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Cover: Species *Elaenia flavogaster* (Yellow-bellied Elaenia). Rutt *et al.* (in this issue), provide a critical revision and update to the list of birds recorded at the Biological Dynamics of Forest Fragments Project in central Amazonia. With 21 additions, including this *E. flavogaster* illustrated on the front cover, the cumulative list for the area now totals 409 species of birds. Photo author: Cameron L. Rutt.

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EDITORIAL

Sociedade Brasileira de Ornitologia: a history

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Our Brazilian Ornithological Society (Sociedade Brasileira de Ornitologia - SBO) was born 30 years ago. The aim of this Editorial is provide a point-of-view of relevant facts that lead the establishment of the SBO, and some key (despite not exhaustive) facts along these three decades.

The 20th Century was an important period for the development of ornithology as a science in Brazil (see Pinto 1979, Paynter-Jr. 1991, Belton 1994, Sick 1997, Alves & Silva 2000, Aleixo & Straube 2007, Fontana *et al.* 2017). The German ornithologist and naturalist Emilie Snethlage (who worked at the Museu Paraense Emílio Goeldi and Museu Nacional), Olivério Pinto (ornithologist from the Museu Paulista, today Museu de Zoologia da Universidade de São Paulo) and another German ornithologist, Helmut Sick (from the Museu Nacional, Rio de Janeiro), were amongst those who made substantial contributions to build the knowledge of our birds. In addition to undertaking extensive expeditions to different Brazilian biomes, they were responsible for innumerable publications and also scientific collections that were fundamental for the development of ornithology until now.

However, prior to the creation of the SBO, some Brazilian institutions and universities already had researchers dedicated to the study of birds, although they still had only limited integration, largely due to the physical distances separating them in a country of continental size, besides other logistic difficulties. The first entity - the Clube de Observadores de Aves (COA) of Rio Grande do Sul - aimed to bring together those interested in ornithology and bird watching arose in the 1970's. William "Bill" Belton, a retired but influential north-American diplomat and passionate birdwatcher in Rio Grande do Sul, was the mentor in 1974 of this first birdwatcher club.

This initiative was followed by other clubs of birdwatching in various states of Brazil, such as the Centro de Estudos Ornitológicos (CEO) founded in 1984, in the Departamento de Zoologia of the Instituto de Biociências of the Universidade de São Paulo. A decade before the founding of the SBO, in 1977, the CEMAVE (formerly named Centro de Estudos de Migrações de Aves) was founded at a national level by the Instituto Brasileiro de Desenvolvimento Florestal [Brazilian Institute for Forestry Development], whose first course in bird watching was ministered by Bill Belton, with the participation of Helmut Sick. Today the CEMAVE is one of the 13 National Centers for Research and Conservation under the auspices of the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). These entities, the CEMAVE, COAs and CEO, were seeds for the future development of the SBO.

At the onset of the 1980's amateur and professional ornithologists organized a series of meetings that brought together ornithologists at local and national levels, especially the Encontros de Anilhadores de Aves [birdbanders meetings] promoted by CEMAVE, the first of which was held at Universidade Federal de Viçosa (Minas Gerais) from 02 to 24 January of 1985. At these events, contacts between ornithologists were gradually increased and gave rise to the idea of the creation of a national entity in the form of a society that would bring together people interested in ornithology and also a regular meeting of this society.

Subsequently, the first attempts to organize a society dedicated to the study of birds occurred within the scope of the congresses of the Sociedade Brasileira de Zoologia (SBZ) by way of the Brazilian Ornithological Meetings. Thus, in 1984, on the occasion of the XI Congress of the SBZ in Belém (Pará), during the II Encontro Brasileiro de Ornitologia, on 16 February, the creation of the SBO was proposed. At that time there were in Brazil only a few

professional ornithologists working in different national institutions, but many students were interested in the study of birds.

In the following year, 1985, during the XII Congresso Brasileiro de Zoologia held in Campinas (São Paulo), a new meeting affirmed the foundation of the SBO, and ruled that participants who signed up, in addition to those who signed prior to the official founding date, would be considered as founding members of the society.

In February 1987, during the XIV Congresso Brasileiro de Zoologia in Juiz de Fora (Minas Gerais) the first Board of Directors (1987–1989) of the SBO was elected, with Roberto Brandão Cavalcanti as president, Maria Alice dos Santos Alves as secretary, and Paulo de Tarso Zuquim Antas as treasurer. The first Deliberative Council (1985–1989) was composed by Jacques M.E. Vielliard, Pedro Scherer Neto and David Oren. They were responsible for all of the initial organizational work for the new society, and they had to overcome many obstacles to get it established.

Subsequently, on 16 July 1987, at the III Encontro Nacional de Anilhadores de Aves, held at the Universidade do Rio dos Sinos (UNISINOS), in São Leopoldo (Rio Grande do Sul), the creation of the SBO was formally established during an extraordinary meeting of the General Assembly.

SBO was officially founded on the 13 November (supplement of the Diário Oficial do Distrito Federal, 1987, number 214, page 36) with a summary of the objectives of the society: to bring together people interested in ornithology, represent the community of Brazilian ornithologists national and internationally, promote and provide courses, lectures, meetings and regional, national and/or international congresses, stimulate the conservation of the avifauna, spread knowledge about ornithology, and bring together within the scope of the SBO organized groups dedicated to diverse aspects of ornithology. The board of directors of the SBO is elected each two years, and comprises a chair, two secretaries and two treasures members, beside a deliberative supervisory board (see statute at www.ararajuba.org.br).

The founding document for the society reported 72 founding members, most of whom were biologists, of which 16 were undergraduate students, and of the remaining 56, many were undertaking graduate studies. This founding minute was registered at the notary's office in Brasília, DF, on 25 November 1987.

In February 1988, during the General Assembly meeting of the SBO, at the XV Congresso Brasileiro de Zoologia in Curitiba (Paraná), it was decided that the date for future ornithological meetings should still coincide with those of the Congresso Brasileiro de Zoologia; it was also decided that the value of the annual subscription for the SBO would be fixed at 1 OTN (a Brazilian monetary index in use until 1989) for regular members, and half this for student members. The national currency was the *cruzado*, and 1 OTN corresponded to Cz$ 695.50, but its value was in constant flux (dollar variation was from Cz$ 71.89 to Cz$ 761.49 along the year of 1988).

At the beginning, to communicate with their members, SBO used a printed informative bulletin (Boletim da SBO) of which the first issue was published in January/February 1988 with José Maria Cardoso da Silva as editor. The bulletins, which were bimonthly until 1990 were interrupted in 1991, and resumed with the editor Walter Voss in 1992 in a biannual format until 1999. These bulletins featured, in addition to general notices, topics related to different species of birds, study groups, new discoveries, announcements of national and international meetings, the launch of journals in the area, articles published by members, news on banding of birds in Brazil, academic theses and dissertations that had been defended, and obituaries. The bulletins were distributed by surface mail and eagerly awaited by members who were keen to receive the ornithological news. It is important to recall that at this time this sort of communication was essential, as there was no other way to spread news in a large scale. The first virtual message was sent in Brazil in 1988, via Bitnet, a network that was only available in some universities. The internet as a tool for general communication only became available to the population at large in 1995.

Amongst other new items, in the first bulletin of 1988 it was announced that the first edition of the SBO scientific journal would be launched in 1989, with Luiz Antonio Pedreira Gonzaga as the editor-in-chief. The creation of the journal *Ararajuba, Revista Brasileira de Ornitologia* already featured in the statutes of the SBO in accordance with article 20. The first edition was published in August 1990, with 11 main papers, 8 short communications and 1 *In Memoriam* (Necrology). The cover of *Ararajuba* showed a hand-drawing of an Ararajuba (*Guaruba guarouba*) made by Carlos Yamashita until 2004 (volume 12, issue 21), when it started to show color photographs of birds. *Ararajuba* published two issues per year between 1996 and 2005. In 2005 (volume 13, issue 23) the journal's name was changed to *Revista Brasileira de Ornitologia/Brazilian Journal of Ornithology*, publishing four issues per year since 2006, and changing from printed to digital format since 2007. The *Revista Brasileira de Ornitologia* had published 69 issues in these 27 years. Today, the digital *Revista Brasileira de Ornitologia*, published in English and with four fascicles each year, is the main reference source for Brazilian ornithology, and has an emphasis on diverse studies of Neotropical birds. The impact factor of the *Revista Brasileira de Ornitologia*, measured by Journal Citation Reports® was 0.414 in 2016.

Only in 1991, during the term of the second board chaired by Pedro Scherer Neto (1989–1991), the Meetings of SBO became independent from those

organized by the Sociedade Brasileira de Zoologia; this was a signal of the scientific atmosphere and maturity of SBO in that period, which allowed the consolidation of the new society. It was also decided that the meetings of the SBO and those of the bird banders would be combined, given the great overlap of participants and the difficulties of attending two separate annual meetings in a country of continental size. The bird banding meetings occurred annually from 1985 until 1990. The last one was held in Pelotas and the book of abstracts comprised 37 contributions. In 1991, the first Congresso Brasileiro de Ornitologia (I CBO), held in Belém (Pará) already had 71 contributions from 78 authors. A significant feature was the participation by young students, and this has persisted for all of the congresses sponsored by SBO. The congresses have grown since then, with 106 abstracts from 124 authors at the II CBO held in 1992 in Cuiabá (Mato Grosso), to 350 abstracts and 500 registered participants at the last congress in Brazil (XXIII CBO), held in 2016 in Pirenópolis (Goiás).

Since the first Congresso Brasileiro de Ornitologia (I CBO) occurred in Belém in 1991, there have been 23 editions of the CBOs in different states of Brazil (eight in the north and northeast regions, three in the middlewest and 12 in southeast and south regions of Brazil). One exception occurred in 2010, when the 25th International Ornithological Congress (IOC) was held in Campos de Jordão (São Paulo). This honorable exception occurred because it was the first time that this very traditional world event was held in South America, recognition of the level of development of ornithology in our country. In 2015, the Congresso Brasileiro de Ornitologia was held in Manaus (Amazonas), in conjunction with the Congreso de Ornitología Neotropical of the Neotropical Ornithological Society (NOS), again re-affirming the importance of the SBO in the Neotropics. In 2017, there was another international initiative by the SBO with the sponsoring of the Ornithological Congress of the Americas, held in Puerto Iguazú, Argentina, in conjunction with two societies: the Aves Argentinas (AA) and the Association of Field Ornithologists (AFO). Again, this international collaboration demonstrates the growing maturity of a young SBO that can promote international meetings with traditional societies of the world, such as the AA and AFO that are 100 and 95 years old, respectively.

We can bear witness to the fact that the SBO has already been through different phases, including some that were difficult to overcome. The number of regular paid-up members has fluctuated over the years (averaged 140 from 2012 to 2014), but there are usually around 100 members/year, some of them researchers who have accompanied the society since its foundation or for much of this time.

Meanwhile, although the number of members has not increased in proportion to the growth of knowledge in ornithology, currently celebrating its 30 years, we can affirm that the SBO is on firm foundations and is sustainable, especially since the *Revista Brasileira de Ornitologia* passed to a digital version published only in English. Its papers are widely cited, which guarantees regular publication of the journal and qualifies it for funding from the Brazilian scientific funders. As always, it depends on the great endeavors of its directors, advisers and editors, who are increasingly more experienced and have been greatly helped by new technologies, and associations with national institutions such as the Sociedade Brasileira do Zoologia (SBZ) and the Sociedade Brasileira para o Progresso da Ciência (SBPC).

The SBO, like other scientific societies in Brazil, depends on the interest and also the annual subscriptions of its members, since this is the only source of assured funds. It is always hoped that the Brazilian congresses have a positive balance that can be credited to the SBO, which has not been always achieved. However, welcome contributions from different institutions, like most of the SBO chair institutions or RBO Editors institutions helped the SBO. For example, the Museu Goeldi has provided facilities to manage and publish electronically manuscripts submitted to the *Revista Brasileira de Ornitologia*. CNPq, the Brazillian Council for Development of Science and Tecnology, supported the printed version of the *Revista Brasileira de Ornitologia* for several years and the online version along recent years.

During these 30 years Brazilian ornithology has significantly advanced in aspects such as the quality of the research done and the presence of members from most public and private universities, museums, and wildlife conservation institutions. Additionally, it broadly reaches out to the community via its website, participation by members in international and national committees (such as the Comitê Brasileiro de Registros Ornitológicos CBRO, the Official Brazilian Bird List), and in platforms such as Wikiaves and e-bird. Currently, there are several Masters and Doctoral graduate research programs that are forming students in areas related to ornithology, thus showing its importance.

New facilities for communication allow a constant increase in the contact between associates of the SBO, and doubtless research studies in progress will be improved by this enhanced integration. This new scenario is very different from that prevailing at the outset of Brazilian ornithology and it will open doors to a new era for research on Brazilian birds.

Of the 72 founding members of the SBO, some have retired, others have passed away, others continue to accompany us from a distance, and some continue to be active in the SBO. Currently, among the 90 members, about half (47) are undergraduate (19) or graduate (28) student members. It is worth recalling that of the young

students who in 1987 contributed to the founding of the SBO, some now have important roles in the academic formation of masters and doctoral students in the area of ornithology, and have become recognized international scientists. We hope that today's student members will follow the same path, with the same ideals as those who founded the SBO, and that with the vigor of these modern times they will be able to celebrate many more decades dedicated to the study of birds in Brazil.

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Our thanks to all those who collaborated to create the SBO, to all of the past and current members of the Board of Directors, all the Presidents of the Brazilian Ornithological Meetings (CBO's) and all Editors-in-chief of the Boletim and the *Ararajuba, Revista Brasileira de Ornitologia/Brazilian Journal of Ornithology*. It is also important to mention the researchers and teachers from museums, universities, or other research institutions who produced and multiplied knowledge, particularly forming human resources. Those members have worked, and continue working, in the construction and maintenance of this 30 years of history. Leandro Bugoni, Miguel Marini and an anonymous reviewer made valuable suggestions to the manuscript.

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ARTICLE

Breeding biology of Chalk-browed Mockingbird *Mimus saturninus* in a natural savanna of central Brazil

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ABSTRACT: The Chalk-browed Mockingbird *Mimus saturninus* (Mimidae) is a common bird in savannas, grasslands, and farmlands, also occurring in urban areas. We studied its breeding biology in a Cerrado savanna inside a reserve at central Brazil, from 2003 to 2013. We monitored 74 nests, which were usually found in the more open phytophysiognomies of the Cerrado. The breeding season lasted from late August to late December. The nest is a cup built with twigs and generally placed on shrubs and small trees. Mean nest height above the ground was 1.3 ± 0.5 m (n = 73). Mean clutch size was of 2.9 ± 0.9 eggs (n = 63), ranging from one (possibly an incomplete clutch) to six eggs (possibly a communal nest). Incubation was asynchronous, the incubation period lasted 14.2 ± 0.9 days (n = 17 nests), and the nestling period lasted 14.1 ± 1.2 days (n = 21 nests). Nestling infestation by botfly larvae was common (60% of nests), but did not cause any nest loss. Its breeding season was similar to most birds of the Cerrado region, but its clutch size was larger. The Chalk-browed Mockingbird breeding biology in central Brazil is similar to that reported from the southern part of its distribution. The species is capable of multiple broods, has cooperative breeding and shows evidence of communal breeding, a rare behavior reported so far for Mimidae. The main difference between our study and those conducted with the Chalk-browed Mockingbird in Argentina, is the very low prevalence of brood parasites, demonstrating the importance of reserves to allow breeding with low brood parasitism rates.

KEY-WORDS: brood parasitism, cooperative breeding, Mimidae, nest, reproduction.

INTRODUCTION

The breeding biology of many tropical birds is still poorly described (Stutchbury & Morton 2001, 2008, Heming *et al.* 2013), especially in the Neotropics, where 42.9% of the species have their breeding biology poorly-known (Xiao *et al.* 2017). The Chalk-browed Mockingbird *Mimus saturninus* (Mimidae) is a tropical species, common and resident in savannas, grasslands, and farmlands, as well as in urban parks and gardens (Ridgely & Tudor 1989, Sick 1997, Brewer 2001, Leveau & Leveau 2004, Cody 2017). Its breeding biology is relatively well described (Cody 2017), but mainly from disturbed or anthropogenic sites in the southern part of its distribution mostly in Argentina (Salvador 1984, Fraga 1985, Mason 1985, De la Peña 2005, Di Giacomo 2005, Rabuffetti & Reboreda 2007), but also in southeastern Brazil (Argel-de-Oliveira 1989). Both habitat disturbance (Boal & Mannan 1999, Vargas *et al.* 2012) and latitude (Jetz *et al.* 2008, Heming & Marini 2015) might affect breeding parameters of birds, such as clutch size and egg size. However, no comprehensive study of its breeding has been done in undisturbed areas and/or in the northern part of its distribution.

The species can be found across much of the Brazilian territory out of Amazonia, extending its range to Bolivia, Paraguay, Argentina and Uruguay, with disjunct populations in savanna areas north of the Amazonia (Ridgely & Tudor 1989, Cody 2017). It feeds on insects and fruits, generally on the ground (Sick 1997, Brewer 2001, Cody 2017), and shows strong territorial behavior, defending its territory against conspecifics (Argel-de-Oliveira 1989, Cody 2017).

The Chalk-browed Mockingbird lives in pairs or small groups of up to six birds, generally formed by one breeding pair, yearlings from previous broods, and juveniles (Argel-de-Oliveira 1989, Cody 2017), with an apparent cooperative breeding system. Cooperative breeding is an unusual breeding system among birds (Cockburn 2006) and, even though more common in tropical and subtropical climates (Brown 1987), there are still few studies in the Neotropics (Macedo 2008). This breeding system is characterized by one or more members of a social group helping the breeding pair with

activities such as parental care, territorial defense and nest-guarding, what can improve the breeding success (Skutch 1961, Brown 1987, Cockburn 1998, Stutchbury & Morton 2001). In this paper, we present a detailed description of several aspects of the breeding biology of the Chalk-browed Mockingbird in a natural savanna of central Brazil, including information about cooperative breeding and evidences of communal nesting.

METHODS

Study area

This study was conducted in the Estação Ecológica de Águas Emendadas (hereafter ESECAE) (15°31'12''S to 15°35'50''S; 47°31'54''S to 47°40'31''W) located about 50 km from Brasília, Distrito Federal, Brazil. The ESECAE is a 10,500 ha reserve and Cerrado (a kind of tropical savanna) is the dominant vegetation (Silva-Jr. & Felfili 1996). Our study was conducted mostly in a 100 ha plot (1 km × 1 km) located in the northwestern portion of the reserve, more than 1 km from the reserve border, with the following phytophysiognomies ranging from open grasslands to dense savannas: *campo limpo*, *campo sujo*, *cerrado ralo*, *parque cerrado*, *cerrado sensu strictu* and *cerrado denso* (Silva-Jr. & Felfili 1996, Ribeiro & Walter 2008). *Campo limpo* is a grassland without trees or shrubs; *campo sujo* is a grassland with a few shrubs; *cerrado ralo* is an open grassland with scattered trees and shrubs; *parque cerrado* is an open grassland with some trees and shrubs growing on scattered small earthmounds; *cerrado stricto sensu* is a savanna with closed scrubs and 5–8 m tall trees; and *cerrado denso* is a savanna with a dense arboreal strata with 5–12 m tall trees. The climate is highly seasonal and predictable, with 1500–1750 mm of annual rains, mostly restricted to the period between October and April, which makes winters exceptionally dry (Nimer 1979).

Bird capture and marking

Chalk-browed Mockingbirds were caught in mist nets and marked with a single numbered metallic band (CEMAVE/ICMBio) on the right tarsus, and with a unique combination of three plastic color bands on the left tarsus. Nestlings were marked in the tarsus with colored nontoxic marker pens since the first days of monitoring. After the 10th or 11th day since birth, nestlings were also banded just as adults.

Given that sexes are alike (Cody 2017), members of the breeding pair could not be sexed properly. Brood patches are almost exclusive to females, but for some mimids, males can develop a passable brood patch (Cody 2017), and both sexes can incubate. Other birds of the social group could also not be sexed. Juveniles were identified by the presence of whitish and enlarged rictal flanges (only in recently fledged birds) and by the buffier underparts with dark streaks on the breast (Cody 2017).

Nest searching and monitoring

We studied the breeding biology of the Chalk-browed Mockingbird in ESECAE from 2003 to 2013 with most of the fieldwork conducted from August to January. SSR intensively searched for nests of the Chalk-browed Mockingbird during the breeding seasons of 2007 and 2008, while in the other years nests were found occasionally. Nests were located after meticulous inspection of the vegetation or, most commonly, after following birds showing signs of being reproductively active, such as nest-guarding or carrying nesting material or food on their bills. We marked nest locations with a colored plastic tape placed ~5–10 m from the nest and took their geographical coordinates with a GPS.

For each nest found we recorded its status (active or inactive) and content (empty, with eggs and/or nestlings), as well as its height above ground and the support plant species. Nests were monitored at intervals of one to four days, with shorter interval visits occurring on egg laying, hatching and fledging, what allowed a better precision of our estimates.

Incubation period was considered as the time from laying of the first egg to hatching of the first egg. Nestling period was considered as the time from hatching of the first egg to fledging of the first young. For those nests which information available did not allow to determine the exact date of hatching, we estimated those dates based on the degree of development of nestlings, as well as on the day of egg laying. For nests that presented one egg and one nestling on the day of monitoring, we assumed that hatching occurred on that very day. We weighed eggs in the early stages of incubation of four nests from 2012 with a Pesola® spring to the nearest 0.1 g.

Length of the breeding season

Breeding season was considered as the interval between the beginning of construction of the first nest and the day when the last nest became inactive. Egg laying season was considered as the interval between the first and the last nest with eggs. During 2007 and 2008 we conducted intensive fieldwork directed to the species, allowing us to estimate more precisely the length of the breeding season and the egg laying season for these two years. Thus, we provide both, estimates for the entire period of nest monitoring (2003–2013) and the two intensively-monitored years (2007 and 2008).

