. 3:* (*hoatzin to auks*). Barcelona: Lynx Edicions.

Gill, F. & Donsker, D. (eds.). 2015. *IOC World bird list* (v. 5.2). doi: 10.14344/IOC.ML.5.2. (access on 15 May 2015).

Grant, T. & Kluge, A. G. 2008a. Clade support measures and their adequacy. *Cladistics*, 24: 1051–1064.

Grant, T. & Kluge, A. G. 2008b. Credit where credit is due: The Goodman–Bremer support metric. *Molecular Phylogenetics and Evolution*, 49: 405–406.

Hellmayr, C. E. & Conover, B. 1948. Catalogue of birds of the Americas and the adjacent islands, 1(3). *Field Museum of Natural History, Zoological Series*, 13: 1–383.

Hennig, W. 1968. *Elementos de una sistemática filogenética*. Buenos Aires: Editorial Universitaria.

ICZN. 1999. *International Code of Zoological Nomenclature,* 4th edn. London: The International Trust for Zoological Nomenclature.

Malling-Olsen, K. & Larsson, H. 1997. *Skuas and jaegers: a guide to the skuas and jaegers of the world*. New Haven: Yale University.

Mathews, G. M. 1912. A reference-list to the birds of Australia. *Novitates Zoologicae*, 18: 171–446.

Mayr, E. 1969. *Principles of systematic zoology*. New York: McGraw-Hill.

Nelson, G. 1973. Classification as an expression of phylogenetic relationships. *Systematic* Biology, 22: 344–359.

Peters, J. L. 1934. *Check-list of the birds of the world*, vol. 2. Cambridge, MA: Harvard University.

Popper, K. R. 2001. *A lógica da pesquisa científica*. São Paulo: Cultrix.

Reichenbach, L. 1852. *Avium Systema Naturale. Das Naturliche System der Vogel*. Dresden and Leipzig: Expedition der vollstandigste Naturgeschichte.

Rieppel, O. 2008. Hypothetico-deductivism in systematics: fact or fiction? *Papéis Avulsos de Zoologia*, 48: 263–273.

Sangster, G.; Collinson, J. M.; Helbig, A. J.; Knox, A. G. & Parkin, D. T. 2004. Taxonomic recommendations for British birds: second report. *Ibis*, 146: 153–157.

Santos, C. M. D. & Capellari, R. S. 2009. On reciprocal illumination and consilience in biogeography. *Evolutionary Biology*, 36: 407–415.

Santos, C. M. D. & Klassa, B. 2012. Sistemática filogenética hennigiana: revolução ou mudança no interior de um paradigma? *Scientiae Studia*, 10: 593–612.

Schuh, R. T. & Brower, A. V. Z. 2009. *Biological systematics: principles and applications*. Ithaca and London: Cornell University.

Vogt, L. 2008. The unfalsifiability of cladograms and its consequences. *Cladistics*, 24: 62–73.

Vogt, L. 2014. Why phylogeneticists should care less about Popper's falsificationism. *Cladistics*, 30: 1–14.

Wiley, E. 1981. *Phylogenetics: the theory and practice of phylogenetic systematics*. New York: John Wiley & Sons.

Associate Editor: Fábio Raposo do Amaral.

Instructions to Authors

The ***Revista Brasileira de Ornitologia*** will accept original contributions related to any aspect of the biology of birds, with emphasis on the documentation, analysis, and interpretation of field and laboratory studies, presentation of new methodologies, theories or reviews of ideas or previously known information. The ***Revista Brasileira de Ornitologia*** is interested in publishing ornithological studies on behavior, behavioral ecology, biogeography, breeding biology, community ecology, conservation biology, distribution, evolution and genetics, landscape ecology, methods and statistics, migration, nomenclature, paleontology, parasites and disease, phylogeography, physiology, population biology, systematics, and taxonomy. Noteworthy range extensions and novel geopolitical (country/state/province) records are also welcome, but not mere lists of the avifauna of a specific locality. Monographs may be considered for publication upon consultation with the editor.