Behavior

We conducted non-systematic observations to describe

parental care, social behavior and the role of helpers. We focused our observations on nest-guarding, feeding of nestlings, sentinel behavior, and intra and interspecific agonistic interactions.

Data analyses

Values presented are means ± 1 standard error.

RESULTS

We monitored 74 active nests (Fig. 1) of the Chalk-browed Mockingbird during the study period, 6 on 2003, 6 on 2004, 6 on 2005, 10 on 2006, 14 on 2007, 15 on 2008, 4 in 2009, 3 in 2010, 2 in 2011, 5 in 2012 and 4 in 2013. A variable number of these nests were used to estimate breeding parameters and to characterize habitat use and support plant, as specified below.

Breeding season

The Chalk-browed Mockingbird breed in the study area from late August to late December, considering all years. We found two nests being built as early as 29 August of 2006 and 2008, and the last nest fledged nestlings on 29 December 2007. Two nests built on the second half of December, but soon predated, suggest that the breeding

Figure 1. Nests, eggs, nestlings and fledgling of the Chalk-browed Mockingbird (*Mimus saturninus*) at ESECAE, Distrito Federal, Brazil. (**A**) Nest with three eggs; (**B**) Nest containing one egg of the Chalk-browed Mockingbird and another very small unidentified egg (arrow); (**C**) Four-days-old nestling; (**D**) Six days old nestling; (**E**) Ten days old nestling; (F) Recently fledged juvenile. Ages of nestlings were estimated.

season might extends through January. Among all years, eggs were laid between the last week of August and the first week of December (Fig. 2). The peak of breeding activity occurred from late September to mid-November (Fig. 2). Breeding season lasted around four months (~3 September–29 December) in 2007 and 3.5 months (~29 August–11 December) in 2008. Egg laying season lasted 92 days in 2007 and 75 days in 2008. Multiple breeding attempts were observed in 2007 and 2008, irrespective of the success or failure of the previous nest. By this way, 64.3% (n = 9) of the nests found in 2007 (n = 14), and 57.1% (n = 12) of the nests found in 2008 (n = 21) were the result of subsequent breeding attempts.

Nests and nest sites

Nests were a cup, mainly built with twigs and layered with rootlets and other fibrous matter (Fig. 1). Nests were built in shrubs and small trees, generally concealed among dense foliage at 1.3 ± 0.5 m above ground (n = 73; Fig. 3). Eighteen species of plants were used as support for 60 nests, with *Davilla elliptica* St. Hill. (Dilleniaceae) being the most commonly used species (38.3%; Fig. 4). A few other nests were built in a dead tree (n = 1) and in tussock grasses (n = 2).

We found more nests of the Chalk-browed Mockingbird in the more open areas of the Cerrado, as suggested by the number of nests found in each phytophysiognomy sampled. Among 66 nests, 25 nests were in *cerrado ralo* (37.9%), 19 in *parque Cerrado* (28.8%), 9 in *cerrado stricto sensu* (13.6%), 5 in *campo limpo* (7.6%), and 8 in disturbed *cerrado* (12.1%).

Eggs, nestlings and parental care

Eggs were laid mostly on successive days (n = 11), and in 2 nests with 5 and 6 eggs, 4 eggs were laid in 3 days and 5 eggs were laid in 4 days, respectively, suggesting that more

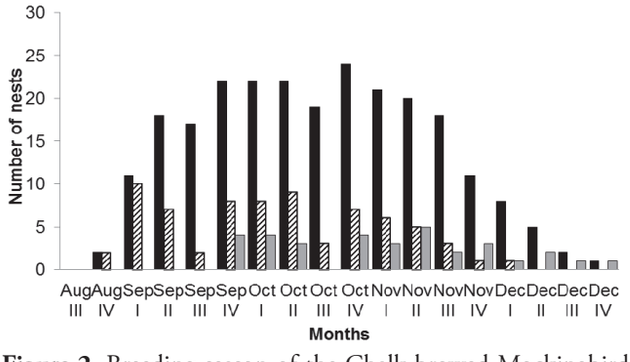

Figure 2. Breeding season of the Chalk-browed Mockingbird (*Mimus saturninus*) in the Estação Ecológica de Águas Emendadas, central Brazil. Number of active nests (solid bars, n = 73), number of nests with eggs (cross-hatched bars, n = 72), and number of nests with nestlings (gray bars, n = 33) during the breeding seasons of 2003 through 2013. Months were subdivided in four intervals of 7–8 days each.

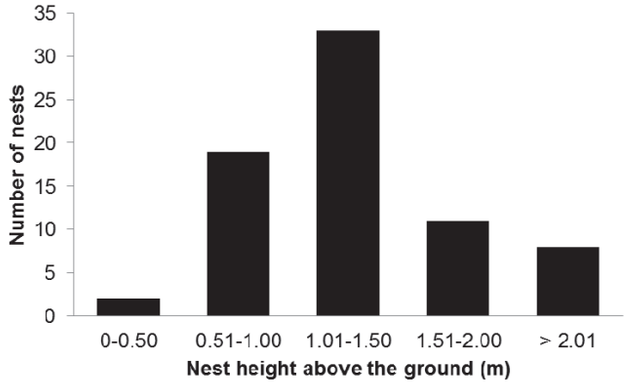

Figure 3. Number of nests (n = 73) of the Chalk-browed Mockingbird (*Mimus saturninus*) found in the breeding seasons of 2003 through 2013 in the Estação Ecológica de Águas Emendadas, central Brazil, accordingly to its height above ground (m).

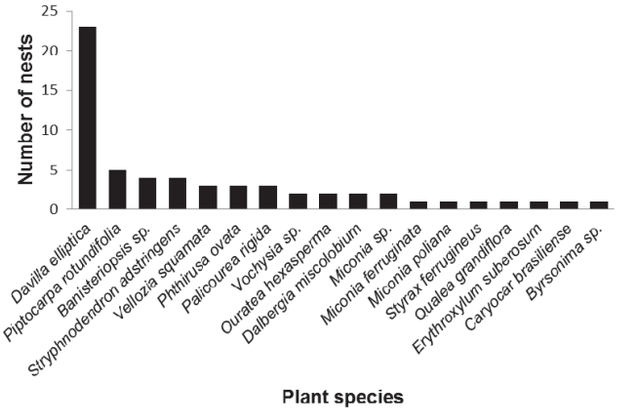

Figure 4. Number of nests (n = 60) built on each plant species of the Chalk-browed Mockingbird (*Mimus saturninus*) monitored in the breeding seasons of 2003 through 2013 in the Estação Ecológica de Águas Emendadas, central Brazil.

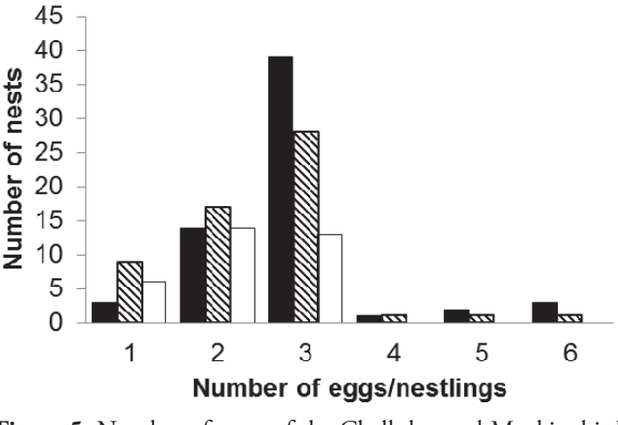

Figure 5. Number of nests of the Chalk-browed Mockingbird (*Mimus saturninus*) monitored in the breeding seasons of 2003 through 2013 in the Estação Ecológica de Águas Emendadas, central Brazil, in relation to clutch size (solid bars, n = 63), number of nestlings (cross-hatched bars, n = 57), and number of fledglings (open bars, n = 33).

than one female laid eggs in the same nest. In one of these nests the incubating bird and a second bird defended the nest simultaneously during 3 nest checks. Mean clutch size was 2.9 ± 0.9 eggs (n = 63), ranging from 1 (possibly an incomplete clutch) to 6 eggs (possibly a communal nest, see below) (Fig. 5). Eggs were usually oval and weighed 5.3 ± 0.5 g (n = 10 eggs from 4 clutches), with an intra-clutch variation of up to 30% of egg mass (4.5 to 5.9 g). Eggs measured 26.6 ± 1.3 mm (length) by 19.3 ± 0.8 mm (width) (n = 19; 6 clutches).

Incubation started from the laying of the first egg in 10 nests closely monitored, what demonstrates that incubation is asynchronous. Incubation period was estimated in 14.2 ± 0.9 days (n = 17 nests), ranging from 12 to 16 days. The nestling period was estimated in 14.1 ± 1.2 days (n = 21 nests), ranging from 10.5 to 15.5 days. Thus, early fledging occurred as soon as after 10.5 days.

Nestlings from the same clutch generally show distinct sizes and, in some cases, the smallest nestling disappeared from the nest without signs of predation, what suggests that they probably starved. Nestlings body was covered with downy feathers since hatching (Fig. 1), with the exception of the ventral surface, which is almost naked. Young nestlings present pinkish skin, orange yellow gape and yellowish-white rictal flanges. The eruption of pin feathers occurs between the 4th and 5th day, eyes begin to open on the 6th day, and after the 9th day the entire body and wings are covered with developing feathers (Fig. 1).

Youngs fledged between the last week of September and the last week of December (Fig. 2). Fledglings usually stay perched in the same plant where the nest was constructed soon after leaving the nest. They move away from the nest site during the following days, but always remaining concealed in the dense vegetation. All adults of the social group feed the fledglings for about six weeks. Yearlings born on 2007 breeding season were observed twice feeding juveniles born in the same territory on 2008.

Adults showed strong territorial behavior and are very aggressive against potential nest predators. Once a potential predator is detected, adult birds generally fly to the top of a tall tree and elicit an alarm call. We observed agonistic interactions against the Southern Caracara *Caracara plancus* and the Curl-crested Jay *Cyanocorax cristatellus*. The Chalk-browed Mockingbird also associated with the Fork-tailed Flycatcher *Tyrannus savana* and mobbed potential predators that approached the nest site.

Social groups

We monitored 10 social groups during 2007 and 2008. Two of those groups were formed by 2 birds each, 7 groups by 4 birds and 1 group had 6 individuals in 2007 and 4 in 2008.

Brood parasitism

A single nest monitored contained 1 very small beige egg (Fig. 1B), either from the brood parasite Shiny Cowbird *Molothrus bonariensis* or a very small abnormal mockingbird egg. This egg was laid just after the first egg of the Chalk-browed Mockingbird, but was probably ejected before our next visit to the nest, 3 days later. Also, 2 other nests at the reserve border had 1 egg each of Shiny Cowbird on 06 and 26 October 2009. The first nest also had 1 mockingbird egg and the second had 2 mockingbird eggs. None of these eggs were measured and these nests were not monitored.

Botfly parasitism

Among the 20 nests with nestlings monitored on 2007 and 2008, 12 (60%) contained at least 1 nestling parasitized by botfly larvae *Philornis* sp. (Diptera: Muscidae), but no nest loss was attributed to botfly parasitism. We did not estimate botfly infestation (number of larvae per bird).

DISCUSSION

The breeding biology of the Chalk-browed Mockingbird at our study site was similar to that of previous studies with respect to most aspects. The main difference between our study and those conducted with the Chalk-browed Mockingbird in Argentina, is the very low prevalence of brood parasites, demonstrating the importance of reserves to allow breeding with low brood parasitism rates. Also, we provide evidence that the species has cooperative breeding and communal breeding, the latter a rare behavior reported so far for Mimidae.

We recorded both breeding pairs and breeding groups in our study site. All members of the groups participated in nest defense and nestling feeding, but only some marked individuals (probably females) were observed incubating eggs. Studies conducted in Argentina also found both breeding pairs and groups (Fraga 1979, Salvador 1984). Another study conducted in an urban area in southeastern Brazil found only breeding groups (Argel-de-Oliveira 1989). Cooperative breeding with helpers at nest has also been reported for several *Mimus* mockingbirds and the White-breasted Thrasher *Rhamphocinclus brachyurus* (Cody 2017). The presence of breeding groups might be related to a reduction in opportunities for breeding territory acquisition either due to high adult survival or habitat saturation (Gaston 1978, Stutchbury & Morton 2001).

The breeding season of the Chalk-browed Mockingbird extends from late August to late December, what coincides with the end of the dry season and the

first half of the wet season, a similar pattern to that described for the species in southeastern Brazil (Argel-de-Oliveira 1989). The length of the breeding season is similar to those reported for Argentina, but they start and end latter there [start in mid-September (Fraga 1985, Di Giacomo 2005, Rabuffetti & Reboreda 2007] to first week of October (Salvador 1984, De la Peña 2005); end in the second half of January (Salvador 1984, Fraga 1985, De la Peña 2005, Di Giacomo 2005, Rabuffetti & Reboreda 2007). Differently, the Tropical Mockingbird *Mimus gilvus* breeds in Venezuela in two distinct periods, from April to June and from October to December, coinciding with the onset of the unusual bimodal wet seasons usually observed there (Paredes *et al*. 2001). The egg laying period recorded (75 and 92 days) in this study was slightly shorter than that reported for the species in Argentina (93 to 121 days) (Salvador 1984, Fraga 1985). In the temperate region, the egg laying period recorded for the Northern Mockingbird *Mimus polyglottos* was highly variable, ranging from 80 to 150 days (Fischer 1981, Means & Goertz 1983). The onset as well as the extent of the breeding season of the Chalk-browed Mockingbird was similar to that observed for other passerines in the Cerrado (Alves & Cavalcanti 1990, Lopes & Marini 2005a, Medeiros & Marini 2007, Marini *et al.* 2009, Santos & Marini 2010, Duca & Marini 2011) and central-southeast Brazil (Marini & Durães 2001, Pinho *et. al.* 2006, Marques-Santos *et al*. 2015).

The nests found are very similar to those previously described for the species (Salvador 1984, Fraga 1985, Mason 1985, Argel-de-Oliveira 1989, De la Peña 2005, Rabuffetti & Reboreda 2007). The Chalk-browed Mockingbird commonly built its nest in dry and shrubby areas with small and isolated trees (Salvador 1984, Fraga 1985, Argel-de-Oliveira 1989, this study), similarly to other members of the genus (Cody 2017). That might help the Chalk-browed Mockingbird to nest in disturbed and even urban areas (Argel-de-Oliveira 1989, Brewer 2001). Nevertheless, this apparent habitat preference at our study site must be seen with care, because we did not conduct standardized searches in all the phytophysiognomies available in the study area.

Eggs were laid in successive days as reported by Di Giacomo (2005) in nests with clutches of up to three eggs. The 2 nests with 5 or 6 eggs with more than 1 egg laid per day suggest that more than 1 female is laying in the same nest. Egg mass and measurements were very similar to those from Argentina reported by Di Giacomo (2005), but slightly smaller than those reported by De la Peña (2005).

Previous studies on the breeding of the Chalk-browed Mockingbird reported that usual clutches are of 3 or 4, exceptionally 2 or 5 eggs (Salvador 1984, Fraga 1985, Mason 1985, De la Peña 2005, Di Giacomo 2005, Rabuffetti & Reboreda 2007). Argel-de-Oliveira (1989) reported 1 nest with 6 eggs, what corresponds to the maximum clutch size recorded in this study. Clutches of 3 to 4 eggs are common for mockingbirds, with clutches larger than that observed only at higher latitudes (Cody 2017) as expected. The Patagonian Mockingbird *Mimus patagonicus* has also been reported to lay up to 6 eggs (Cody 2017).

The mean incubation and nestling periods found in this study were similar to that previously described for this (Salvador 1984, Fraga 1985, Argel-de-Oliveira 1989, De la Peña 2005, Di Giacomo 2005) and other species of mockingbirds (Skutch 1945, Fischer 1981, Means & Goertz 1983, Paredes *et al.* 2001, Cody 2017). We observed mostly one bird per pair (possibly females) incubating eggs. Both members of a pair, however, defended the nest and fed nestlings. For the Gray Catbird *Dumetella carolinensis* only females are known to incubate eggs (Cody 2017). The asynchronous incubation observed for the Chalk-browed Mockingbird might confer some competitive advantage for the first nestlings to hatch (Slagsvold 1986, Stenning 1996). Early fledging of nestlings still with incomplete plumage, as reported here, is common among mockingbirds (Cody 2017), but fledglings remain close to the nest for some days until able to fly. Nest defense and nestling feeding in the species is performed by all members of the social group, the same observed for other mockingbirds (Cody 2017), and other cooperative breeding species in the Cerrado (Santos & Marini 2010, Manica & Marini 2012).

We also found evidence of communal breeding, a rare behavior among birds and mammals (Gilchrist 2007), where more than one female lay eggs and raise young synchronously in the same nest (Brown 1987). Five nests had either 5 or 6 eggs, and in 2 of them more than 1 egg was laid per day, indicating that more than 1 female was laying in those nests. Similarly, communal breeding has been reported only for the Galapagos Mockingbird *Mimus parvulus* (Kinnaird & Grant 1982).

Brood parasitism by the Shiny Cowbird is one important cause of nest failure reported for Neotropical mockingbirds (Fraga 1985, Di Giacomo 2005), and is most frequent in disturbed areas (Cavalcanti & Pimentel 1988). The frequency of brood parasitism found in this study (2 or 3 out of 76 nests) is very low when compared with that found in disturbed areas in the Cerrado (4 out of 14, 28.6%) (Cavalcanti & Pimentel 1988). However, at our study site, 2 of these 3 parasitism events occurred at the reserve border, where only 1 other unparasitized mockingbird nest was found with eggs, and were 3 other nests were found already with mockingbird nestlings. At our study site, França & Marini (2009) found very low and similar brood parasitism rates between edge and interior nests of 9 species. Studies conducted in Argentina revealed much higher incidence of brood parasitism for

the Chalk-browed Mockingbird (44–88%; Salvador 1984, Fraga 1985, Sackmann & Reboreda 2003, De la Peña 2005, Di Giacomo 2005).

Species frequently found in disturbed areas will not necessarily be victimized by the brood parasite, because they might be adapted to such conditions (Cavalcanti & Pimentel 1988). The ejection of a "foreign" egg has been observed for the Chalk-browed Mockingbird (Fraga 1985) as well as for other species in the genus (Peer *et al.* 2002, Sackmann & Reboreda 2003, Cody 2017). The Chalk-browed Mockingbird is also aggressive towards adult Shiny Cowbirds (Brewer 2001, Sackmann & Reboreda 2003). Egg ejection experiments at our study site revealed that the Chalk-browed Mockingbird accepted 77% of mimetic eggs, but only 33% of non-mimetic (blue) eggs (Miranda 2014).

Botfly parasitism can also influence breeding success, and the parasitism of very young nestlings might be one of the main causes of nest failure (Rabuffetti & Reboreda 2007). Entire broods at 4 nests of the Chalk-browed Mockingbird succumbed to botfly parasitism in Argentina (Mason 1985). Also, 22% of the nests of the Chapada Flycatcher *Suiriri islerorum* found at our study site were lost due to parasitism by botfly larvae (Lopes & Marini 2005b). Nevertheless, in our study, despite the high prevalence (%) of nestlings parasitized by *Philornis* sp., infestation (number of larvae per bird) was usually low (< 5 larvae) and no nest was lost due to parasitism. In a similar way, parasitism by botfly larvae did not affect the breeding success of the White-rumped Tanager *Cypsnagra hirundinacea* in the same area (Santos & Marini 2010).

Overall, the Chalk-browed Mockingbird breeding parameters are similar to those reported from studies in the southern part of its distribution in disturbed landscapes. The species has cooperative breeding as other species of *Mimus* and we provide evidence, apparently for the first time, that it breeds communally. The main difference between our study and those conducted with the Chalk-browed Mockingbird in Argentina, is the very low prevalence of brood parasites at our preserved study site, demonstrating the importance of reserves to allow breeding with low brood parasitism rates.

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SHORT-COMMUNICATION

Observations on the breeding behavior of the Variable Hawk (*Geranoaetus polyosoma*) in the Atacama Desert, Chile

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ABSTRACT: Although the Variable Hawk (*Geranoaetus polyosoma*) is a common and broadly distributed raptor in the Neotropics, its breeding ecology is almost unknown. Using video cameras, we collected data on the parental and nestling behavior of this hawk at the early-brood rearing period from one location in the Atacama Desert of Chile. An attempt to collect data in a second nest failed due to methodological deficiencies, which suggested improvements to sampling design in future studies. As most accipitrid raptors, we found that the female performed the majority of the parental activities occurring at the nest: she fed the chicks, protected them from high solar radiation and stayed on the nest at night. Nestlings were fed with Chilean Iguana (*Callopistes macullatus*) and Darwin's Leaf-eared Mouse (*Phyllotis darwini*). We also describe some nestling behaviors. With these observations, we add information to the breeding ecology of this species and encourage the use of low-cost technology to monitor wildlife, but with certain considerations.

KEY-WORDS: Accipitridae, breeding ecology, natural history, parental investment, raptor.

Parental care is a set of traits that enhances the fitness of the offspring (Smiseth *et al.* 2012). In birds, care includes nest construction, egg incubation and the feeding and protection of nestlings, among other behavioral and non-behavioral traits (Collopy 1984, Byholm *et al.* 2011, Smiseth *et al.* 2012). This strategy is based on minimizing energy consumption and maximizing the survival of as many offspring as possible, and is determined by the natural history, the evolutionary history of the species and environmental conditions (Stearns 1992, Dawkins 2006).

The Variable Hawk (*Geranoaetus polyosoma*) is an Accipitridae raptor distributed from Colombia to southern Chile and Argentina (Ferguson-Lees & Christie 2010, Bierregaard-Jr. *et al.* 2016). Although this species has a broad distribution range, information about its breeding is scarce (Jiménez 1995, Bierregaard-Jr. *et al.* 2016) and there is no data from populations in the Atacama Desert. Therefore, our objective is to provide primary information about the parental care of Variable Hawks from two locations in the Atacama Desert of Chile.

We obtained pictures and video recordings from two nests: one was located in the Morado Canyon area (26°46'45''S; 70°42'52''W, 133 m a.s.l.) and another one in the Tamarico canyon area (28°26'17''S; 70°46'58''W, 628 m a.s.l.). In El Morado, we set a trail camera (Bushnell®: Trophy Camera Brown HD, Model 119537C) near an active nest with two nestlings of approximately 30 days-old (*sensu* De Lucca 2011) on a rocky cliff 15 m high. The camera took video recording during the 1st and 2nd of December 2015, and took photographs between 02 and 04 December 2015. We also set an extra camera (Sony camera, model DSH-HX60V) at 6 m from the nest to obtain more detailed footages which continuously filmed for 26 min on the 2 December 2014, starting at 10:28 h. In Tamarico, the camera was set on a pole on 1 October 2015, 20 cm away from an active nest with three chicks of approximately 40 days-old (*sensu* De Lucca 2011). Video recording was made to assess if chicks became habituated to the camera, but this did not happen (see details below).

In the El Morado nest, 23 parental visits were recorded, almost all by the female (95.7%). Due to the limited visual range captured by the cameras, the parental

effort by the male could not be determined. De Lucca (2011) found the male was mainly focused on hunting for the nestlings and defending the nest; it mostly brought food to the nestlings, that was deposited in nearby perches where the female collected it to feed the nestlings. Such behavior may not be recorded by our camera system. Additionally, we have not recorded potential helpers in the nest, as suggested by Alvarado & Figueroa (2006) for this species, based on a nest whose defense against human intruders involved three individuals. In Tamarico we did not record any parental visits, because the proximity of the camera caused the female to fly away from the nest and watch us from a distance.

On 01 December 2015 the day was sunny with high temperature, and the female of El Morado stayed on the nest at noon (11:47–13:04 h). She protected the chicks from the direct solar radiation covering them with her body and wings (Fig. 1A). Similar behavior was recorded by De Lucca (2011) for this species, and for Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*) by Pavez (2001). This is a typical behavior for species that inhabit environments with high solar radiation, and aims to help nestlings to avoid hyperthermia (Whittow 1986). This behavior was not recorded during cloudy days. We also observed the chicks panting to avoid hyperthermia during the day.

In relation to nest predation, the female in El Morado stayed on the nest at night (from 20:55 to 06:57 h) always observing the surroundings. In Tamarico the female performed an immediate defensive reaction when we approached to install the camera: she perched near the nest or flew in circles in the surroundings. The nestlings reacted in a different way: they opened their wings and vocalized a wheezy sound with their beaks open. We think these actions are anti-predatory behaviors when chicks face an unknown threat. De Lucca (2011) reported similar behavior when he touched chicks.

The chicks from El Morado intentionally defecated outside the nest (chicks approached the nest edge raising the tail and ejecting feces far from the nest; Fig. 1B), which was proposed as an adaptation to avoid parasite proliferation (Ibáñez-Álamo *et al.* 2016). This kind of behavior has been reported in other Accipitridae species, which also use sanitizers on nests (Orians & Kuhlman 1956).

In El Morado, chicks were fed with Darwin's Leaf-eared Mouse (*Phyllotis darwini*) (Fig. 1C) and Chilean Iguana (*Callopistes maculatus*) (Fig. 1D). This matches the diet composition of this species found by Faúndez *et al.* (2015) for Variable Hawks, and confirms that not only adults feed on these species. The Chilean Iguana was heterogeneously given to chicks: it was divided in 45

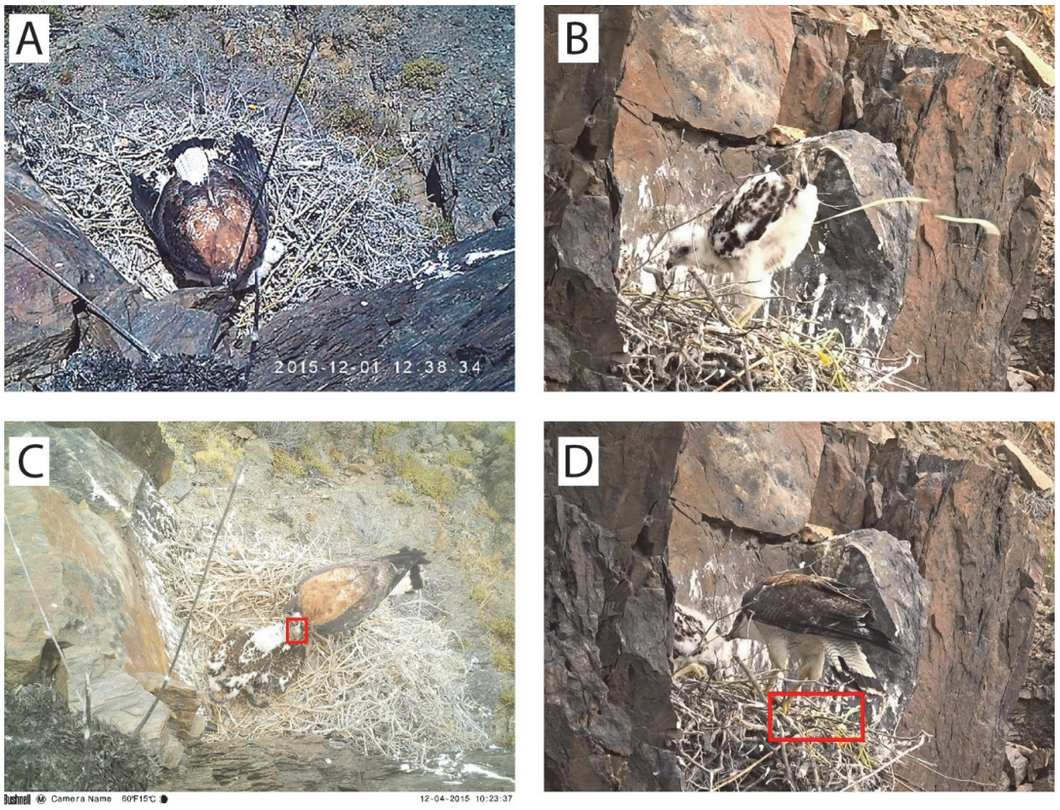

Figure 1. Female covering nestlings at midday (**A**). Chick defecating out of nest (**B**). Female feeding nestlings with *Phyllotis darwini* (red rectangle indicates the mouse position) (**C**). Female feeding nestlings with *Callopistes maculatus* (red rectangle indicates the reptile position) (**D**).

pieces and 30 of them were given to one of the chicks. One of the chicks tried to peck the prey and the female stopped it. This could indicate that parents control the feeding of nestlings. No aggression between chicks was recorded during feeding events, such as Pavez (2001) recorded for Black-chested Buzzard-Eagle.

Given that in South America most of the natural history of bird species is unknown, low cost and daily use technologies represent an opportunity to record basic information in this and other areas of animal life. However, the use of these tools must have adequate, ethical and careful planning so as not to intervene in an invasive way in behavior. The tests in the present study allowed us to conclude that a strange object, for instance a camera, placed directly in the nest can produce an anti-predatory behavior in nestlings. However, at a distance of 3 m and when parents are absent, the installation and permanence of the camera did not produce reaction.

Although this information corresponds to observations on only two nests, this study adds to the limited data that was available on the natural history of the Variable Hawk in the Atacama Desert. Also, the study confirms some behaviors for the species. We consider that descriptions from other environments and nests will be useful for discerning and understanding general patterns of parental care for this species.

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SHORT-COMMUNICATION

Collared Forest-Falcon (*Micrastur semitorquatus*) preying on a squirrel in a fragment of Atlantic Forest with a revision of the predation events for the species

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ABSTRACT: We recorded predation on the squirrel *Guerlinguetus ingrami* by a Collared Forest-Falcon (*Micrastur semitorquatus*) through camera trapping in a forest fragment of Atlantic Forest in the interior of São Paulo state, Brazil. The squirrel was captured while it moved across the forest floor. A compilation from bibliographic and other sources resulted in 68 vertebrate and 03 invertebrate species as prey of the Collared Forest-Falcon, with birds more commonly reported in the diet of the species. The majority of prey (66% of species) did not exceed 300 g, but some prey species (12%) such as guans (*Penelope* spp.) were heavier than the falcon. The Collared Forest-Falcon could affect the population dynamics of smaller vertebrates in forest fragments of Atlantic Forest due to its flexibility in diet and habitat use, an aspect that deserve a more thorough investigation.

KEY-WORDS: bird-mammal, hawk diet, interaction, predator-prey, Seasonal Semideciduous Forest.

The Collared Forest-Falcon (*Micrastur semitorquatus*) is the largest member of the genus composed of seven species of forest falcons, with a total size varying from 46 to 58 cm with average body mass of 563 g for males and 800 g for females (Thorstrom 2000, Ferguson-Lees & Christie 2001, Menq 2016).

The species is found from southern Mexico to central Argentina, including Brazil (Ferguson-Lees & Christie 2001, Thorstrom 2007, Sigrist 2014). Its known habitat includes primary forest, forest edge and secondary forest with dense undergrowth (del Hoyo *et al*. 1993). Individuals nest in cavities of trees and rocks; though there are also records of nests in human buildings (Carrara *et al*. 2007, Vallejos *et al*. 2008, Viana *et al*. 2012). In Guatemala, the home range of Collared Forest-Falcon varied from 996 ha during the reproductive season to 555 ha during the non-reproductive season (Thorstrom 2007).

The Collared Forest-Falcon is a predator that captures its prey on the ground and in vegetation, through ambushes from hidden perches (Sigrist 2014, Menq 2016). It also follows army ant columns, where it captures insectivorous birds (Ferguson-Lees & Christie 2001, Antas 2005). Here we report the predation of the squirrel *Guerlinguetus ingrami*, a predominantly arboreal rodent some 19.6 cm in length and 242 g in body mass (Bonvicino *et al*. 2008), which also forages on the ground, by *M. semitorquatus* (Collared Forest-Falcon), and include a summary of the predation events known for this falcon.

Our study area was a forest fragment of 79 ha in the Abraão de Moraes Astronomical Observatory, with a predominance of Atlantic Forest Biome, Semideciduous Seasonal Forest phytophysiognomy, in Valinhos city, São Paulo state, southeastern Brazil. This is one of the few forest remnants remaining in the region.

The predation event was recorded through a camera trap (MiniTrapa model - with infrared sensor) installed 30 cm from the ground as part of a survey of medium and large mammals. In addition, we collated the available data on predation events by *M. semitorquatus* from the bibliography and public databases such as Google Images, Wikiaves, YouTube and Flickr using as keyword search "*Micrastur semitorquatus*".

At 09:00 h on 9 October 2016 we recorded a single squirrel *G. ingrami* squirrel foraging on the ground on the leaf litter under a closed canopy of an old (45 years) secondary forest (Fig. 1A). The following day, at about the same time and location (23º0'17.48''S; 46º57'48.22''W), we recorded a *M. semitorquatus* attacking a *G. ingrami* on the ground (Fig. 1B). Seconds later, the falcon carried away its prey, probably towards a perch to feed on it. The photographed bird had barred chest plumage, a dark throat and collar and a long and voluminous tail (Fig. 1B), field marks that characterize it as a juvenile of *M. semitorquatus* (Ferguson-Lees & Christie 2001, Menq 2016).

The revision of predation events of *M. semitorquatus* resulted in the identification of 71 predated species (Appendix I) with birds being the most common prey (50 species), followed by mammals (n = 11), reptiles (n = 6), invertebrates (n = 3) and amphibians (n = 1). Although most prey species (66%) had a mean body mass less than 300 g (Fig. 2). Prey of *M. semitorquatus* cover a wide size spectrum, with 12% of prey exceeding the mass of the predator itself (Fig. 2).

This note presents the first documented predation record of a *G. ingrami* squirrel by *M. semitorquatus*. Other species of squirrels (*Sciurus deppei* and *S. yuacatanensis*) have been reported as prey of this raptor (Throstrom 2000). *Guerlinguetus* squirrels are arboreal and inhabit the intermediate and lower strata of the forest descending to the ground to forage (Bonvicino *et al.* 2008), where they are potentially more vulnerable to predators. In the

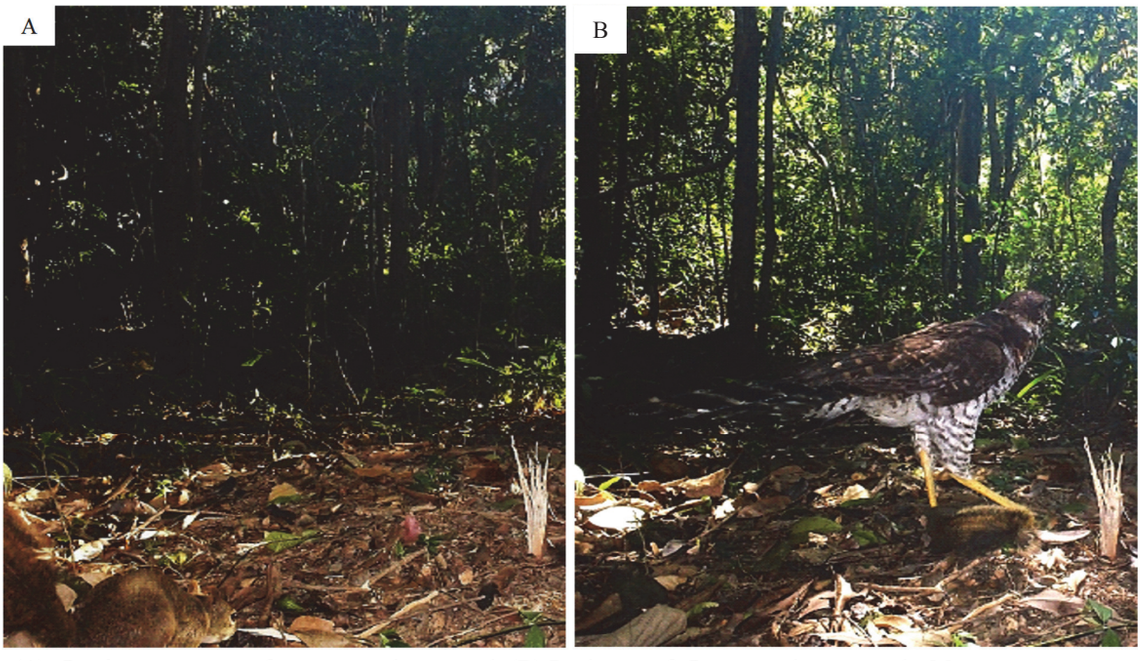

Figure 1. (**A**) *Guerlingetus ingrami* foraging on the ground; (**B**) Predation of *G. ingrami* by a juvenile *Micrastur semitorquatus*.

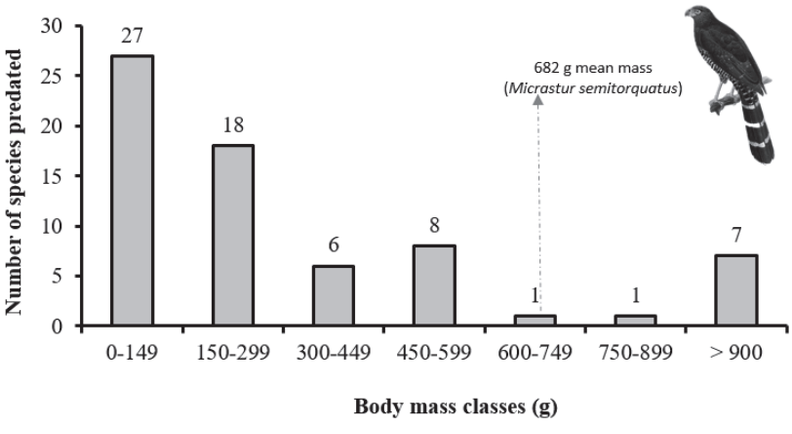

Figure 2. Prey eaten by *Micrastur semitorquatus* distributed in 150 g body mass classes. Data from Appendix I.

studied forest fragment, we recorded other potential prey of Collared Forest-Falcon, including Plumbeous Pigeon (*Patagioenas plumbea*), Rusty-margined Guan (*Penelope superciliaris*), Calico Lizard (*Tropidurus torquatus)*, Black-and-white Tegu (*Salvator marianae*), and Brazilian Forest Rabbit (*Sylvilagus brasiliensis*).

The predation event described here demonstrates the agility and behavioral flexibility of *M. semitorquatus* as a predator that inhabits the forest interior. Others studies suggest that this falcon has the most diversified diet within the *Micrastur* genus (Thorstrom 2000, Appendix I). Our compilation indicates that birds are also a relevant dietary component, in terms of both diversity and biomass, in the diet of Collared Forest-Falcon.

The occurrence of *M. semitorquatus* in a forest remnant surrounded by a highly human-modified landscape highlights the capacity of the species to adapt to disturbed environments (Viana *et al*. 2012). In addition, the study site is located in a region with abundant granite outcrops whose crevices and cavities provides suitable nesting sites for *M. semitorquatus* individuals, as shown in other regions of Brazil (Vallejos *et al*. 2008).

The demonstrated flexibility in diet and habitat use (del Hoyo *et al*. 1993, Thorstrom 2000) suggests that *M. semitorquatus* could be a local avian top predator (Brook *et al*. 2012, Colman *et al*. 2014) affecting the population dynamics of small vertebrates in forest fragments in the Atlantic Forest. The role of *M. semitorquatus* (and other forest falcons) in the trophic webs of forest fragments should be accessed through quantitative ecological studies, similar to those conducted in Guatemala (Thorstrom 2000).

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APPENDIX I

List of prey species of *Micrastur semitorquatus* compiled from different sources.

Prey species	Adult body length (cm)	Adult body mass (g)	Study regions	Sources
Arthropods				
Unidentified species (ant)	-	<5	Costa Rica	Skutch (1981), Mays (1985)
Unidentified species (cicada)	-	10	Brazil, Pantanal	Carrara *et al.* (2007)
Unidentified species (spider)	-	10	Costa Rica	Skutch (1981)
Amphibian				
Unidentified species (frog)	-	20	Guatemala	Thorstrom (2000)
Birds				
Amazona amazonica	32[1]	384[7]	Brazil, Pantanal	Carrara *et al.* (2007)
Anodorhynchus hyacinthinus#[1]	70–100[1]	1500[7]	Brazil, Mato Grosso	Salles (2010)
Aramides cajaneus	42[1]	403[7]	Brazil, Pantanal	Guedes (1993), Carrara *et al.* (2007)
Aulacorhynchus spp.	33*	150[3]	Guatemala	Thorstrom (2000)
Brotogeris chiriri	23[1]	50*	Brazil, Pantanal	Carrara *et al.* (2007)
Cacicus cela	26[1]	80[7]	Brasil, Pantanal, Peru[a]	Robinson (1994)[a], Carrara *et al.* (2007)[b]

Prey species	Adult body length (cm)	Adult body mass (g)	Study regions	Sources
Caprimulgidae	20*	70*	Brazil, Pantanal	Carrara *et al.* (2007)
Celeus spp.	25*	85[3]	Guatemala	Thorstrom (2000)
Columbina picui	17[1]	53[7]	Brazil, Pantanal	Carrara *et al.* (2007)
Crax rubra	-	500[3]	Guatemala	Thorstrom (2000)
Crotophaga ani	36[1]	148[7]	Brazil, Pantanal	Guedes (1993), Carrara *et al.* (2007)
Crotophaga major	46[1]	150[7]	Brazil, Pantanal	Guedes (1993)
Crotophaga sulcirostris	34*	80*	Mexico	Willis *et al.* (1983)
Crypturellus obsoletus	25–30[1]	360–600[1]	Brazil, São Paulo	Souza (2015)
Cyanocorax chrysops	34[1]	200*	Brazil, Mato Grosso	Salles (2012)
Cyanocorax morio	35*	200[3]	Guatemala	Thorstrom (2000)
Dendrocincla homochroa	-	42[4]	Guatemala	Thorstrom (2000)
Eurypyga helias	45[1]	220[4]	Brazil, Mato Grosso	Labelle (2010)
Gallus gallus domesticus	50*	>3000	El Salvador	Slud (1964), West (1988)
Guira guira	38[1]	141[7]	Brazil, Pantanal	Guedes (1993), Carrara *et al.* (2007)
Geotrygon albifaces	24*	55*	Guatemala	Vannini (1989)
Geotrygon montana	24[1]	55*	Guatemala	Vannini (1989)
Heliornis fulica	28[1]	150[7]	Brazil, São Paulo	Souza (2014)
Icterus gularis	20*	65*	Mexico	Sutton *et al.* (1942)
Laterallus viridis	18[1]	140*	Brazil, Pantanal	Carrara *et al.* (2007)
Leptotila spp.	27*	160[3]	Guatemala	Thorstrom (2000)
Melanerpes spp.	18*	81[3]	Guatemala	Thorstrom (2000)
Meleagris ocellata	100[1]	3000[3]	Guatemala	Thorstrom (2000)
Mesembrinibis cayennensis	58[1]	750[7]	Brazil, Pantanal	Carrara *et al.* (2007)
Momotus spp.	44*	133[3]	Guatemala	Thorstrom (2000)
Odontophorus capueira	24[1]	426.5[6]	Brazil, Paraná	Vallejos *et al.* (2008)
Ortallis canicollis	50–56[1]	480–600[1]	Brazil, Pantanal	del Hoyo (1997), Olmos *et al.* (2006), Carrara *et al.* (2007)
Ortallis spp.	50*	450*	Mexico, Panama[b]	Sutton *et al.* (1942), Wetmore (1965)[b]
Ortalis vetula	50*	450[3]	Guatemala	Thorstrom (2000)
Patagioenas plumbea	34[7]	215[7]	Brazil, São Paulo	This study
Penelope jacquacu	71[1]	1530[1]	Peru	Robinson (1994)
Penelope obscura	68–75[1]	1000–1200[1]	Brazil, Paraná[a]; Argentina[b]	Vallejos *et al.* (2008)[a], Cuñado (2014)[b]
Penelope purpurascens	50*	600[3]	Guatemala	Thorstrom (2000)
Penelope sp.	68[1]	1000[1]	Brazil, Rio de Janeiro	Blanco (2013)
Piaya cayana	44[1]	75*	Brazil, Pantanal	Carrara *et al.* (2007)
Primolius auricollis	40[1]	250[7]	Brazil, Pantanal	Carrara *et al.* (2007)
Psarocolius angustifrons	41[1]	258*	Peru	Robinson (1994)