Manuscripts submitted to The ***Revista Brasileira de Ornitologia*** must not have been published previously or be under consideration for publication, in whole or in part, in another journal or book. **Manuscripts may be written only in English** and must be typed in Microsoft Word, using Times New Roman 12, double spaced and left justified. Scientific names must be shown in *italic,* and authors are encouraged to follow the latest systematic sequence of the Brazilian (www.cbro.org.br/CBRO/index.htm) or South American (www.museum.lsu.edu/~Remsen/SACCBaseline.html) bird lists, when pertinent and at their discretion. When using one of each of those sources, please be explicit about which one is being used, following it consistently throughout the manuscript. Common names should follow those recommended by the South American Checklist Committee (www.museum.lsu.edu/~Remsen/SACCBaseline.html).

Authors for whom English is not their native language are strongly recommended to have their manuscript professionally edited before submission to improve the English. Two of these independent suppliers of editing services in Brazil can be found through maryandriani@yahoo.com or the web site www.idstudio.art.br. All services are paid for and arranged by the author, and use of one of these services does not guarantee acceptance or preference for publication.

SUBMISSION

Originals must be submitted by email only (editoriarbo@gmail.com) and as a single Microsoft Word file (figures and table must me imbedded into the manuscript). Upon manuscript acceptance, high quality image files (extensions JPG, TIF, PSD, CDR, AI, EPS, WMF or XLS; minimum resolution of 300 DPI) of the original figures will be requested. The *title* must be concise and clearly define the topic of the manuscript. Generic expressions such as "contribution to the knowledge..." or "notes on..." must be avoided. The name of each author must be written fully, followed by the full mailing address, and author for communication in the case of multiple authors.

The parts of the manuscript must be organized as follows:

– **Title** (of the manuscript, in lowercase – not capitals - with names and addresses of all the authors)
– **Abstract/Key-Words** (with title and up to 300 words; five key-words related to the main topics of the manuscript and *not already mentioned in the title* must be provided in alphabetical order and separated by semicolons)
– **Introduction** (starting on a new page)
– **Methods** (this and subsequent parts continue without page breaks)
– **Results** (only the results, succinctly)
– **Discussion**
– **Acknowledgements**
– **References**
– **Tables**
– **Figure Legends**
– **Figures**

For short notes, the same *Abstract* and *Key-Words* structure outlined above must be included. The *text* must provide a brief introduction, description of methods and of the study area, presentation and discussion of the results, acknowledgements and references. Conclusions may be provided after the discussion or within it.

Each Table should be on a separate page, numbered in Arabic numerals, with its own legend. The legend should be part of the table, and occupy the space made by inserting an extra line at the beginning of the table, in which the cells are merged. Figure legends, occupying one or more pages following the tables, should be numbered successively, also in Arabic numerals. Figures will follow, one to each page, and clearly numbered in agreement with the legends.

As necessary, subsections may be identified and labeled as such. All pages should be numbered in the upper, right hand corner.

The following *abbreviations* should be used: h (hour), min (minute), s (second), km (kilometer), m (meter), cm (centimeter), mm (millimeter), ha (hectare), kg (kilogram), g (gram), mg (miligram), all of them in lowercase (not capitals) and with no "periods" ("."). Use the following *statistical notations:* P, n, t, r, F, G, U, $\chi 2$, df (degrees of freedom), ns (non significant), CV (coefficient of variation), SD (standard deviation), SE (standard error). With the exception of temperature and percentage symbols (*e.g.*, 15°C, 45%), leave a space between the number and the unit or symbol (*e.g.*, n = 12, P < 0.05, 25 min). Latin words or expressions should be written in italics (*e.g.*, *et al., in vitro, in vivo, sensu).* Numbers one to nine should be written out unless a measurement (*e.g.*, four birds, 6 mm, 2 min); from 10 onwards use numbers.