Prey species	Adult body length (cm)	Adult body mass (g)	Study regions	Sources
Psarocolius decumanus	42[1]	258[7]	Brazil, Pantanal	Carrara *et al*. (2007)
Pteroglossus torquatus	-	220[3]	Guatemala	Thorstrom (2000)
Quiscalus mexicanus	42[9]	160[9]	Mexico	Flores (2017)
Ramphastos sp.	42–61[1]	350*	Brazil, Paraná	Vallejos *et al*. (2008)
Ramphastos sulfuratus	50*	350[3]	Guatemala	Thorstrom (2000)
Rupicola rupicola	27–32[1]	200[4]	North Amazonia[a]; Guiana[b]	Trail (1987)[b], Sigrist (2014)[a]
Strix virgata	34[1]	240[3]	Guatemala	Thorstrom *et al*. (1990)
Taraba major	19[1]	50*	Brazil, Pantanal	Guedes (1993)
Mammals				
Artibeus spp.	90*	50[3]	Guatemala	Thorstrom (2000)
Callithrix humeralifer	21.5[2]	470[2]	Brazil, Mato Grosso	Rylands (1981)
Callithrix jacchus	21.5[2]	470[2]	Brazil, Paraíba[a]	Alonso & Langguth (1989)[a], Pontes & Soares (2005)[b]
Callithrix penicillata	21.5[2]	470[2]	Brazil, São Paulo	This study
Guerlinguettus ingrami	19.6[4]	242[5]	Brazil, São Paulo	This study
Heteromys spp.	-	76[3]	Guatemala	Thorstrom (2000)
Sciurus deppei	-	205[3]	Guatemala	Thorstrom (2000)
Sciurus yucatanensis	-	400[3]	Guatemala	Thorstrom (2000)
Sigmodon hispidus	-	150[3]	Guatemala	Thorstrom (2000)
Unidentified rodent #[2]	-	-	Brazil, Paraná	Vallejos *et al*. (2008)
Unidentified marsupial#[2]	-	-	Brazil, Paraná	Vallejos *et al*. (2008)
Reptiles				
Ameiva sp.	15*	40*	Brazil, Pantanal	Guedes (1993)
Corytophanes spp.	-	<150*	Guatemala	Thorstrom (2000)
Coluber sp.	-	45[3]	Guatemala	Thorstrom (2000)
Ctenossaura similis	130[8]	1500[8]	Vera Cruz, México	Haemig (2012)
Salvator marianae	100*	>1000*	Brazil, São Paulo	Martinhão (2012)
Micrurus sp. (coral snake)	-	<150*	Brazil, Mato Grosso do Sul	Messias (2015)

[1]Sigrist (2014), [2]Reis *et al*. (2015), [3]Throrstrom (2000), [4]Hilty 2002, [5]Ribeiro *et al*. (2010), [6]del Hoyo *et al*. (1993), [7]Wikiaves, [8]Savage (2002), [9]Wehtje (2003).
"[a]" and "[b]" refers to the authors responsible for information.
*Based on species of the same genus.
data not used in the graphic;
#[1] the predation reported was of macaw nestlings (undefined mass);
#[2] undefined species (may be great variation on the mass).

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ARTICLE

Brazilian bird collections: a decade after Aleixo & Straube (2007)

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ABSTRACT: We compiled the main results of a second diagnosis of Brazilian ornithological collections. Our starting point was the survey by A. Aleixo and F. Straube, with data up to 2005 and published in 2007. Ten years later, in 2015, curators or managers from 35 collections of birds (out of 59) answered 12 questions related to the status of the collection they curate. These collections cover all regions of the country, and many have grown in number of specimens, especially in northeastern Brazil. As verified by Aleixo & Straube, most ornithological Brazilian collections are concentrated in southeastern and southern Brazil (66%). Also, some basic shortcomings persist, such as the lack of specialized curators, taxidermists, and access to digitalized information. The three oldest and biggest collections (Museu Nacional da Universidade Federal do Rio de Janeiro - MN, Museu Paraense Emílio Goeldi - MPEG and Museu de Zoologia da Universidade de São Paulo - MZUSP) together continue to hold more than half of all Brazilian ornithological specimens and 83% of all type specimen. Some collections, (especially new ones) have been actively collecting and preparing specimens in a much-diversified way, saving different body parts of a single individual as distinct types of materials. Government and other online data information systems (*e.g.*, Brazilian Biodiversity Information System - SiBBr and Center for Reference in Environmental Information - CRIA) have been developed, and now provide digital data from some relevant collections. Brazilian ornithological collections are completely or partially digitized (85%), although for most specimens and collections, data are not freely available and is mostly accessed between researchers. Despite the efforts of some researchers and institutions, improvements in the maintenance and protection of the collections are still necessary. Nevertheless, we conclude that the situation of Brazilian ornithological collections has improved in the past 10 years. Finally, herein we propose a rank for Brazilian ornithological collections classifying them according their role for both research and education activities, which are considered in the current bibliography as key roles of natural history collections.

KEY-WORDS: bird biodiversity, classifying criteria, conservation, database, museums, specimens.

INTRODUCTION

Collections of biological specimens, which in the past were the privilege of aristocratic collectors and/or curious people interested in nature, have come to be recognized as repositories of evidence or results of evolution (Joseph 2011). Even today they serve this purpose, supporting research on taxonomy, systematics, distribution and biology, as well as studies of changes in populations, species and the environment, playing a very important role in research and education, defined as key internal scholarly museum functions, and also in the education of the non-specialized public (external museum function) (Allmon 1994, Cracraft 2002, Suarez & Tsutsui 2004, Winker 2004). Museum collections have also been used successfully to analyze declines of many species and are a valuable tool in documenting the changes that have occurred in the planet's biodiversity in the last century (Shaffera *et al.* 1998). Despite the intrinsic value of the collections and their value for research and education, museum collections are sources of inspiration and other connections that occur when a researcher examines and compares objects "first hand and ponders their significance" (Allmon 1994).

Biological scientific collections traditionally consist of specimens or parts of them stored, hopefully, for perpetuity. Worldwide natural history collections are an enormous and incomparable sampling of global biodiversity of all taxonomic groups. Currently, these collections contain about 3 billion specimens curated in museums and universities (Brooke 2000), which were acquired over the past 500 years thanks to the efforts of generations of naturalists and curators (Rouhan *et al.* 2017). Due to new technological advances (such as sound recordings, photographs, geographic information systems and DNA sequencing) and the development of new disciplines such as genomics and bioacoustics, there is an ever-increasing need to diversify the items to be included, stored, preserved, identified and cataloged in a biological collection. In parallel with the generation of these new

types of data, the development of the World Wide Web (WWW) and its access through the internet allows the sharing, almost instantaneously, of data. Of course, this is accompanied by a growing demand for information availability.

We do not know current complete surveys of the number of specimens deposited in Brazilian collections, but by 2003 its number was about 26 million specimens, being the largest collection in the world of Neotropical biodiversity (Zaher & Young 2003). A complete survey of the Brazilian Bird Collections was published by Aleixo & Straube (2007), which constitutes a general overview of most known collections of birds in Brazil. That study was part of a project on the status of the Brazilian collections promoted by the government-funded Brazilian Biodiversity Research Program (PPBio), with the aim of consolidating an information system of integrated data on biodiversity (Aleixo & Straube 2007). That study compiled data on 22 collections and 250,311 specimens (skins, anatomical and exhibition series). Currently, after 10 years, few government grant calls aimed at enabling the creation and maintenance of collections or parts of them have been put forward. Some of these, such as the "Edital MCT/CNPq No. 35/2012 - PPBio/Geoma - Networks for Research, Monitoring and Modeling in Biodiversity and Ecosystems, Part I" belonging also to the PPBio project, were essentially discontinued, resulting in strong negative impacts to the knowledge of Brazilian biodiversity (Fernandes *et al.* 2017).

While recognizing the efforts of federal, state and private entities, foundations and, especially, researchers in creating and maintaining Brazilian collections, the shortcomings still outweigh the gains. Thus, a survey of the current situation compared to the past is relevant to establish future guidelines for all Brazilian bird collections. Our objectives here are to: (1) list the current Brazilian ornithological collections; (2) compare the information obtained with those of the diagnosis made in 2007 (Aleixo & Straube 2007); and (3) to draw a qualitative and quantitative outline based on criteria related to the management and maintenance of the collections, and the availability of their data for scientific and educational purposes.

METHODS

In October 2014 and from January to March of 2015, an online Google questionnaire was sent to all specialists responsible for maintaining the collections of birds in Brazil, identified in Aleixo & Straube (2007) or found using the keywords "bird collections" and "ornithological collections" within search engines, such as the Lattes platform of the Brazilian National Council for Scientific Development and Technological (CNPq). J.P.S. sent questionnaires (see Appendix I) that took no longer than 3 minutes to answer, with 12 questions (much smaller than the questionnaire proposed by Aleixo & Straube 2007, with 26 questions). The highest percentage of questionnaires (78%) was answered by 2015 and some were answered in August and September 2016, when questionnaires were re-sent. However, all the results are based on data from collections up to 2015. We tried to correct some inconsistencies observed in the questionnaire responses, by telephone or electronic correspondence, until November 2017. In all, we contacted managers at 59 collections (see list in Table 1). In case of differences of information between the current study and Aleixo & Straube (2007), we placed the older information between parentheses.

Additionally, with the information requested through the questionnaire in hand, in 2017 we searched for bird collections on the Internet, in the databases of the CRIA - Center for Reference in Environmental Information (CRIA 2017) and SiBBr - Brazilian Biodiversity Information System (SiBBr 2017). Both entries had more than 400 collections in 2017, of which 10 were of birds. Some of these collections (eight) are the same ones contacted via questionnaire and three others were opportunistically added to this work. Collections of sounds, videos, photos, tissues, DNA, or collections of microorganisms or other organisms related to birds were not considered when they were not associated with traditional vouchers such as skins and/or, skeletons and deposited in the same collection.

To establish a ranking of the status of Brazilian bird collections we evaluated and compared the answers of the questionnaires on a scale of 0–1 according to the criteria described below. Criteria and weights were based on the assumptions that a collection serves to two main functions - research and education - considering what was asked in the questionnaires and what is cited in the literature as important features and functions for a collection (*e.g.*, Allmon 1994, Lane 1996). Most of these criteria have been considered a good basis for evaluation in previous publications (Allmon 1994, Lane 1996, Dance 2017). Rankings were based on the following parameters:

(A) Total size of the collection - 1, greater than 10,000 specimens; 0.75, from 5000 to 10,000 specimens; 0.5, from 1000 to 5000 specimens; 0.25, from 500 to 1000 specimens; 0, less than 500 specimens;

B) Relationship between the total number of specimens/ total years of existence (*i.e.*, annual growth rate) - 1, more than 200 specimens, 0.75, between 200 and 150 specimens; 0.5, between 150 and 100 specimens; 0.25, between 100 and 50 specimens; 0, less than 50 specimens;

(C) Curator - 1, presence of a curator and/or professional ornithologist in the collection (based on *Lattes* CV; www.lattes.cnpq.br); 0.5, without a curator but with a head researcher with a degree in any area of Zoology, based on

the *Lattes* CV; 0, Museum general manager, even with an academic degree in a different area or who answered "no curator" in the questionnaire;
(D) Taxidermist - 1, presence of a taxidermist; 0, absence of a taxidermist;
(E) Diversification of the Collection - 1, six or more preparation forms (*e.g.*, skins, skeletons, tissues, nests, eggs, carcasses, syringes, stomachs, etc.); 0.5, between three and five types of preparation; 0, only one or two types of forms;
(F) Presence of type specimens reported (*e.g.*, Holotypes, Paratypes, Syntypes) - 1, presence; 0, absence;
(G) Average proportion of digitalization of the collection, such as: total digitalization (1), partial digitization (0.5) and non-digitalization (0), and the availability of the database to the public (1), to researchers (0.5), or only to the internal public (0);
(H) Average between the number of visits/year (1, more than 13 visits; 0.5, 1 to 12 visits; 0, no visit) and the number of loans per year (1, more than 12 loans; 0.5, 12 loans; 0, no loans);
(I) Geographical representativeness of the collection - 1 (Global); 0.5, regional (Brazil, regions); 0, state where the collection is located;
(J) Known citations of the collection in scientific articles - 1, 13 or more articles; 0.5, 1 to 12 articles; 0, no articles.

RESULTS

Thirty-eight of 59 curators/managers (64%) answered the electronic questionnaire in full (35) or partially (3) (Table 1). Additionally we received electronic correspondence, updating us on the current situation of four other collections as followed.

In October 2014, we were informed that the Museu de História Natural da Universidade Estadual do Centro-oeste (MEHS) in Guarapuava (Paraná state - PR) was closed, but that few specimens are stored, and that the skins were only for didactic purposes, since they did not have data of origin. However, we recently discovered that the museum was reopened in December 2015 (Prefeitura de Guarapuava 2015). The Zoology Collection of the Delta do Parnaíba, of the Universidade Federal do Piauí (UFPI), Parnaíba campus, contains fish, reptiles, amphibians and insect specimens from the Parnaíba region, but only three birds. The Bird Collection of the Museu de História Natural (MHNB) of the Universidade Estadual Paulista (UNESP), at Botucatu (São Paulo state - SP), has a didactic collection of animals. The collection UCG (Universidade Católica de Goiás) held in Goiânia, cited in Aleixo & Straube (2007), is currently known as the Bird Collection of CEPB (Centro de Estudos e Pesquisas Biológicas) of Pontifícia Universidade Católica de Goiás in the same city. It is a research nucleus of the Escola de Ciências Agrárias e Biológicas, which unites the biological collections of each individual laboratory. According to the curator, this collection is being reorganized and re-inventoried, and currently has 518 specimens belonging to 212 bird species from Goiás, Minas Gerais, Mato Grosso do Sul, Rondônia, and Tocantins states (W. Vaz, *in litt.*).

Concerning the three collections that managers answered partially the questionnaire, we find that the Museu de Ornitologia de Goiânia (MOG) lists over 15,000 specimens in its catalogue. However, of this total, thousands of specimens were taken to foreign collections and it is currently estimated that the collection of birds has between 5000 and 8000 skins, distributed in the serial and expository collections (information received through the questionnaire, without identification of the author, forwarded to J.P.S. on 20 September 2016). Apparently, MOG has an excellent didactic collection, although the origins of many of its specimens are questionable. In relation to this collection, we still found that the Legislative Assembly of the state of Goiás approved the decree number 3652/17, which authorizes the transfer of financial resources to the *Sociedade Goiana de Cultura*, responsible for the PUC-GO for the creation and construction of the Museum of Zoology of this university (Assembleia Legislativa do Estado de Goiás 2017a). According to the source, this museum will be built to house the collection donated by José Hidasi, which has more than 27,000 specimens (invertebrates, reptiles, birds and mammals) (Assembleia Legislativa do Estado de Goiás 2017b). The information on the total number of specimens and presence of type specimens were absent in the reply from the Museu das Culturas Dom Bosco (MCDB), Campo Grande, Mato Grosso do Sul state - MS. The number of specimens of the Bird Collection of the Museu Oceanográfio da UNIVALI (MOVI), Itajaí, Santa Catarina state - SC, was also mistakenly informed (200,000) and after no reply to our attempt to correct it we decided do not consider this number. On the website of this Museum, there is a citation indicating that 650 specimens of oceanic birds are housed in the bird collection. For the purpose of this work, MOG, MCDB, MOVI were considered only in the ranking of the collections.

From the answers of the questionnaires, searches on the Internet and the full collection's list mentioned by Aleixo & Straube (2007), we were able to list 62 collections of birds, or collections that may potentially contain birds, in Brazil (Table 1). Except for the four collections mentioned above, plus the MOG, MCDB and MOVI collections, which partially answered questionnaires, the remaining 35 respondents answered the full questionnaire (collections C), eight of which have databases available on the Internet (collections D). Sixteen collections did not answer the questionnaire (collections NC) and two

Table 1. List of currently known Brazilian bird collections. State: Brazilian state abbreviations. Region: N – north, NE – northeast, CO – midwest, SE – southeast, S – south. Jurisdiction/funding: S – State, F – Federal, M – Municipal, P – Private. Abbreviations on column Aleixo & Straube (2007) and column This study: A – Checked, C – Included in analysis, CNC – contacted, but not considered (information in the text), D – Data in online database (CRIA or SiBBr), NA – Not investigated, NC – Not considered, questionnaire response not obtained, or collection created after 2005. The data in parentheses are from Aleixo & Straube (2007), different from the current data.

Acronym	Collection	City	State	Region	Jurisdiction	Aleixo & Straube (2007)	This study
CGFA	Coleção Científica Fauna do Amapá, Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá, IEPA	Macapá	AP	N	S	C	NC
CRAR	Coleção de Referência da Avifauna de Rondônia, Fundação Universidade Federal de Rondônia, UNIR	Porto Velho	RO	N	F	NA	D
INPA	Coleção de Aves, Instituto Nacional de Pesquisas da Amazônia, INPA	Manaus	AM	N	F	C	C
MPEG	Coleção Ornitológica Fernando da Costa Novaes, Museu Paraense Emílio Goeldi	Belém	PA	N	F	C	C, D
NZT (UNITINS)	Núcleo de Zoologia e Taxidermia, Universidade Estadual do Tocantins, UNITINS	Palmas	TO	N	P	C	C
UFAC	Coleção Ornitológica, Universidade Federal do Acre, UFAC	Rio Branco	AC	N	F	NA	C
ZEE-AVI	Zoneamento Ecológico-Econômico do Acre, Avifauna, Secretaria do Meio Ambiente	Rio Branco	AC	N	M	NA	D
CAHZ (UFPB)	Coleção de Aves Heretiano Zenaide, Universidade Federal da Paraíba, UFPB	João Pessoa	PB	NE	F	C	C
CHNUFPI	Coleção de História Natural Universidade Federal do Piauí, UFPI, Campus Amílcar Ferreira Sobral	Floriano	PI	NE	F	NA	C
MCNC	Coleção Ornitológica, Museu de Ciências Naturais da Cetrel. Cetrel: Empresa de Proteção Ambiental S.A.	Camaçari	BA	NE	S	C	NC
MHN	Museu de História Natural, Universidade Federal de Alagoas, UFAL	Maceió	AL	NE	F	NA	C
MHNU	Museu de História Natural da Urca, Universidade Regional do Cariri, UHC	Crato	CE	NE	P	A	NC
MMOL	Museu do Mar Onofre Lopes, Universidade Federal do Rio Grande do Norte, UFRN	Natal	RN	NE	F	A	C
MZFS	Divisão de Aves do Museu de Zoologia, Universidade Estadual de Feira de Santana, UEFS	Feira de Santana	BA	NE	S	NA	C
UFPE	Coleção Ornitológica, Universidade Federal de Pernambuco, UFPE	Recife	PE	NE	F	NC	C

Acronym	Collection	City	State	Region	Jurisdiction	Aleixo & Straube (2007)	This study
UFPI	Coleção Zoológica Delta do Parnaíba, Universidade Federal do Piauí, UFPI, Campus Parnaíba	Parnaíba	PI	NE	F	NA	CNC
CEPB (UCG)	Centro de Estudos e Pesquisas Biológicas, Pontifícia Universidade Católica de Goiás, PUC-Goiás	Goiânia	GO	CO	P	C	CNC
COMB	Coleção Ornitológica Marcelo Bagno, Museu de Zoologia, Universidade de Brasília, UnB	Brasília	DF	CO	F	C	C
COUFMT	Coleção Ornitológica, Universidade Federal de Mato Grosso, UFMT	Cuiabá	MT	CO	F	NA	C, D
MCDB (MDB)	Museu das Culturas Dom Bosco, Universidade Católica Dom Bosco, UCDB	Campo Grande	MS	CO	P	NC	CNC
MOG (FMOG)	Museu de Ornitologia de Goiânia, Prefeitura Municipal de Goiânia	Goiânia	GO	CO	M	C	CNC
DZUFMG	Coleção Ornitológica, Departamento de Zoologia, Universidade Federal de Minas Gerais, UFMG	Belo Horizonte	MG	SE	F	C	C
IAL	Coleção de Aves, Instituto Adolfo Lutz, Secretaria Estadual de Saúde, Governo de São Paulo	São Paulo	SP	SE	S	NC	NC, D
IB/UFFRJ (UFFRJ)	Museu de Zoologia, Coleção Ornitológica, Instituto de Biologia, Universidade Federal Rural do Rio de Janeiro, UFFRJ	Seropédica	RJ	SE	F	A	NC
MBML	Coleção Ornitológica, Museu de Biologia Prof. Mello Leitão, Instituto Nacional da Mata Atlântica	Santa Teresa	ES	SE	F	C	C, D
MCN-UNESP	Coleção de Aves, Museu de Ciências da Natureza, Universidade Estadual Paulista, UNESP, Campus de Rio Claro	Rio Claro	SP	SE	S	NC	NA
MCNA (MCNP)	Museu de Ciências Naturais, Pontifícia Universidade Católica de Minas Gerais, PUC-Minas	Belo Horizonte	MG	SE	P	NC	C
MHNB	Coleção de Aves, Museu de História Natural, Universidade Estadual Paulista, UNESP, Campus Botucatu	Botucatu	SP	SE	S	NC	CNC
MHNPAP	Museu de História Natural Professor Antônio Pergola	Atibaia	SP	SE	M	NA	NC
MHNT	Coleção de Aves, Museu de História Natural de Taubaté, Fundação de Apoio à Ciência e Natureza, FUNAT	Taubaté	SP	SE	P	C	C
MHN-UFJF	Museu de História Natural, Universidade Federal de Juiz de Fora, UFJF	Juiz de Fora	MG	SE	F	A	NC

Acronym	Collection	City	State	Region	Jurisdiction	Aleixo & Straube (2007)	This study
MN	Coleção de Aves. Setor de Ornitologia, Departamento de Vertebrados, Museu Nacional, Universidade Federal do Rio de Janeiro, UFRJ	Rio de Janeiro	RJ	SE	F	C	C, D
MZUFU	Museu de Zoologia, Universidade Federal de Uberlândia, UFU	Uberlândia	MG	SE	F	A	NC
MZUFV	Museu de Zoologia João Moojen de Oliveira, Universidade Federal de Viçosa, UFV	Viçosa	MG	SE	F	C	C
MZUSP	Coleção Ornitológica, Museu de Zoologia da Universidade de São Paulo, USP	São Paulo	SP	SE	S	C	C
UENF	Universidade Estadual do Norte Fluminense	Campos	RJ	SE	S	A	NC
ZUEC	Coleção Ornitológica, Museu de Zoologia Adão José Cardoso, Universidade Estadual de Campinas, UNICAMP	Campinas	SP	SE	S	C	C, D
ANCHIETA	Museu Anchieta de Ciências Naturais, Colégio Anchieta	Porto Alegre	RS	S	P	NA	C
CZFURB	Coleção Zoológica, Universidade Regional de Blumenau, FURB	Blumenau	SC	S	P	C	NC
MCN	Coleção Ornitológica, Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul	Porto Alegre	RS	S	S	C	C
MCNCR	Museu de Ciências Naturais Carlos Ritter, Universidade Federal de Pelotas, UFPEL	Pelotas	RS	S	F	A	C
MCNCS	Museu de Ciências Naturais, Universidade de Caxias do Sul, UCS	Caxias do Sul	RS	S	P	A	C
MCN-UFPR	Museu de Ciências Naturais, Universidade Federal do Paraná, UFPR	Curitiba	PR	S	F	NC	NC
MCP	Coleção de Ornitologia, Museu de Ciências e Tecnologia da Pontifícia Universidade Católica do Rio Grande do Sul, PUCRS	Porto Alegre	RS	S	P	C	C, D
MEHS	Coleção de Aves, Museu de Ciências Naturais, Universidade Estadual do Centro-Oeste, UNICENTRO, Campus Cedeteg	Guarapuava	PR	S	S	NC	CNC
MGS	Museu Guido Straube, Colégio Estadual do Paraná	Curitiba	PR	S	S	A	NC
MHNCI	Coleção Ornitológica, Museu de História Natural Capão da Imbuia, Secretaria Municipal de Meio Ambiente, Prefeitura Municipal de Curitiba	Curitiba	PR	S	M	C	C, D

Acronym	Collection	City	State	Region	Jurisdiction	Aleixo & Straube (2007)	This study
MHNLTS	Museu de História Natural Prof. Luiz Trajando da Silva, Universidade Estadual do Norte do Paraná, UENP	Cornélio Procópio	PR	S	S	NC	NC
MLE	Museu Luiz Englert, Universidade Federal do Rio Grande do Sul, UFRGS	Porto Alegre	RS	S	F	A	NA
CAFURG[1] (MOECR)	Coleção de Aves da Universidade Federal do Rio Grande, FURG	Rio Grande	RS	S	F	A	C
MOVI	Coleção Ornitológica, Museu Oceanográfico, Universidade do Vale do Itajaí, UNIVALI	Itajaí	SC	S	P	C	CNC
MSQ	Museu Sete Quedas, Prefeitura Municipal de Guaíra	Guaíra	PR	S	M	NC	NC
MUCIN (MOUFRGS)	Museu de Ciências Naturais, Centro de Estudos Costeiros, Limnológicos e Marinhos, CECLIMAR, Universidade Federal do Rio Grande do Sul, UFRGS	Imbé	RS	S	F	A	C
MUCPEL	Museu de História Natural, Universidade Católica de Pelotas, UCPel	Pelotas	RS	S	P	NA	C
MuRAU (MRAUM)	Coleção de Aves, Museu Regional do Alto Uruguai, Universidade Regional Integrada do Alto Uruguai, URI, Campus de Erechim	Erechim	RS	S	P	NC	C
MUZAR	Coleção de Aves, Museu Zoobotânico Augusto Ruschi, Universidade de Passo Fundo, UPF	Passo Fundo	RS	S	P	NC	C
MZPUCPR	Coleção de Aves, Museu de Zoologia, Pontifícia Universidade Católica do Paraná, PUCPR	Curitiba	PR	S	P	C	C
MZUEL	Coleção de Aves, Museu de Zoologia, Universidade Estadual de Londrina, UEL	Londrina	PR	S	S	NC	C, D
UFSC	Coleção de Aves, Universidade Federal de Santa Catarina, UFSC	Florianópolis	SC	S	F	A	NC
ULBRA	Museu de Ciências Naturais, Setor de Zoologia de Vertebrados e Invertebrados, Universidade Luterana do Brasil, ULBRA	Canoas	RS	S	P	NA	NC
UNISC	Universidade de Santa Cruz do Sul, UNISC	Santa Cruz do Sul	RS	S	P	NA	C
UNISINOS	Universidade do Vale do Rio dos Sinos, UNISINOS	São Leopoldo	RS	S	P	NA	C

[1] Correct acronym (L. Bugoni pers. comm.).

were not investigated (collections NA), among them the MLE (Coleção de Mineralogia e Petrologia da UFRGS), which had been cited by Aleixo & Straube (2007) for future investigation of the presence of specimens of birds. Two collections were found only in online database of the CRIA system (*Species*Link) or SiBBr - CRAR and ZEE-AVI. The first is a small reference collection of the avifauna of Rondônia, with 24 records online. The second is a collection of relevance, from the Zoneamento Ecológico-Econômico do Acre – Avifauna, da Secretaria do Meio Ambiente do estado do Acre, in Rio Branco. This collection has 3561 records online, the majority of which are specimens preserved, and several of them collected by Fernando Novaes and Olivério Mário de Oliveira Pinto in the 1950s.

We contacted 24 more collections than Aleixo & Straube (2007) and added 27 collections to their list of Brazilian Ornithological Collections. We considered 13 more collections in the current study (see Table 1).

The 35 collections considered (C) have 335,152 listed specimens (*e.g.*, skins, skeletons, skin-skeletons, tissues, nests and eggs) (Table 2). About 80% of these collections are kept with federal (17) or private (12) funds and 20% are maintained by state (5) and municipal (1) funds. The representativeness of the collections are mainly to the regional or state levels (66%), but 12 collections have some representation of birds from Brazil, South America and the world (34%). Most of the collections are from southeastern and southern Brazil, from sites located in the Atlantic Forest Biome (~60%). Among the new collections or those which grew the most, two are in northern Brazil (MPEG and INPA); one is in northeastern Brazil (CAHZ); one in midwestern Brazil (COMB); and five are located in southeastern (the MZUSP, MN, MHNT and DZUFMG), and in southern Brazil (MCP) (Fig. 1, Table 2). Some collections from the northern, midwestern, southeastern and southern regions also have preserved complementary materials such as gonads, stomachs, syringes, eyes, tongues, ecto and/or endoparasites (Fig. 2). In 10 years, we observed an increase in the number of collections in northeastern and southern Brazil. Northeastern collections are mostly young collections (initiating in the 2000s), such as the collections from Paraíba state, Bahia state (Feira de Santana), Alagoas state, and Rio Grande do Norte state. These are being cited for the first time in this survey and maintain collections in the style of the most traditional ornithological collections, with skins, skeletons, nests and eggs and with little supplementary material (Fig. 2). Although young, these collections are well organized and are important for their representation of the avifauna of the Caatinga Biome, in addition to the Atlantic Forest Biome.

Based on the answers, we could classify the collections into three types:

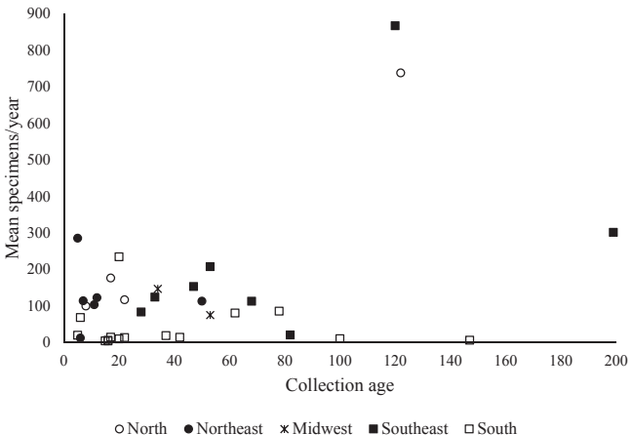

Figure 1. Growth of collections according to the annual rate of specimens accessed since their foundation. Each collection listed in Table 2 is represented with the symbol of its regional localization. Original data is presented in Table 2.

(1) Exhibition collections - located in institutions that have primarily didactic purposes, although they also have material that is scientifically relevant. Examples are the collection of the Museu Anchieta, Porto Alegre, Rio Grande do Sul state - RS, which has perhaps the last *Harpia harpyja* specimen from the metropolitan region of Porto Alegre (RS) (Bencke *et al.* 2003); and the Museu de Ciências Naturais Carlos Ritter (MCNCR) with an important collection of birds from RS collected by the naturalist Carlos Ritter, who lived from 1851 to 1926 in Pelotas. These collections are curated and continue to carry on the activities they support, although their holdings are not growing (Fig. 1). Other collections such as the Museu Guido Straube (MGS), or the Museu Sete Quedas (MSQ) which did not respond to the questionnaire, would be classified as Exhibition collections.

(2) Inactive or underactive collections - located mostly in public and private university teaching institutions, which do not have associated museums and which therefore depend on the voluntary action of collaborating researchers, students and teachers in order to maintain the collection's adequate structure. This contingent of personnel is ephemeral and/or the researchers fail to meet all the demands of maintaining a collection, which, after being initiated, are stagnated or go through processes of temporary growth and stagnation. Such collections that are not growing in number of specimens, without visitation or research in the last years, or do not even have staff to respond to the demands related to maintanance of the collection, such as answering our questionnaire. Under this category are included didactic and reference collections for undergraduate classes (Tables 1 & 2).

(3) Active collections - collections of museums or/and universities that have curatorship and/or researchers taking care of the collection and minimal infrastructure

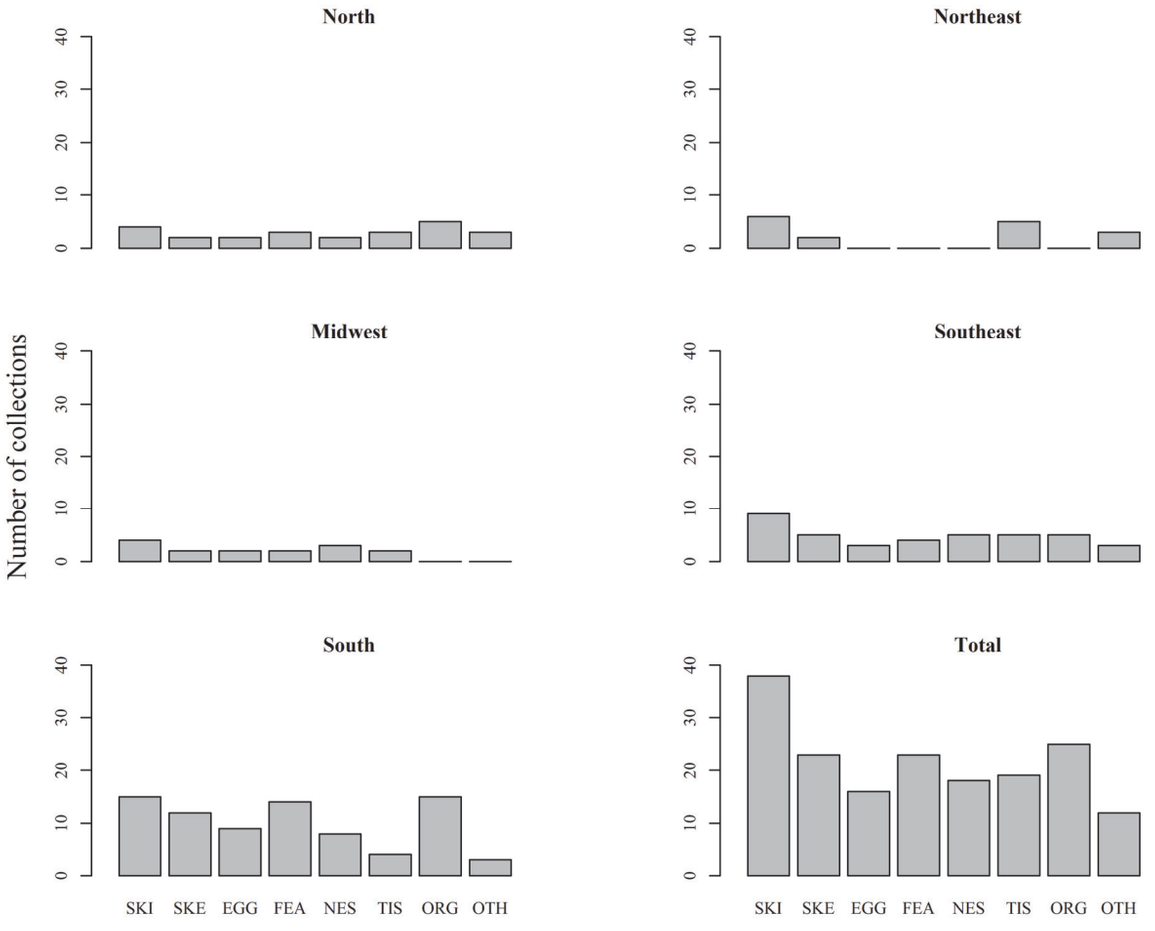

Figure 2. Types of ornithological materials available in collections by Brazilian region. Abbreviations: SKI – skin, SKE – skeleton, EGG – egg, FEA – feathers (feathers and open wing), NES – nest, TIS – tissue, ORG – organs (gonads, eyes, tongue, syrinx and gizzard), OTH – others (specimens in liquid, stomach contents, photo, video, claw, endo- and ectoparasites). Original data is presented in Table 3.

Table 2. Information on the 35 Brazilian ornithological collections that answered the questionnaire in full, and comparisons with the data provided by Aleixo & Straube (2007). Collections are sorted by current number of specimens. Collection acronyms are listed in Table 1. Region: N – north, NE – northeast, CO – midwest, SE – southeast, S – south. Geographic scope: S - State, R – Regional, B - Brazilian, SA – South America, W - Worldwide. Biome: Am – Amazon, Ce – Cerrado, Ca – Caatinga, Af – Atlantic Forest, Pt – Pantanal, P – Pampas, C - Coastal. The data in parentheses are from Aleixo & Straube (2007), different from the current data received.

Collection	Region	Foundation year	Number of specimens		Growth (%)	Number of type specimens		Geographic scope	Biome
			Aleixo & Straube (2007)[1]	This study		Aleixo & Straube (2007)[1]	This study		
MZUSP	SE	1897 (1898)	83,400	104,000	20	140	150	SA, W	Af, Ce
MPEG	N	1895	58.874	90,000	35	80	111	W	Am
MN	SE	1818 (1915)	58,100	60,000	3	n.i.	114	B	Af, Ce
MHNT	SE	1964	5650	11,000	50	-	-	W	Af
MBML	SE	1949	7508	7678	5	22	45	W	Af
DZUFMG	SE	1970	4550	7201#	38	1	-	B	Af, Ce
MHNCI	S	1939 (1930)	6100	6700	10	-	n.i.	R	Af
UFPE	NE	1967	NC	5659	-	NC	2	R	Ca, Af

Collection	Region	Foundation year	Number of specimens		Growth (%)	Number of type specimens		Geographic scope	Biome
			Aleixo & Straube (2007)[1]	This study		Aleixo & Straube (2007)[1]	This study		
COUFMT	CO	1983	NC	5000	-	NC	-	R	Ce, Pt
MCN	S	1955 (1950)	3635	5000	30	-	-	R	Af, P
MCP	S	1997	2365	4689	53	5	25	B	Af, P
MCNA	SE	1984	NC	4100	-	NC	-	B	Af, Ce
COMB	CO	1964 (1965)	2803	4000	31	-	-	R	Ce
INPA	N	2000 (1984)	633	3000	79	-	4	R	Am
NZT	N	1995 (1993)	2315	2577	10	-	-	W	Am, Ce
ZUEC	SE	1989 (1970)	1840	2340	30	-	-	B	Af, Ce
MZUFV	SE	1935 (1932)	1450	1700	16	-	-	R	Af
MZFS	NE	2005	NC	1473	-	NC	-	R	Af
CAHZ	NE	2012 (1976)	155	1428	89	-	-	R	Ca, Af
MMOL	NE	2006	NC	1140	-	NC	-	R	Ca, Af
ANCHIETA	S	1917	NC	1058	-	NC	-	R	Af, P
UNISINOS	S	1870	NC	933	-	NC	-	B, Antarctica	P, C
UFAC	N	2009	NC	800	-	NC	-	R	Am
MHN	NE	2010	NC	800	-	NC	-	R	Ca, Af
CAFURG	S	1980	NC	700	-	NC	-	B	Af, P, C
MUCPEL	S	1997	NC	600	-	NC	-	R	Af, P
MUCIN	S	2011	NC	411	-	NC	-	R	Af, P, C
MCNCS	S	1995	NC	300	-	NC	-	R	Af
MZPUCPR	S	2000 (1978)	378	250	-29*	-	-	S	Af
MuRAU	S	1975	NC	200	-	NC	-	R	P
MCNCR	S	2012	NC	100	-	NC	-	R	Af, P
UNISC	S	2001	NC	100	-	NC	-	R	Af
CHNUFPI	NE	2011	NC	75	-	NC	-	R	Am, Ce
MUZAR	S	2002	NC	70	-	NC	-	R	Af, P
MZUEL	S	2001	NC	70	-	NC	-	R	Af

[1] Sum of number of skins, anatomical collections and exhibition collection.
NC – not considered.
n.i. – not informed.
* negative value, we believe the curator informed us only of skins which did not change since Aleixo & Straube (2007).
# pers. commun. by Marcelo Ferreira de Vasconcelos in 13 November 2017.

for the collection. These collections are generally well-established and can grow constantly because they are independent of the voluntary work. They have researchers and technicians and institutionally guaranteed infrastructure. Most of the collections compared in this work and in the previous study are of this type, as well as the largest and best-rated collections, such as MPEG, MZUSP, MCP, MN, INPA, MCN, MHNCI, MNHT, UFPE and MBML (Tables 2 & 3, Fig. 1).

The largest Brazilian collection (MZUSP) and the oldest (MN), in addition to other collections over 50 years old, are from the southeastern region. This region concentrates almost 60% of the ornithological collections of Brazil, with the youngest collection (MCNA) having more than 30 years. In contrast, the collections from northeastern Brazil are the youngest ones on average (Fig. 1). The collections of MZUSP and MN together have more than 250 type specimens of birds, exemplifying

their importance, although they are restricted to researchers until the present and their database is only partially computerized (see ranking, Table 3). Until 2015, 15 (40%) of the 38 collections analyzed were fully digitalized (CAFURG, CAHZ, CHNUFPI, DZUFMG, MBML, MCN, MCNA, MHN, MHNCI, MOVI, MPEG, MZFS, NZT, UNISINOS, ZUEC), 17 (45%) were partially digitalized, and only six (16%) were not digitized. In addition, four (11%) are available for general public consultation, 14 (37%) are restricted to researchers, and half (19) are available for internal use only. Approximately 50% of the 37 collections (35 collections considered, plus MCDB and MOVI) do not make any type of loan, while 35% (13) lend annually few materials (one to six loan proforma invoices). The percentage of collections with more than six documented loans is 15% (Table 3). We found the same pattern regarding visitors, with half of the collections (19) receiving on average one to six researchers annually, and 19% (7) receiving more than 19 researchers per year (Table 3). Finally, as for the published articles using the collection, 54% of them have one to four articles citing them, and about 22% of the collections have 13 or more published articles (Table 3). The MOG collection did not provide information regarding the issues: number of loans, number of visitors and number of published articles. Only one collection (DZUFMG) informed that it does not have a curator.

DISCUSSION

The percentage of questionnaires returned was similar to that of Aleixo & Straube (2007), about 63% in both cases. This aspect suggests that the data compiled portrays most of the bird collections in Brazil and certainly the most important ones. The percentage of responses are higher than the results of the research conducted in 2013 by SiBBr to know the Brazilian scientific collections, whose questionnaire was answered by only 35% of the institutions (SiBBr 2017) and no collections were found in Amapá, Rondônia, Maranhão, Piauí and Goiás states. We verified using forms, internet and bibliographic sources that there are at least 23 Brazilian states and the Federal District with ornithological specimens in their collections; that is, seven more states than in the Aleixo & Straube study (2007). We did not find collections of birds in the states of Roraima, Maranhão and Sergipe only. We found some minor inconsistencies between the data of Aleixo & Straube (2007) and the present data (*e.g.*, acronyms, year of foundation, number of specimens; see

Table 3. Ranking of the most valuable Brazilian ornithological collections according to the criteria considered in this paper. Collection acronyms are listed in Table 1. Region: N – north, NE – northeast, CO – midwest, SE – southeast, S – south.