Author *citations* in the text must follow the pattern: (Pinto 1964) or Pinto (1964); two publications of the same author must be cited as (Sick 1985, 1993) or (Ribeiro 1920a, b); several authors must be presented in chronological order: (Pinto 1938, Aguirre 1976b); for two-author publications both authors must be cited: (Ihering & Ihering 1907), but for more than two authors, only the first one should be cited: (Schubart *et al.* 1965); authors' names cited together are linked by "&". Unpublished information by third parties must be credited to the source by citing the initials and the last name of the informer followed by the appropriate abbreviation of the form of communication: (H. Sick pers. comm.*)* or V. Loskot (*in litt.);* unpublished observations by the authors can be indicated by the abbreviation: (pers. obs.); when only one of the authors deserves credit for the unpublished observation or another aspect cited or pointed out in the text, this must be indicated by the name initials: "... in 1989 A. S. returned to the area...". *Unpublished manuscripts* (*e.g.*, technical reports, undergraduate monographs) and *meeting abstracts* should be cited only exceptionally in cases they are absolutely essential and no alternative sources exist. The *reference* list must include all and only the cited publications (titles written in full, not abbreviated), in alphabetical order by the authors' last name:

Articles

Fargione, J.; Hill, J.; Tilman, D.; Polasky, S. & Hawthornez, P. 2008. Land clearing and the biofuel carbon debt. *Science*, 319: 1235–1238.
Santos, M. P. D. & Vasconcelos, M. F. 2007. Range extension for Kaempfer's Woodpecker *Celeus obrieni* in Brazil, with the first male specimen. *Bulletin of the British Ornithologists' Club*, 127: 249–252.
Worthington, A. H. 1989. Adaptations for avian frugivory: assimilation efficiency and gut transit time of *Manacus vitellinus* and *Pipra mentalis. Oecologia*, 80: 381–389.

Books and Monographs

Sick, H. 1985. *Ornitologia brasileira, uma introdução*, v. 1. Brasília: Editora Universidade de Brasília.

Book Chapters

Remsen, J. V. & Robinson, S. K. 1990. A classification scheme for foraging behavior of birds in terrestrial habitats, p. 144–160. *In*: Morrison, M. L.; Ralph, C. J.; Verner, J. & Jehl Jr., J. R. (eds.). Avian foraging: theory, methodology, and applications. Lawrence: Cooper Ornithological Society (Studies in Avian Biology 13).

Theses and Dissertations

Novaes, F. C. 1970. *Estudo ecológico das aves em uma área de vegetação secundária no Baixo Amazonas, Estado do Pará*. Ph.D. dissertation. Rio Claro: Faculdade de Filosofia, Ciências e Letras de Rio Claro.

Web-based References

CBRO - Comitê Brasileiro de Registros Ornitológicos. 2011. Listas das aves do Brasil, 10th Edition. http://www.cbro.org.br/CBRO/pdf/AvesBrasil2011.pdf (access on 20 January 2013).
IUCN. 1987. A posição da IUCN sobre a migração de organismos vivos: introduções, reintroduções e reforços. http://iucn.org/themes/ssc/pubs/policy/index.htm (access on 25 August 2005).
Dornas, T. 2009a. [XC95575, *Celeus obrieni*]. http://www.xeno-canto.org/95575 (access on 25 February 2012).
Dornas, T. 2009b. [XC95576, *Celeus obrieni*]. http://www.xeno-canto.org/95576 (access on 25 February 2012).
Pinheiro, R. T. 2009. [WA589090, *Celeus obrieni* Short, 1973]. http://www.wikiaves.com/589090 (access on 05 March 2012).

Footnotes will not be accepted.

Illustrations and *tables.* The illustrations (photographs, drawings, graphics and maps), which will be called figures, must be numbered with Arabic numerals in the order in which they are cited and will be inserted into the text. Upon manuscript acceptance, high quality image files (extensions JPG, TIF, PSD, CDR, AI, EPS, WMF or XLS; minimum resolution of 300 DPI) of the original figures will be requested. Tables and figures will receive independent numbering and must appear at the end of the text, as well as all legends to the figures that must be presented on separate sheets. In the text, mentioning figures and tables must follow the pattern: "(Figure 2)" or "... in figure 2." Table headings must provide a complete title, and be self-explanatory, without needing to refer to the text. All figure legends must be grouped in numerical order on a separate sheet from the figures.

All materials must be submitted through the *Revista Brasileira de Ornitologia* web site: www.museu-goeldi.br/rbo

Only submissions through the web site will be considered. A letter of submission must accompany the manuscript. Notification of receipt of the submission will be sent to the corresponding author. Once the manuscript is finally accepted and a final version consolidated, PDF proofs will be sent by email to the corresponding author for revision. The correction of the final version sent for publication is entirely the authors' responsibility. The first author of each published paper will receive via e-mail, free of charge, a PDF file of the published paper. In the case of doubts as to the rules of format, please contact the editor prior to submission:

Leandro Bugoni

Universidade Federal do Rio Grande - FURG
Instituto de Ciências Biológicas, Caixa Postal 474, CEP 96203-900, Rio Grande - RS, Brazil.
Phone: (55) 53 3293 5059.
E-mail: editoriarbo@gmail.com

Revista Brasileira de Ornitologia

Issue 24 – Number 2 – June 2016

CONTENTS

BEHAVIOR

Behavioral repertoire of the poorly known Red-legged Seriema, *Cariama cristata* (Cariamiformes: Cariamidae)
Aline N. Silva, Rhewter Nunes, Dieferson C. Estrela, Guilherme Malafaia and André L. S. Castro 73

Parental care of Chestnut-capped Puffbird *Bucco macrodactylus* on the middle Juruá River, Amazonas, Brazil
Gabriel Augusto Leite, Izeni Pires Farias and Carlos Augusto Peres 80

Description of the nest of two Thamnophilidae species in Brazilian Amazon
Gabriel Augusto Leite, Marcelo Henrique Mello Barreiros, Izeni Pires Farias and Carlos Augusto Peres 83

Extreme use of feathers for nest construction by the Chilean Swallow (*Tachycineta leucopyga*) in the sub-Antarctic forests of southern Chile
Esteban Botero-Delgadillo and Rodrigo A. Vásquez 86

First record of the White-chinned Swift *Cypseloides cryptus* in the state of Acre, Brazil, with notes on its breeding biology
Renata Neves Biancalana and Agimiro Magalhães 90

ECOLOGY

Breeding seabird populations in Brazilian oceanic islands: historical review, update and a call for census standardization
Patrícia L. Mancini, Patrícia P. Serafini and Leandro Bugoni 94

Intra-tropical migration and wintering areas of Fork-tailed Flycatchers (*Tyrannus savana*) breeding in São Paulo, Brazil
Alex E. Jahn, Nathaniel E. Seavy, Vanesa Bejarano, Marcela Benavides Guzmán, Ivan Celso Carvalho Provinciato, Marco A. Pizo and Maggie MacPherson 116

Diet of the Burrowing Owl *Athene cunicularia*, in two locations of the inter-Andean valley Ecuador
Héctor Cadena-Ortíz, César Garzón, Santiago Villamarín-Cortéz, Glenda M. Pozo-Zamora, Gabriela Echeverría-Vaca, Javier Yánez and Jorge Brito-M. 122

Stomach contents of some poorly known Brazilian birds with focus on species from the Caatinga biome
Nelson Buainain and Giovanna Forcato 129

SYSTEMATICS, TAXONOMY, AND DISTRIBUTION

Birds from Cáceres, Mato Grosso: the highest species richness ever recorded in a Brazilian non-forest region
Leonardo Esteves Lopes, João Batista de Pinho, Aldo Ortiz, Mahal Massavi Evangelista, Luís Fábio Silveira, Fabio Schunck and Pedro Ferreira Develey 137

A collection of birds from Presidente Kennedy and adjacent areas, Tocantins: a further contribution to knowledge of Amazonian avifauna between the Araguaia and Tocantins Rivers
Guilherme R. R. Brito, Guy M. Kirwan, Claydson P. Assis, Daniel H. Firme, Daniel M. Figueira, Nelson Buainain and Marcos A. Raposo 168

Confirmation of the hybridization of *Chiroxiphia* Cabanis, 1847 and *Antilophia* Reichenbach, 1850 (Passeriformes: Pipridae) using molecular markers
Wagner Brito Alves, Ciro Albano, Weber Andrade de Girão e Silva, Juliana Araripe and Péricles Sena do Rêgo 185

How many genera of Stercorariidae are there?
Caio J. Carlos 191

Instructions to Authors 197