Collection	A	B	C	D	E	F	G	H	I	J	Total	Ranking	Region
MPEG	1	1	1	1	1	1	0.75	1	1	1	9.75	1	N
MZUSP	1	1	1	1	1	1	0.25	1	1	1	9.25	2	SE
MCP	0.5	1	1	1	1	1	0.75	0.75	0.5	1	8.5	3	S
MN	1	1	1	1	1	1	0.5	0.25	0.5	1	8.25	4	SE
INPA	0.5	0.75	1	1	0.5	1	0.25	1	0.5	1	7.5	5	N
MCN	0.75	0.25	1	0	1	0	0.75	0.75	0.5	1	6	6	S
MHNCI	0.75	0.25	0.5	1	0.5	0	1	0.75	0.5	0.5	5.75	7	S
MHNT	1	1	1	0	0.5	0	0	0.25	1	1	5.75	7	SE
UFPE	0.75	0.5	1	1	0	1	0.25	0.25	0.5	0.5	5.75	7	NE
MBML	0.75	0.5	0.5	0	0	1	1	0.25	1	0.5	5.5	8	SE
COMB	0.5	0.25	1	1	0.5	0	0.5	0.5	0.5	0.5	5.25	9	CO
COUFMT	0.75	0.5	1	0	1	0	0.5	0.5	0.5	0.5	5.25	9	CO
CAHZ	0.5	1	1	0	0	0	0.75	0.5	0.5	0.5	4.75	10	NE
MZFS	0.5	0.5	1	0	0.5	0	0.75	0.5	0.5	0.5	4.75	10	NE
CAFURG	0.25	0	1	0	1	0	0.75	0.25	0.5	0.5	4.25	11	S
MUCPEL	0.25	0	0.5	1	1	0	0	0.5	0.5	0.5	4.25	11	S
MUZAR	0	0	1	1	0.5	0	0.25	0.5	0.5	0.5	4.25	11	S
MZUFV	0.5	0	1	0	1	0	0.25	0.5	0.5	0.5	4.25	11	SE
UFAC	0.25	0.5	1	0	1	0	0	0.5	0.5	0.5	4.25	11	N

Collection	A	B	C	D	E	F	G	H	I	J	Total	Ranking	Region
MCNA	0.5	0.5	1	0	0	0	0.75	0.25	0.5	0.5	4	12	SE
MCNCS	0	0	1	1	0.5	0	0.25	0.25	0.5	0.5	4	12	S
MMOL	0.5	0.5	1	0	0.5	0	0.5	0.5	0.5	0	4	12	NE
MUCIN	0	0.25	1	0	1	0	0.25	0.5	0.5	0.5	4	12	S
NZT	0.5	0.5	0.5	0	0	0	0.75	0.25	1	0.5	4	12	N
UNISINOS	0.25	0	0.5	0	1	0	0.5	0.5	0.5	0.5	3.75	13	S
ZUEC	0.5	0.25	1	0	0	0	0.5	0.5	0.5	0.5	3.75	13	SE
DZUFMG	0.75	0.75	0	0	0	0	0.75	0.25	0.5	0.5	3.5	14	SE
ANCHIETA	0.5	0	0.5	0	0.5	0	0.5	0.25	0.5	0.5	3.25	15	S
MHN	0.25	0.5	1	0	0.5	0	0.5	0	0.5	0	3.25	15	NE
MOVI	n.i.	n.i.	0	0	0.5	0	0.75	0.5	0.5	1	3.25	15	S
MZUEL	0	0	0.5	1	0.5	0	0.75	0	0.5	0	3.25	15	S
MCNCR	0.5	0	1	0	0.5	0	0	0.5	0.5	0	3	16	S
MuRAU	0	0	0.5	0	0.5	0	0.25	0.75	0.5	0.5	3	16	S
CHNUFPI	0	0	0.5	0	0.5	0	0.5	0.25	0.5	0	2.25	17	NE
MCDB	n.i.	n.i.	0	0	0	0	0.25	0.5	1	0.5	2.25	17	CO
MZPUCPR	0	0	1	0	0	0	0.25	0.25	0	0.5	2	18	S
UNISC	0	0	0.5	0	0	0	0	0	0.5	0.5	1.5	19	S
MOG	n.i.	n.i.	0	0	0.5	0	0	n.i.	0.5	n.i.	1	20	CO

Avaliation Criteria:
(A) Total size of the collection - 1, greater than 10,000 specimens; 0.75, from 5,000 to 10,000 specimens; 0.5, from 1000 to 5000 specimens; 0.25, from 500 to 1000 specimens; 0, less than 500 specimens;
B) Relationship between the total number of specimens/total years of existence (*i.e.*, annual growth rate) - 1, more than 200 specimens, 0.75, between 200 and 150 specimens; 0.5, between 150 and 100 specimens; 0.25, between 100 and 50 specimens; 0, less than 50 specimens;
(C) Curator - 1, presence of a curator and/or professional ornithologist in the collection (based on *Lattes* CV; www.lattes.cnpq.br); 0.5, without a curator but with a head researcher with a degree in any area of Zoology, based on the *Lattes* CV; 0, Museum general manager, even with an academic degree in a different area or who answered "no curator" in the questionnaire;
(D) Taxidermist - 1, presence of a taxidermist; 0, absence of a taxidermist;
(E) Diversification of the Collection - 1, six or more preparation forms (*e.g.*, skins, skeletons, tissues, nests, eggs, carcasses, syringes, stomachs, etc.); 0.5, between three and five types of preparation; 0, only one or two types of forms;
(F) Presence of type specimens reported (*e.g.*, Holotypes, Paratypes, Syntypes) - 1, presence; 0, absence;
(G) Average proportion of digitalization of the collection, such as: total digitalization (1), partial digitization (0.5) and non-digitalization (0), and the availability of the database to the public (1), to researchers (0.5), or only to the internal public (0);
(H) Average between the number of visits/year (1, more than 13 visits; 0.5, 1 to 12 visits; 0, no visit) and the number of loans per year (1, more than 12 loans; 0.5, 12 loans; 0, no loans);
(I) Geographical representativeness of the collection - 1 (Global); 0.5, regional (Brazil, regions); 0, state where the collection is located;
(J) Known citations of the collection in scientific articles - 1, 13 or more articles; 0.5, 1 to 12 articles; 0, no articles.
n.i. = not informed.

Tables 1 & 2); these must follow from the broad character and the simplified format of the general questions of our questionnaire, to minimize the time spent by the interviewee.

Corroborating the previous study, the southeastern and southern regions continue to be those with the highest number of ornithological collections, 39 of the 59 collections (approximately 66%). This result was expected due to the oldest and most traditional research in ornithology being located in southeastern Brazil, being the home of great ornithologists and bird collectors since the late nineteenth century, such as Herman von Ihering (MZUSP), Olivério Mário de Oliveira Pinto (MZUSP), Helmut Sick (MN), Emilie Snethlage (MN, besides MPEG), and Augusto Ruschi (MBML), among others. Another aspect to consider is the bias arising from the authors of this paper being from southern Brazil, which have more detailed knowledge of the collections of that region. Larger collections (MPEG, MN and MZUSP) also have the largest number of type specimens, around 375, approximately 83% of those in Brazil. Two other collections are worth mentioning in terms of the number of registered specimens - INPA and MCP - since they are relatively recent collections (up to 20 years since their foundation), with about 8000 specimens in total and 30 type specimens until 2015. There are some young

collections in the midwestern and northeastern regions of the country, which is desirable to improve the knowledge from such parts of the country and especially from the Pantanal, Cerrado and Caatinga Biomes.

As already reported in Aleixo & Straube (2007), few ornithological collections have projects aimed at scientific collections of specimens, and for this reason, the growth of these collections fluctuates. Several collections obtain specimens through donations, road kills, and studies using capture/release of birds, or specific taxonomic projects. In the previous diagnosis (data from 2005; Aleixo & Straube 2007), the Brazilian ornithological collections had problems of administration, infrastructure, maintenance and organization. They suggested at least five measures to overcome the obstacles faced by Brazilian ornithological collections, which made difficult for them to expand, diversify and modernize them: (1) development of institutional programs that can fund basic improvements and infrastructure; (2) professional training of people in curation, taxidermy and data digitalization; (3) create specific funding to finance publishing periodicals (*e.g.*, about collecting and taxidermy manuals), staff and student training, digitalizing data and other tasks related to curate of specimens and other aspects of ornithological collections; (4) funding proposals that guide the inventory and collection of ornithological specimens; and (5) regulation of the use of firearms by zoologists in scientific collections of specimens. In this regard we observed the follow issues. Only 12 (32%) of the 38 collections have a hired or resident taxidermist, which is not a higher value than that reported by Aleixo & Straube (2007), who mention that taxidermists exist in 45% of the 22 collections considered. The percentage of total digital data, however, increased from 18% to 40% and there was a decrease from 60% to 45% in the number of collections with only partially digital data, but the number of collections studied here is higher. These data are quite favorable when compared to 10 years ago, where there was no collection available online. The data digitalization is the first step in making data available to use, which means a great step forward in the advancement of knowledge. Such a task is easier for younger collections than for those that are older and larger. Perhaps for this reason, most digitalized collections are small or medium sized and bigger collections, with exception of MPEG, are still in the process to digitalizing. Two of the four collections with complete data digitalization in Aleixo & Straube (2007) are now available on the Internet (MPEG and MBML), which we considered a limited advance. Only a few collections are partially available to the public (CRAR, COUFMT, IAL, MCP, MHNCI, MZUEL, ZEE-AVI, ZUEC) despite availability of data being a requirement of support by government development agencies (CNPq, Agency of the Ministry of Science and Technology of Information and Communication [MCTIC]), and in spite of initiatives involving the digitalization of the collections. This involves a paradigm shift in the use of collections and of initiatives of global knowledge of biodiversity such as the Systematic Agenda, whose mission was to understand the role of systematics in biology, education and politics (Claridge 1995, Lane 1996, Systematics Agenda 2000). An example of this is the CRIA (*Species*Link) project, created in 2001, which integrates programs for managing collections around the world, such as the Specify Program, which has existed for 30 years.

Approximately 76% of the collections have up to eight publications citing specimens in their holdings, which may be a consequence of the expansion of the postgraduate courses in Zoology, improvement of Zoology courses according to the evaluation criteria used by "CAPES" (Coordination of Improvement of Higher Education Personnel), as well as an increase in the impact factors of journals in this area. Such aspects are among the main accomplishments made by collections since the publication of Aleixo & Straube (2007). Advances were also found in licenses to collect specimens with the use of digital systems of Sisbio (Information System of Brazilian Biodiversity) that allowed curators to handle quickly a permanent collecting license in the whole national territory. An amendment to the Brazilian national firearms control statute (PL 3722/12) is under analysis in Congress, and, if approved, will give every citizen the right to carry firearms, and in the case of biologists using guns for scientific purposed, registration will be with the Brazilian Army and will be valid for 5 years, being renewed in succession.

Regarding the new classification ranking of the collections we propose, large national collections also face problems related to the maintenance of the collection and there is little difference of quality among Brazilian collections. Twelve collections have reached a grade higher than 5 (from a 0 to 10 scale) and most of the collections have intermediate marks (between 4 to 5) (Table 3). Although most of the better-ranked collections are in the southeast and southern Brazil, it is in the northern Brazil that we find the best classified Brazilian collection (MPEG) according to our ranking system. This is due to the criteria used, which are not based solely on the number of species and representativeness of the collection, but also on their use and availability to the scientific community and the public.

Finally, we conclude that the Brazilian ornithological collections expanded the number of specimens recorded in the last 10 years by about 28% and the general use and issues related to maintenance and access had limited improvements in comparison with Aleixo & Straube (2007). We consider that the number of collections in Brazil is adequate, since it covers most states in the country. We recommend the improvement of the current

active collections instead of creating more collections. An exception to that would be the states where collections do not exist. There is still a shortage of projects and funding for collections in Brazil, and this requires a better understanding of the importance of scientific collections and where resources should be applied. Therefore, we suggest that improvement in personal, financial and logistical issues and the proper recognition of the active collections as a means of biodiversity conservation is still necessary in Brazil. Among the many benefits of collections cited here, we also highlight their relevance in supporting studies on bird ecology, understanding climate change and population declines, as well as habitat loss. Even field guide illustrators are dependent on the specimens of the collections (Joseph 2011, Cavarzere *et al.* 2017).

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APPENDIX I

Questionnaire sent to curators/managers of 59 Brazilian bird collections, in October 2014 and from January to March 2015.

Name of curator or manager

Name of Institution

Collection acronym

1. Year of collection's foundation

2. Approximate number of listed specimens

3. Presence of taxidermist (if there is a taxidermist hired)

a. Yes b. No

4. Nature of deposited material

a. Egg b. Feathers c. Skeleton d. Skin (taxidermy specimens)

e. Nest f. Tissue (muscle of the chest, heart, kidneys and liver)

g. Gonads h. Eyes i. Tongue j. Syrinx

k. Gizzard l. Open wing m. Other:

5. Presence of type specimen

a. Yes b. No

6. If yes, how many type specimens

7. Geographic scope of collection

a. Regional b. Brazilian c. Other:

8. Digitalization of the collection

a. No b. Partial c. Total

9. Digitalization is available

a. General public b. Restricted to researches c. Intern use

10. Number of annual loan documents

a. None b. 1 to 6 c. 7 to 12 d. 13 to 18

e. 19 or more f. We do not make a loan

11. Average annual visits to the collection

a. None b. 1 to 6 c. 7 to 12 d. 13 to 18 e. 19 or more

12. Number of published articles citing collection

a. None b. 1 to 4 c. 5 to 8 d. 9 to 12 e. 13 or more

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SHORT-COMMUNICATION

Breeding of the Greenish Schiffornis (*Schiffornis virescens*, Tityridae)

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ABSTRACT: Like several Neotropical bird species, the breeding biology of the seven species of *Schiffornis* (Tityridae) is poorly known. Only three of these species have some aspects of their breeding biology described. This study provides description of two rare unreported clutches of the Greenish Schiffornis (*Schiffornis virescens*) housed for more than a century in the egg collection of Museu de Zoologia (MZUSP). Also, we estimated the nesting period for the species based on several scattered evidences of breeding, and compared the data with other Tityridae. Clutch size is of two or three, and museum eggs measure 2.13 ± 0.13 × 1.65 ± 0.08 cm (n = 4). Egg shape varied from oval to elliptical. The breeding season of the Greenish Schiffornis lasts at least between October and February, a known breeding period of forest birds from its distribution range. The still scarce breeding evidences for *Schiffornis* species and their close relatives call for further field studies, especially when considering the debatable phylogeny of the group.

KEY-WORDS: clutch size, egg measurements, nest, nesting, reproduction.

Our knowledge of the breeding biology of several Neotropical bird species are still lacking or incomplete (Heming *et al*. 2013, Crozariol 2016a). The genus *Schiffornis* (Tityridae) currently presents seven species (Remsen-Jr. *et al*. 2016) with most aspects of their breeding biology still poorly known (Skutch 1969, Sick 1997, Snow 2016). Formerly considered Pipridae, *Schiffornis* is presently included in Tityridae, placed in a clade with *Lanisoma* and *Laniocera* (Prum & Lanyon 1989) in the subfamily Laniisominae (Barber & Rice 2007, Tello *et al*. 2009) or Schiffornithinae (Ohlson *et al*. 2013).

Nearly all our knowledge about the breeding biology of the genus consists on a few nests described from three of the seven species. For other two species, the Foothill Schiffornis (*Schiffornis aenea*) and the Russet-winged Schiffornis (*Schiffornis stenorhyncha*), the breeding biology knowledge are based only on collected birds in breeding condition (del Hoyo *et al*. 2017). There is still no information about the Varzea Schiffonis (*Schiffornis major*) reproductive biology (del Hoyo *et al*. 2017).

The Northern Schiffornis (*Schiffornis veraepacis*) has most of its breeding aspects (egg laying season, nest, clutch, eggs, incubation period, nestling, and provisioning) described in Costa Rica (del Hoyo *et al*. 2017), though it is distributed from south Mexico to west Ecuador. For the Olivaceous Schiffornis (*Schiffornis olivacea*) there are only descriptions of breeding season (based on adult condition), nest, clutch, and eggs from Suriname and Guiana (del Hoyo *et al*. 2017). This species is distributed from southeastern Venezuela, to Guianas and northeastern Brazilian Amazon. The Thrush-like Schiffornis (*Schiffornis turdina*) has nest, clutch, eggs, and incubation and nestling period known from four nests found in Central America (Skutch 1969).

The Greenish Schiffornis (*Schiffornis virescens*) is a resident insectivorous species which inhabits the understory of forests and occurs in central and southeast Brazil, east Paraguay and northeast Argentina (Snow 2016). Sexes have similar greenish plumage and are much alike. The only published report of the Greenish Schiffornis nest was given by Snow (2016): "nest found in Brasília, 19th Dec, a large cup of leaves placed 3 m above ground in upright fork of bush, contained 2 eggs". No additional description or source of information was given. However, this description of the nest differs from most *Schiffornis* nests described so far (reviewed by Crozariol 2016b).

This study reports on two rare clutches housed in the Museu de Zoologia (MZUSP) egg collection, estimates the nesting period for the species based on several evidences of breeding from museums as well as from the literature and the website wikiaves.com.br, and compare all the breeding evidence about the genus.

We visited and searched for eggs in the following egg collections: Western Foundation of Vertebrate Zoology (Camarillo, USA), Natural History Museum (Tring, England), Museum fur Naturkundem (Berlin, Germany), "Nationaal Natuurhistorisch Museum"

(Leiden, Netherlands), Naturhistoriches Museum (Vienna, Austria), National Museums Scotland (Edinburgh, Scotland), Muséum National d'Histoire Naturelle (Paris, France), Natural History Museum - Smithsonian Institution (Washington, USA), Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (Buenos Aires, Argentina), Museu de La Plata (La Plata, Argentina), Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (Villa de Leiva, Colombia), and in Brazil, Museu de Zoologia-USP (São Paulo), Museu Nacional (Rio de Janeiro), Museu Paraense Emilio Goeldi (Belém), Coleção Ornitológica Marcelo Bagno (Brasília), Museu de Ciências e Tecnologia da PUCRS and Fundação Zoobotânica do Rio Grande do Sul (Porto Alegre). We also visited the online egg collections of the Field Museum of Natural History (Chicago, USA) and California Academy of Science (San Francisco, USA), and the museum database Arctos Collaborative Collection Management Solution (arctos.database.museum). We measured the eggs of the two clutches found using digital photography (Bridge *et al.* 2007, Troscianko 2014).

We searched for breeding evidence (gonad size) and birds with immature characteristics (fleshy gape or unpneumatized skull, juvenile plumage) on labels and skin specimens at the MZUSP and Natural History Museum. Additionally, we searched the WikiAves website (www.wikiaves.com) on 23–25 March 2016, for photographs of nests, eggs, fledglings and their dates and localities.

We found only two clutches of two eggs each deposited at the MZUSP egg collection. No other Greenish Schiffornis eggs were found elsewhere. The first clutch (eggs 1 and 2 herein) was collected by Ricardo Krone at Itamirim, Iguape, state of São Paulo, Brazil, at an unknown date and labeled as *Scotothorus unicolor* (MZUSP 2675). This clutch was probably collected around (1895–1906), the period that Krone collected another 200 clutches of several bird species, most at Iguape, São Paulo (eggs from MZUSP and NMW). The second clutch (eggs 3 and 4 herein) has no location or date and was labeled as *Heteropelma virescens* (no catalog number). By the condition of the eggs and the data slip, it is also probably from early XX century. Both clutches had light color apparently spotless eggs (though rusted with time) of different sizes and shapes (Table 1). Eggs measured 2.13 ± 0.13 × 1.65 ± 0.08 cm (n = 4). The first clutch had similar eggs but one was narrower, while the second had one egg much smaller (~22%) than the other (n = 4, Table 1).

Table 1. Characteristics of Greenish Schiffornis eggs from MZUSP (eggs 1 and 2 Iguape, SP; eggs 3 and 4 unknown location). Egg length and width were measured in ImageJ (see methods for details).

Egg	Length (cm)	Width (cm)
1	2.23	1.60
2	2.20	1.72
3	2.13	1.71
4	1.94	1.55
Mean	2.13	1.65

The two clutches from MZUSP are in accordance with three additional two-egg clutches for other *Schiffornis* from northern locations. One clutch (MG 426-427) collected by Emile Snethlage at Santo Antônio do Prata, state of Pará, Brazil, on 12 May 1920, had two white eggs. Similarly a clutch (NHM 1952-8-421) collected by T.A.W. Davis at Mahaicony River, Guyana, on 22 April 1934, had two fresh white eggs. Lastly, a clutch of the Northern Schiffornis *Schiffornis veraepacis veraepacis* (MVZ-Berkeley 14376) collected by Prentis T. Burtis at Rio Chalchijapa, Vera Cruz, Mexico, on 3 April 1961, also had two fresh eggs (average size 17.9 × 24.3 mm).

Photos of a nest of the Greenish Schiffornis with three eggs were taken on 18 December 2008 (Table 2) (Wikiaves, WA36059, by A. Bianco). This is in accordance with the three recently described three-egg clutches found in October at Misiones, Argentina (Bodrati & Cockle 2017), but not in accordance with the reports of two eggs from the two MZUSP clutches, the published report by Snow (2016) or the number of eggs reported for Thrush-like Schiffornis (Skutch 1969), Northern Schiffornis, and Olivaceous Schiffornis (del Hoyo *et al.* 2017). The larger clutches from southern locations (Santa Catarina, Brazil and Misiones, Argentina) compared to the northern ones (Skutch 1969, Snow 2016, del Hoyo *et al.* 2017) might be explained by a latitudinal increase in clutch size (Jetz *et al.* 2008, Heming & Marini 2015).

An analysis of 58 skins from MZUSP revealed that a young female with 50% pneumatized skull was caught on 26 November 2011 and a young male with 20% pneumatized skull was caught on 13 March 2012 both at São Paulo state, Brazil. Also, a young male with beak commissure was caught on 17 December 2011 at the state of Minas Gerais, Brazil. Males had developed testes (8 × 11 and 6 × 8 mm) on 16 November 2005 and 25 November 2011, respectively, also at São Paulo state.

When considering all the reproductive evidence we found, the breeding period of the Greenish Schiffornis lasts at least from October to February, a common period of breeding of forest birds in its distribution range in Brazil (Marini & Durães 2001, Marini *et al.* 2007, Repenning & Fontana 2011, Maurício *et al.* 2013, Marques-Santos *et al.* 2015). Also, a photo of a fledgling perched in a branch taken on 29 February 2013 at Caraguatatuba, São Paulo state (WA 585213, by M. Nema) (Table 2), is in agreement with this breeding period. The Northern Schiffornis lays eggs from February to August in several

Table 2. Date, location, stage, collection number, and author name of Greenish Schiffornis egg and fledgling records.

Day	Month	Location	Latitude (S)	Longitude (W)	Stage	WikiAves/ Museum ID	Author
-	-	-	-	-	Eggs	MZUSP no number	-
-	-	Iguape, SP, Brazil	24º	47º	Eggs	MZUSP 2675	R. Krone
3–6	10	San Pedro, Misiones, Argentina	26º	54º	Eggs	-	Bodrati & Cockle (2017)
18	12	Urussanga, SC, Brazil	28º	49º	Eggs	WA36059	A. Bianco
19	12	Brasília, DF, Brazil	15º	47º	Eggs	-	Snow (2016)
29	02	Caraguatatuba, SP, Brazil	23º	45º	Fledgling	WA585213	M. Nema

countries in the Northern Hemisphere (del Hoyo *et al*. 2017). The Olivaceous Schiffornis is suggested to breed from August to September (adults in breeding condition), but a nest with eggs was found in April in Guyana (del Hoyo *et al*. 2017). Adults in breeding condition of Foothill Schiffornis were collected in March and June in east Ecuador and of Russet-winged Schiffornis from January to June in north Colombia (del Hoyo *et al*. 2017).

We found no nests at museums, but the description of nests by Bodrati & Cockle (2017) is similar to the nest in the photo published at Wikiaves, but both differ from the description given by Snow (2016). The nests described by Bodrati & Cockle (2017) are much lower (0.43–0.64 m above ground) and though not inserted in cavities, were laterally protected by petioles of tree ferns. Similarly to Wikiaves reports, a nest of the Thrush-like Schiffornis (NHM 1952-8-421) collected by T.A.W. Davis at Mahaicony River, Guyana, was built in a palm cavity. The Northern Schiffornis eggs collected by Prentis T. Burtis in Mexico (MVZ-Berkeley 14376) were in an open nest built entirely with dried leaves lined with black strands, 1.8 m up in a small palm.

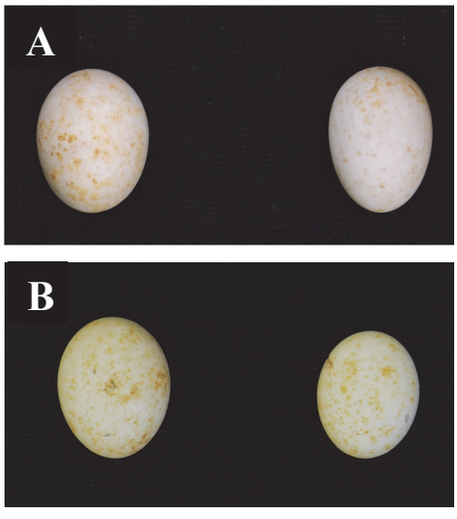

Figure 1. Greenish Schiffornis eggs from (**A**) Itamirim, Iguape, state of São Paulo, Brazil (MZUSP 2675, eggs 1 and 2) and (**B**) unknown location (MZUSP no catalog number, eggs 3 and 4).

Similarly to descriptions of *Schiffornis* nests and eggs, the Cinereous Mourner (*Laniocera hypopyrra*) nest consists of a bulky cup made of dry leaves (Londoño & Cadena 2003). The breeding evidence summarized above (nest type, clutch size and egg color and markings) supports the hypothesis of closer relationship between *Laniocera* and *Schiffornis* (Prum & Lanyon 1989, Barber & Rice 2007, Tello *et al*. 2009, Ohlson *et al*. 2013), and that several of these characteristics are homologous.

Considering all the above, the breeding of the Greenish Schiffornis is similar to that of the Thrush-like Schiffornis and the Northern Schiffornis. The Greenish Schiffornis seems to build its nest in a similar way to the Thrush-like Schiffornis, but at more variable heights (~0.5–3 m, n = 5) than it (~1.1–1.5 m, n = 4). Since clutch size, date and location (one clutch) from the MZUSP records are unknown, it makes difficult further comparisons between these clutches and the other records. The still scarce breeding evidences for *Schiffornis* species and their close relatives (Shrike-like Cotinga *Laniisoma elegans*, Speckled Mourner *Laniocera rufescens* and the Cinereous Mourner) call for further field studies, especially when considering its debatable phylogeny.

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SHORT-COMMUNICATION

Nest, eggs and reproductive behavior of Greenish Schiffornis (*Schiffornis virescens*)

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ABSTRACT: *Schiffornis* (Aves: Tityridae) includes seven species of Neotropical forest birds whose breeding biology is poorly known. We studied three nests of Greenish Schiffornis (*Schiffornis virescens*) in the Atlantic Forest of Misiones, Argentina. Nests were bulky cups of dead leaves and other vegetative fibres, lined with *Marasmius* rhizomorphs and fine rootlets. They were attached laterally to tree fern (*Alsophila procera*) stems, supported from below, and camouflaged by abundant epiphytes and tree fern petioles. Each contained three eggs, which were creamy white speckled with chestnut. Only one adult was seen to incubate, with on-bouts of 65, 69 and 89 min, and off-bouts of 18, 25 and 28 min. Two nests were depredated at the incubation stage, and the third was not followed. Considering that no *Schiffornis* nest has been followed to fledging, we strongly encourage researchers and bird watchers to be alert to *Schiffornis* flushing in the understory, and to follow nests to completion whenever possible.

KEY-WORDS: Atlantic Forest, clutch size, cup nest, incubation, uniparental care.

After a long history of being transferred among various oscine families, the genus *Schiffornis* has been placed in the family Tityridae on the basis of morphology, life history, and genetics (Prum & Lanyon 1989, Barber & Rice 2007). *Schiffornis* includes seven species endemic to the Neotropics (Remsen-Jr. *et al*. 2017). Reproductive biology has been studied only for the Northern Schiffornis (*Schiffornis veraepacis*; Skutch 1969, Snow 2004).

The Greenish Schiffornis (*Schiffornis virescens*) is endemic to the Atlantic Forest of southeastern Brazil, eastern Paraguay, and northeastern Argentina (province of Misiones and extreme north of Corrientes), where it inhabits the forest understory and midstory (Saibene *et al*. 1996, Snow 2004, de la Peña 2016, pers. obs.). Snow (2004:169) mentions a single record of a nest "found in Brasília, 19th Dec, a large cup of leaves placed 3 m above ground in upright fork of bush, contained 2 eggs", but Crozariol (2016) doubted the species identification and we could not trace the original source. Based on a review of museum collections and on-line photos, Marini & Heming (2017) place the breeding season between October and February, and report two sets of two eggs, which they describe as "light color apparently spotless", probably collected around 1900 and possibly discolored. Saibene *et al*. (1996) and Bodrati *et al*. (2010) mentioned that the species breeds in Misiones, but without providing details. Here, we contribute a detailed, first-hand description of the nest, eggs, and adult behavior during incubation.

We studied nests at Parque Provincial Cruce Caballero, San Pedro, Misiones, Argentina (26°31'S; 54°00'W; 550–600 m a.s.l.), where the Greenish Schiffornis is an abundant resident of primary and secondary forest (Bodrati *et al*. 2010). The vegetation is mixed Atlantic Forest with laurel (Lauraceae), Guatambú (*Balfourodendron riedelianum*) and Paraná Pine (*Araucaria angustifolia*; Cabrera 1976), and annual rainfall is 1200–2400 mm distributed evenly throughout the year. We found nests of Greenish Schiffornis while conducting a site inventory and other bird studies from 2003 to 2016 (*e.g.*, Bodrati *et al*. 2010, Cockle *et al*. 2017). We measured eggs using callipers and nests using a measuring tape. We watched one of the nests (nest 3) for 7 h 46 min during the incubation period (Table 1). We collected this nest after it failed, and deposited it at Museo de la Plata. We used R version 3.2.2 (R Core Team 2015) for statistical analysis.

We found three nests, all well-camouflaged within the shady understory of tree fern (*Alsophila procera*) patches in primary forest, more than 800 m from the nearest edge (Table 1). All were bulky cups of leaves and fibers, considerably larger than the adult bird, loosely

Table 1. Nests of Greenish Schiffornis (*Schiffornis virescens*) in Parque Provincial Cruce Caballero, Misiones, Argentina.

	Nest 1	**Nest 2**	**Nest 3**
Date found	5 Oct 2010	3 Oct 2011	6 Oct 2014
Height above ground (cm)	43	64	48
External height of nest (from rim to bottom; cm)	16	17	15
External (horizontal) diameter (cm)	10 × 8	9 × 8	10 × 8
Internal depth (cm)	10	10	9
Internal diameter (cm)	7 × 8	7 × 6	7 × 6
Clutch size	3	3	3
	24 × 18	24 × 17	23 × 16
Egg measurements (mm)	23 × 16	23 × 15	23 × 17
	22 × 16	23 × 16	24 × 16

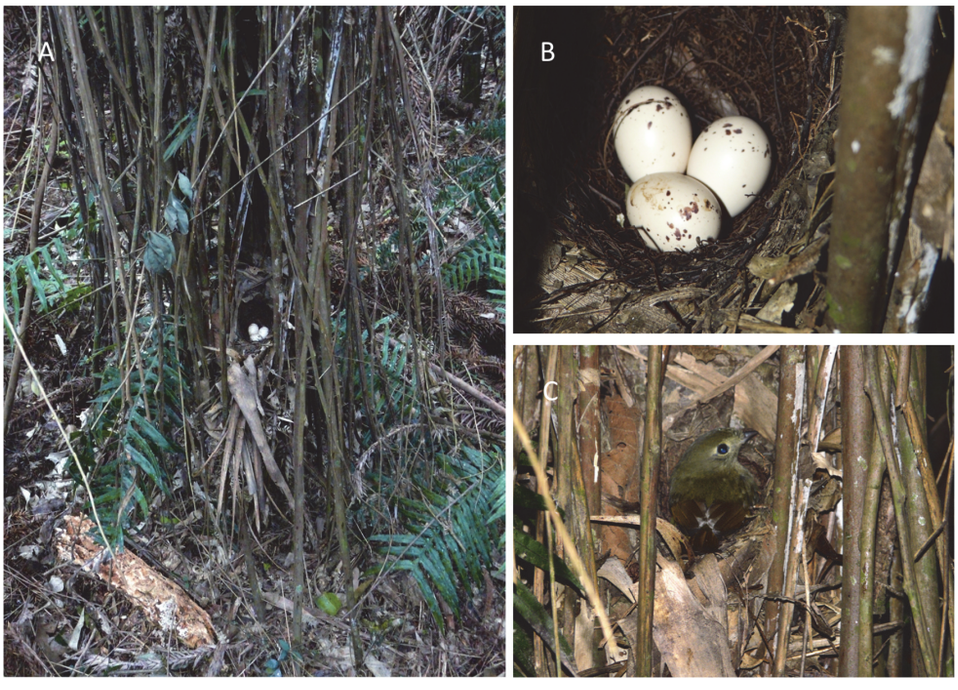

Figure 1. Nest 3 of Greenish Schiffornis (*Schiffornis virescens*) in Parque Provincial Cruce Caballero, Misiones, Argentina, on 8 October 2014. (**A**) Nest is attached laterally to a tree fern and sits on a large dead epiphytic bromeliad, within a curtain of dead tree fern petioles. Note inclination of nest toward the photographer and away from the stem of the tree fern. (**B**) Complete clutch of three speckled eggs. (**C**) Incubating adult in typical position, facing the tree fern. Photo author: Marcos Cenizo.

attached laterally to the stems of tree ferns and supported underneath by epiphytes (Figs. 1 & 2). All were inclined noticeably outward, with the nest cup facing away from the stem of the tree fern. Although nest interiors were well constructed of woven fibres, the outer portion of the nest, constructed of larger plant material, was loose, and the nests moved slightly when touched.

Nest 1 was wedged between a living tree fern and a second, partly fallen, dead tree fern. This nest was very well hidden by the dead petioles of the living tree fern and by the epiphytic ferns that grew from its stem. Nest 2 was attached laterally to a tree fern and rested on an accumulation of epiphytic bromeliads and ferns that grew from the tree fern stem. Nest 3 sat on an accumulation of dead epiphytic bromeliads (*Tillandsia* spp.) attached to a tree fern, and was well hidden behind the curtain created by the tree fern's pendant dead petioles (Fig. 1).

Nest materials were similar for all three nests, but we only examined them in detail for nest 3. The outer part of the nest was formed of loosely woven bamboo (*Merostachys* spp. and *Guadua trinii*) culm sheaths; leaves of *Merostachys* spp., *Alchornea triplinervia*, and laurels (Lauraceae), including several leaf skeletons; whole inflorescences; pieces of tree fern petioles; and leaf rachises. This outer cup was lined with a pad of black *Marasmius* rhizomorphs, which was further lined, up to the edge of

the cup, with a woven mat of fine brown roots, tree fern fibers, a few leaf skeletons, and a few lichens.

All nests contained three (incubated) eggs, which were creamy white, speckled with reddish chestnut, and measured 23 ± 0.2 × 16 ± 0.3 mm (mean ± SE; Table 1, Fig. 1B). The speckles were accentuated toward the larger end, forming an open wreath. These eggs were similar in width (Wilcoxon Rank Sum Test, W = 15.5, P = 0.75) but significantly longer (W = 34.5, P = 0.01) than the four "apparently spotless" century-old eggs reported by Marini & Heming (2017).

We only ever saw one adult at any nest. When on the nest, the incubating adult always faced the tree fern stem (Fig. 1C). When completing an incubation bout, it flew about 30 m, sang, and was answered by another adult (presumably the pair). We sometimes heard this other adult singing 20–100 m away, but it never approached the nest. When we approached the adult on the nest, it would flush and perform a distraction display, as if injured. As time went by, we could get very close (40 cm), and the adult would remain on the eggs, flattening its body against the nest. At nest 3 we observed three complete incubation bouts, on 9, 10 and 12 October 2014. On-bouts lasted 65, 69 and 89 min, and off-bouts lasted 18, 25 and 28 min.

We visited nest 1 only once, so its fate is unknown. Nests 2 and 3 were found empty and deteriorated on 6 October 2011 and 14 October 2014, respectively, and were presumed to have been depredated.

We observed fledglings at Parque Provincial Cruce Caballero twice. On 16 November 2008 we observed an adult feeding a juvenile, which had a tail about ¾ the length of the adult's tail and pale pink-yellowish gape flanges. On 3 November 2012 we observed an adult capturing larvae in the forest understory, feeding two juveniles which emitted short calls when the adult approached them. The juveniles remained perched on two adjacent branches about 2 m high, hidden under a plant. When the adult fed one chick, the other flew clumsily to the same branch. These fledglings had yellow gape flanges (pink nearest the bill and at the base of the lower maxila). Their tails were half as long as the adult's tail.

Overall, Greenish Schiffornis was very similar to Northern Schiffornis in nest structure, nest placement, egg size and coloration, and parental care (Skutch 1969). Similar to Greenish Schiffornis, Northern Schiffornis builds a bulky cup nest of leaves and other fibers, lined with fungal rhizomorphs and/or rootlets, and attached laterally to a sturdy stem (small tree or palm), with its base resting on some other structure (epiphytes, crisscrossed stems and vines, or the abandoned nest of another bird; Skutch 1969). Nests of the Greenish Schiffornis were, however, deeper (9–10 cm) than those of Northern Schiffornis (4–6 cm; Skutch 1969). Clutch size of Greenish Schiffornis (3) was larger than that of Northern Schiffornis (1–2; Skutch 1969), consistent with the general pattern that avian clutch size increases with latitude (Lack 1948, Jetz *et al*. 2008). Similar to our observation that only one Greenish Schiffornis parent appears to incubate, Skutch (1969) noted that the Northern Schiffornis fails to pair, and the male pays no attention to the nest. He also noted that the incubating female became more confident as the incubation period progressed, consistent with our observations of Greenish Schiffornis.

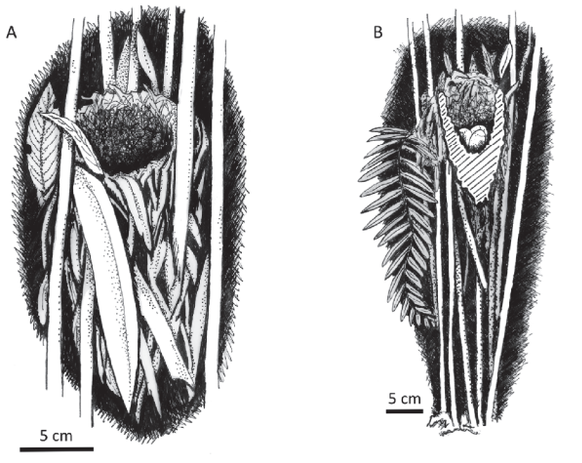

Figure 2. Nest 3 of Greenish Schiffornis (*Schiffornis virescens*) showing (**A**) close-up and (**B**) cut-away view with eggs. Illustration author: Luis Pagano.

Unfortunately, we were unable to study the nests of Greenish Schiffornis beyond the incubation period. Length of incubation period, nestling development and parental care of nestlings remain unknown. Furthermore, although Skutch (1969) was able to study part of the nestling period in Northern Schiffornis, he was unable to follow any nest until fledging, which means that the nestling period and late-nestling development remain unknown for any species of *Schiffornis*. Considering that nests have only been partially studied, and only for two of the seven *Schiffornis* species, we strongly encourage researchers and bird watchers to be alert to *Schiffornis* flushing suddenly in the understory, and to study their nests as long as possible, whenever the chance arises.

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ARTICLE

Twenty years later: an update to the birds of the Biological Dynamics of Forest Fragments Project, Amazonas, Brazil

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ABSTRACT: Although species lists from throughout Amazonia have become available, relatively complete inventories based on long-term work remain rare. Longitudinal comparisons at well-studied sites provide the best opportunities for describing communities and identifying changes in regional avifaunas. Within central Amazonia, no region has received as much consistent ornithological coverage as the *terra firme* forests north of Manaus, Brazil, at the Biological Dynamics of Forest Fragments Project (BDFFP). Here we provide an updated list of the area, including notes on all species added between 1997 and 2017. We recorded 21 species new for the site, most of which (>75%) are birds that prefer *várzea* or second-growth forest. This brings the cumulative BDFFP list up to 409 species, the majority (66%) of which inhabit primary *terra firme* forest. Together, this confirms that the regional *terra firme* community had been well-characterized by the 1990s, and that species additions to the list over the last 20 years are consistent with a changing landscape as urbanization, agriculture, and second-growth spread from Manaus. The final product continues to represent the most complete avian inventory for a single site in all of lowland Amazonia.

KEY-WORDS: Amazon, avifauna, inventory, Neotropics, *terra firme*.

INTRODUCTION

Although published species lists from throughout Amazonia have become increasingly available [for example, see a special issue entitled "Bird surveys in the Amazon" in *Revista Brasileira de Ornitologia* 19(2)], relatively complete, long-term avifaunal inventories – spanning multiple years – are rare. Furthermore, locations that contain updated, longitudinal inventories enabling discussion of changes over time within the avian community or in knowledge are rarer still (*e.g.*, Manu National Park in Peru, and Alta Floresta and the Santarém region in Brazil), and most of these strain the definition of a site, instead covering a broad region or a so-called "sprawling site" (Terborgh *et al.* 1984, Karr *et al.* 1990, Zimmer *et al.* 1997, Lees *et al.* 2013a, b). The extreme paucity of these site-specific avian inventories with longitudinal data, from otherwise remote tracts of rainforest, greatly increases the value of such information.

Within central Amazonia, no region has received more ornithological coverage than the *terra firme* forests north of Manaus and, consequently, the avifauna here is well-described. The first avifaunal survey of the region was published in 1977 (Willis) and included 289 species of birds that had been recorded in the vicinity of the northwestern corner of Reserva Ducke. This list, however, was considered preliminary as it was compiled from ~15 months between 1972 and 1974 (Willis 1977), and, as has become clear from subsequent fieldwork in the region, it takes considerably longer to describe a complete avifauna in such a species-rich ecosystem, especially in an era with very limited access to regional field guides or bird vocalizations. Stotz & Bierregaard-Jr. (1989) studied a nearby site, the Biological Dynamics of Forest Fragments Project (hereafter BDFFP), connected to Reserva Ducke by about 50 km of seemingly similar and unbroken forest all within the same Guianan area of endemism (Cracraft 1985). They summarized seven years of intensive fieldwork at the BDFFP and documented 352 species of birds. Willis (1977) found 32 species at Reserva Ducke that were not recorded at the BDFFP by 1986, despite substantially more effort at the latter site; this difference was largely due to a suite of open and forest edge species that was then restricted to Reserva

Ducke (Stotz & Bierregaard-Jr. 1989). Eight years of additional fieldwork at the BDFFP further diminished this difference, adding another 49 species to the BDFFP list (Cohn-Haft *et al.* 1997). Taking into account various revisions and removals, Cohn-Haft *et al.* (1997) presented a comprehensive checklist of 394 species for the BDFFP, which included all but 16 species documented from nearby Reserva Ducke.

Twenty years have now passed since the last published update (Cohn-Haft *et al.* 1997). Both the physical and ornithological landscape have changed markedly since then. This further allows us to evaluate how much of the difference between successive inventories is a response to the accretion of records accompanying changes in the physical landscape and the passage of time or are instead a product of advancements in field identification criteria, the availability of reliable field guides for the region, accessible regional audio recordings, and an increased resolution of species' distributions and taxonomic relationships. Here we present an updated and annotated list to the birds of the BDFFP, including all species added between 1997 and 2017. The final product represents the most complete avian inventory for a single site in all of lowland Amazonia. Furthermore, this single, comprehensive list consolidates taxonomic and nomenclatural changes that have accumulated during the past two decades.

METHODS

Study area

The BDFFP (2°20'S; 60°00'W) is located ~80 km north of Manaus, Amazonas, Brazil (Fig. 1). The project was initiated in 1979 to help determine the minimum critical size needed to preserve an intact ecosystem and, today, is the largest and longest-running experiment on forest fragmentation (Bierregaard-Jr. *et al.* 2001, Laurance *et al.* 2018). Prior to the late 1970s, the entire study area and surrounding region consisted of virtually unbroken, primary *terra firme* forest, with forest trees dominated by members of the families Lecythidaceae, Fabaceae, and Sapotaceae (Rankin-de-Mérona 1992). Over a period of about 10 years beginning in 1980, three ~15,000 ha cattle ranches (the *fazendas* Dimona, Porto Alegre, and Esteio) were established and then gradually abandoned or operated at low production levels. Thus, the current landscape is still predominantly primary forest, with a relatively small, but intensely studied, mosaic of open pastures, second growth of various heights and ages (from 3 to >30 years), and experimentally isolated forest fragments (for more detailed information about the primary and secondary forest tree communities, see Rankin-de-Mérona 1992 and Mesquita *et al.* 2001, respectively).

The BDFFP is characterized by nutrient-poor soils, supporting a typical canopy height of 25–30 m, although emergent trees can reach as a high as 40 m (C.L.R., unpubl. data). The understory of the forest is relatively open and is characterized by palms. Average annual rainfall in the region is ~2550 mm, as measured at Reserva Ducke over the span of 50 years, with peak rainfall in March and April and the driest months from June through August (L.A. Candido, pers. comm., see also Stouffer *et al.* 2013). The annual cycle here is typically split evenly between a six-month rainy season (December–May) followed by a six-month dry season (June–November).

Sampling

Fieldwork at the BDFFP by ornithologists interested in the comprehensive list has varied in intensity since 1997, with the result that most opportunities for adding new species have been since 2004. Most work from 1997–2004 was in the form of 1–2 months/year, during the dry season, based at ZF-3 KM41 (Fig. 1; Stouffer 2007). This continuous primary forest site offers little habitat variation except for roadsides and two small forest ponds. During the dry seasons of 2000–2002, we also conducted standard-effort mist netting and surveys for particular species of interest in the fragments (Stouffer *et al.* 2009). From 2005 to 2009, year-round, whole-community surveys were conducted at two continuous forest plots (see TEAM [2017] for more information). This work also offered the researchers the opportunity to explore the mosaic of pastures and second-growth of various ages near ZF-3 KM24. From 2007 onward, considerably more research effort was focused on second growth at all three

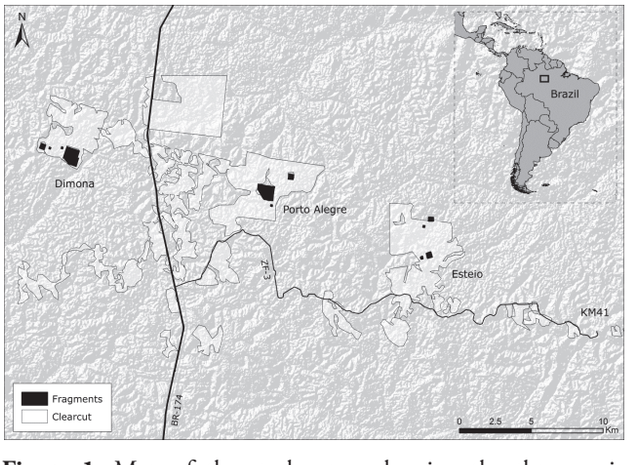

Figure 1. Map of the study area, showing the three main *fazendas* that comprise the Biological Dynamics of Forest Fragments Project, as well as the additional roads and localities mentioned in-text. All 11 forest fragments, ranging in size from 1 to 100 ha, are shown, and the region's digital elevation model is here represented using a hillshade effect. It is important to note that the vast majority of original clearcuts delineated here in this figure have since regenerated.

fazendas, in addition to continuing long-term sampling in fragments and continuous forest, again predominantly during the dry season. Here we report all species added from 1997 to 2017.

Additionally, we update the abundance and habitat codes published in Cohn-Haft *et al.* (1997) to reflect the current status of each species. Although there are now areas of second growth as much as 35 years old, these regenerating forests are converging on a primary forest avifauna (P.C.S., unpubl. data). Thus, to maintain comparability with Cohn-Haft *et al.* (1997), we define secondary forest as relatively early successional forest (*capoeira*), less than 15 years old (the oldest those authors encountered), most of which is currently dominated by *Cecropia* trees. For a few species, the changes in abundance that we present represent genuine changes over time (*e.g.*, declines in some terrestrial insectivores or early successional species), whereas for most it merely represents an increase in the precision of our understanding.

When possible, we documented new records with digital vouchers (or e-vouchers) archived at the Macaulay Library (Lees *et al.* 2014). These are accessible via the Macaulay Library catalog numbers in the text below (*e.g.*, ML51348641); those catalog numbers additionally provide date, location, observer, and a link to a corresponding eBird checklist (*e.g.*, S26343524, which corresponds to http://ebird.org/ebird/view/checklist/S26343524). Taxonomy and nomenclature follow the South American Checklist Committee (Remsen-Jr. *et al.* 2017) for simplicity of comparison with earlier lists from which this taxonomy diverges relatively little.

RESULTS

A total of 409 species representing 57 families have now been recorded from the BDFFP, the majority (270 species; 66%) of which we classified as preferring primary *terra firme* forest (Appendix I). We added 21 species to the list that had not been confirmed prior to 1997 and removed two species based upon updated knowledge (see Identification revisions below). Because of more intensive sampling effort in the latter decade, most new records were added after 2006: 1997 (n = 2), 2006 (n = 2), 2007 (n = 7), 2009 (n = 2), 2015 (n = 3), 2016 (n = 3), and 2017 (n = 1). However, this resolution means that it is impossible to ascertain when exactly a colonizing species may have first arrived at the BDFFP.

Unlike Cohn-Haft *et al.* (1997), we exclusively defined the study area as the BDFFP proper: the three aforementioned *fazendas* along the ZF-3 road. Cohn-Haft *et al.* (1997) also included four species (*Avocettula recurvirostris*, *Chrysolampis mosquitus*, *Accipiter poliogaster*, *Tachyphonus phoenicius*) that had only been registered from the canopy tower along the ZF-2 road 13 km to the south of the BDFFP. Of these, only *A. poliogaster* has subsequently been documented from the BDFFP (17 November 2007 in the Dimona 100 ha fragment). Therefore, for consistency, we remove the three remaining species because they have not subsequently been found at the BDFFP proper.

Records of new species since 1997

Cairina moschata (Muscovy Duck): this widespread Neotropical duck has been found on two occasions at the BDFFP. Open water is limited at the BDFFP, restricted to seven ponds primarily embedded within pasture, although two seasonal ponds are found amidst continuous primary forest (Cohn-Haft *et al.* 1997). P.C.S. found an adult female on 02 July 1997 at the seasonal forest pond and a pair was present on 02–13 August 2010 at one of the pasture ponds (P.C.S. and E.I.J.). Although *C. moschata* prefers a variety of forested wetlands (*e.g.*, rivers, lakes, lagoons), they are known to undergo local or seasonal movements, especially during the dry season (Hilty & Brown 1986, Carboneras 1992). Thus, our records at the beginning of the dry season agree with this pattern, although the majority of fieldwork also occurs during that time of year. Undoubtedly, records are primarily limited by a paucity of this species' preferred habitat (ML75923911).

Bartramia longicauda (Upland Sandpiper): this long-distance migrant from North American boreal breeding grounds has been found only once, during southbound migration. A single bird was discovered on 08 October 2007 in the largest complex of remaining pastures at the project (E.I.J.). The timing of this record is consistent with this species' regional migration phenology: mid-October–mid-November (Ilha da Marchantaria, just upriver from Manaus on the Rio Solimões), September–October (Venezuela), early September–late October (Colombia), and late August–October (Suriname; Haverschmidt 1966, Hilty & Brown 1986, Stotz *et al.* 1992, Hilty 2002). Open habitat is limited at the BDFFP, occurring only near roads and pastures actively used by cattle or horses.

Patagioenas speciosa (Scaled Pigeon): P.C.S. discovered an immature in its first preformative molt (F.P.F.; Johnson *et al.* 2011) on 22 June 2007 in second-growth that appears to have been the vanguard for this species' recent colonization. In recent years (2015–2017), small numbers of *P. speciosa* have continued to be found at the Porto Alegre *fazenda*, especially as eastbound commuters over second-growth forest shortly after sunrise. This includes 3–4 confirmed individuals (25 November 2015 and 30 January 2016), but possibly as many as 9 different birds on the former date. This species uses a variety of forested habitats, including forest borders, old second-growth, and gallery forests, but does not usually inhabit interior *terra*

firme forests (Hilty & Brown 1986, Hilty 2002). It occurs regularly only some 40 km farther north near the town of Presidente Figueiredo, where its preferred *campina* (white-sand) vegetation is more abundant (ML53594681 and ML51348641).

Glaucis hirsutus (Rufous-breasted Hermit): C.L.R. captured a female on 10 September 2015 within a 10 ha fragment (~140 m to the nearest border) and aged the bird as an adult (F.A.J.; Johnson *et al.* 2011) based on bill corrugations (Ortiz-Crespo 1972). *Glaucis hirsutus* is an understory hummingbird in a wide variety of wooded habitats outside of primary forest (Schuchmann 1999); locally, this species is found predominantly in *várzea* and also frequents second-growth and edge habitat (ML51349111 and ML51349121).

Touit huetii (Scarlet-shouldered Parrotlet): although never previously noted in the area, we now have at least 21 records (2006–2013, 2017) from every month between April and December at the BDFFP, without any obvious peak in seasonality. These detections are predominantly auditory and come from continuous primary *terra firme* forest, although the species has also been detected from large 100 ha fragments and once over secondary forest. Additionally, a BDFFP study using autonomous sound recorders in both primary and secondary forest (21–32 years old) registered 60 detections between June and August 2011 (Figueira *et al.* 2015). Although in that study *T. huetii* was easier to detect in primary forest than in secondary forest, there was no difference in probability of use between the two habitats (Figueira *et al.* 2015), and it has even been detected once in the city of Manaus (M.C.H.). The published distribution of this poorly known parrotlet is disjunct, leaving out most of central Amazonia, including the vicinity around Manaus (Collar 1997). However, M.C.H. has now encountered the species in scattered localities throughout the Brazilian Amazon, usually in *terra firme* or black-water flooded forest, especially in regions with a considerable presence of *campina* or white sand habitats. We have no evidence of breeding or even local residence and suspect the species engages in as yet undetermined regional movements, perhaps only passing through the study area. It is likely that this low-density and unobtrusive species has simply been overlooked at the BDFFP prior to 1997 and is not a recent arrival. Thus, it is best treated as part of the "core primary *terra firme* avifauna" at our site (*sensu* Cohn-Haft *et al.* 1997), although its status remains unclear.

Megascops choliba (Tropical Screech-Owl): this common and widespread South American screech-owl has been found sporadically (2007, 2010, 2011, 2016, 2017) in second-growth forests that border pastures and field camps, and it is probably now a resident in low numbers. Detections span three distinct locations at the project, but spontaneous calling has only been recorded during June, July, August, and September. Throughout its range, *M. choliba* is less numerous within interior primary forest, instead preferring more lightly wooded areas such as tall second-growth, borders of *terra firme* and *várzea*, and trees around human settlements (Hilty & Brown 1986, Hilty 2002), but in central Amazonia it appears to be entirely absent from primary *terra firme* (ML59899251).

Hypocnemoides melanopogon (Black-chinned Antbird): although this species was included in the first iteration of the project checklist (Stotz & Bierregaard-Jr. 1989), it was subsequently removed when it became apparent that the single record was outside of the study area (Cohn-Haft *et al.* 1997). However, on 31 December 2016, a female-plumaged bird was heard calling and then seen briefly at dawn before heading in the direction of a forest stream (M.C.H.). This species' occurrence was all the more surprising because it appeared at a remote camp surrounded by extensive *terra firme* forest. *Hypocnemoides melanopogon* chiefly inhabits forests that are tied to stagnant or slow-moving water, predominantly *várzea* or *igapó*, but also gallery forests and *terra firme* where it is not well-drained (Hilty & Brown 1986, Ridgely & Tudor 1994, Hilty 2002, Krabbe & Schulenberg 2003). Thus, this single record appears to refer to a non-territorial, dispersing individual and may represent a rare, long-range dispersal event.

Elaenia flavogaster (Yellow-bellied Elaenia): the most widespread member of its genus, this species has been found at two of the three *fazendas*: on 10 June 2009 in second-growth forest just outside the border of a 100 ha fragment (C.B.A.) and a territorial pair in August–September 2017 at the edge of an active pasture (C.L.R.). Absent from heavily-forested habitats, *E. flavogaster* is found in semi-open areas that include woodland borders, second-growth, scrub, and even parks and gardens (Hilty 2002, Fitzpatrick *et al.* 2004) and appears to be increasing within the city of Manaus, in other nearby settlements, and throughout the central Amazon (Borges *et al.* 2017; ML68467031 and ML68467051).

Sublegatus sp. (Scrub-Flycatcher species): only a single sighting has been registered at the BDFFP on 08 June 2009 (C.B.A.) inside, but near the border of, a 100 ha fragment. It is our opinion that the status and identification of members of this genus within the Amazon are poorly defined. Austral migrant *S. modestus* may appear in the canopy of *terra firme* forest, at least in southern Amazonia, and individuals present (throughout the year?) in *várzea* along the main Amazonian rivers are believed to be *S. obscurior*, and other taxa and vocal types (as yet not clearly distinguished) may be involved. Regional photographs and sound recordings archived in WikiAves (Costa 2008, Padua 2013, Carvalho 2015) provide further support of *S. obscurior*, as this species has been recorded more frequently than *S. modestus* in the region (Manaus and Novo Airão), including from the *terra firme* (Presidente Figueiredo).

Mionectes oleagineus (Ochre-bellied Flycatcher): this subtle flycatcher is strikingly similar to its much more common congener, *M. macconnelli*, and as such, may have been overlooked when Cohn-Haft *et al.* (1997) was published. Potential evidence in support of this is a capture of a putative *M. oleagineus* on 18 December 1991 from a 10 ha fragment; however, as this capture record lacks supplementary details about plumage or soft part coloration used to differentiate it from *M. macconnelli*, we consider this report hypothetical. Subsequently, five individuals have been captured six times, in addition to a single sighting (2007–2009). This species has been exclusively recorded from forest fragments (1 ha, 10 ha, and 100 ha) during July, September, and November. In the vicinity of Reserva Ducke, *M. oleagineus* is confined to second-growth, patchy woodlands, and forest edge, generally avoiding interior *terra firme* forests, which *M. macconnelli* inhabits (Willis *et al.* 1978); this same pattern was also described where the two species are sympatric in Venezuela (Hilty 2002; ML 53618181, ML 53618211, ML 53618221, ML53618291).

Hemitriccus josephinae (Boat-billed Tody-Tyrant): this poorly known endemic resident of the Guianan Shield was first discovered in September 2007, which marked a *c.* 60 km range extension and the southwestern-most outpost for this species' distribution (Cohn-Haft *et al.* 1997, Johnson *et al.* 2010). Intensive fieldwork subsequently resulted in the documentation of at least seven individuals on five territories from 2007–2009, mostly in continuous primary forest (n = 4 territories), but also included a single territory from a 10 ha fragment (Johnson *et al.* 2010). Although all sightings stemmed from *terra firme* forest, habitats were characterized by some level of disturbance or localized seasonal flooding (Johnson *et al.* 2010). This matches the general habitat description of disturbed areas in humid forest for *H. josephinae* – typically vine tangles along treefall gaps and forest edges, but also dense vine tangles in seasonally flooded forest (Ridgely & Tudor 1994, Hilty 2002, Fitzpatrick *et al.* 2004, Robbins *et al.* 2007). This species is one of only a few previously known from *c.* 60 km northeast of our sites, at Balbina, and thenceforth across the Guianan area of endemism (Cohn-Haft *et al.* 1997). We have interpreted this as a microhabitat association with forests with higher topographical relief, the presence of rocks, presumed higher rates of treefall, a more broken canopy, and the presence of more and denser vine tangles. Unlike most of the Guianan species that occur in the BDFFP and in Reserva Ducke, these birds appear to reach their southernmost limit away from the Amazon and Negro Rivers. As such, we suspect that the presence of *H. josephinae* at the BDFFP represents an ephemeral population at the limit of the species' distribution.

Myiophobus fasciatus (Bran-colored Flycatcher): this species has only recently been sighted in the central Amazon (Gomes 2013, 2014, Braga 2014). Thus, it is perhaps unsurprising that C.L.R. found a single individual 05–10 August 2015 along the edge of a small cattle pond in overgrown pasture. *Myiophobus fasciatus* prefers early successional vegetation, such as overgrown pastures, forest borders, shrubby regrowth, hedgerows, and thickets (Hilty 2002). Published distributions show this species to be absent from most of the Amazon Basin, except at the periphery (Ridgely & Tudor 1994, Fitzpatrick *et al.* 2004). With deforestation, the species appears to be colonizing areas within the heart of the Amazon, similar to its expansion into historically forested regions in Colombia (Hilty & Brown 1986; ML51348451 and ML51348461).

Megarynchus pitangua (Boat-billed Flycatcher): although this widespread flycatcher occurs throughout the Neotropics, it has only recently been detected at the BDFFP. The first record occurred on 27 July 2007 (E.I.J. and C.F.V.), but it was found at all three *fazendas* that year, suggesting some indication of establishment prior to discovery. This species has been subsequently found in secondary forest and fragments of all sizes, with sightings ranging from July to October, as recently as 08 September 2017. In general, this species prefers lightly wooded areas, such as forest borders, plantations, and second-growth (Hilty 2002); however, in Amazonia, it is primarily a bird of *várzea* forest canopies, often associated with water (Ridgely & Tudor 1994), or of extensively disturbed areas with scattered tall trees, such as city parks.

Myiarchus tyrannulus (Brown-crested Flycatcher): similar to the aforementioned species, this is another widespread Neotropical flycatcher that was first discovered here in 2007 (E.I.J.). By 2010, it had been found in all three *fazendas*, always in secondary forest, often within close proximity to forest fragments. Its continued presence at specific sites and the most recent sighting (08 September 2017) suggests that individuals were not simply dispersing through the region, but rather had been gradually colonizing. The species is found in a variety of drier open to semi-open habitats, including scrubby disturbed areas, arid scrub, second-growth, gallery forests, and forest borders (Ridgely & Tudor 1994, Hilty 2002, Fitzpatrick *et al.* 2004) and had been noted by us (M.C.H., unpubl. data) at scattered localities in and near Manaus before appearing at the study site (ML59897621, ML59897631, ML59897701, ML59902381, ML59902691, ML59902771).

Attila cinnamomeus (Cinnamon Attila): this local, but occasionally common, flycatcher ranges throughout the Amazon Basin (Hilty 2002). It has been found only once at the BDFFP, heard singing by M.C.H in a Moriche Palm (*Mauritia flexuosa*) swamp at KM21 of the ZF-3 road. This species is found near water, mostly in seasonally flooded forests (Ridgely & Tudor 1994, Hilty 2002). The closest thing to its preferred habitat within

the study area are scattered palm swamps and narrow forest streams within the *terra firme*, none of which may be extensive enough to support permanent populations.

Tyrannus albogularis (White-throated Kingbird): this austral migrant breeds in most of the eastern Amazon and adjacent Cerrado to the south and east, but may be found throughout the Amazon during austral winter (May–August; Ridgely & Tudor 1994, Fitzpatrick *et al.* 2004). On 24 June 1997, P.C.S. spotted a single individual at the same seasonal forest pond where *C. moschata* was noted (see above). The species is seldom found far from water (*e.g.*, edges of gallery forests, river islands, palm swamps, and shrubby areas), although it occupies a wider variety of semi-open habitats when not breeding, including cities and towns (Hilty & Brown 1986, Ridgely & Tudor 1994, Fitzpatrick *et al.* 2004).

Heterocercus flavivertex (Yellow-crested Manakin): an apparent adult male was captured and banded on 10 September 2016 in secondary forest – the first and only record for the BDFFP (A.D.C., G.J.F., and I.R.C.). This species occurs in so-called white sand forest (*campina*/*campinarana*; Adeney *et al.* 2016) in upland and seasonally flooded localities (Hilty 2002, Borges 2004). The nearest known locality for the species is the INPA Campina Reserve *c.* 26 km away, separated by continuous *terra firme* forest. This record suggests that the forest mosaic around white sand habitats is at least a partially permeable matrix for the dispersal of habitat specialist species (Capurucho *et al.* 2013, ML52201591).

Pachyramphus polychopterus (White-winged Becard): the most widely distributed of all the *Pachyramphus* becards, this species has only been found once here (30 January 2016; C.L.R.). An immature male was seen along the border where a cleared swath of regrowth abuts older second-growth forest, adjacent to a dry seasonal pond. Because *Pachyramphus* have been shown to exhibit a Complex Alternate Strategy molt, the bird's mix of adult male-like and female-like plumage – with at least four adult male-like rectrices and a single tertial – suggest that the bird was in its first cycle alternate (F.C.A.) plumage (Johnson & Wolfe 2017). The contrast between this male's dark gray underparts and black crown and wings suggests that it was *P. p. tristis*, a taxon that we suspect to be a rare migrant into the Amazon, as opposed to *P. p. nigriventris*, the mostly black form found resident in Amazonian flooded forests.

Tachyphonus rufus (White-lined Tanager): a male probably of this species was seen in 2016, and a pair was photographed on 08 September 2017, with both records stemming from very young second-growth adjacent to active pastures (C.L.R.). Although *T. rufus* was once described only from the "extreme lower Amazon area" in Amapá and Pará states (Ridgely & Tudor 1989), there are now numerous documented records from western Pará and eastern Amazonas, including about 40 km due north of the study area in the town of Presidente Figueiredo (*e.g.*, Antunes 2013, Czaban 2015). This non-forest species favors shrubby clearings, cultivated areas, and forest borders (Hilty & Brown 1986, Hilty 2002, ML68469551, and ML68469581).

Geothlypis aequinoctialis (Masked Yellowthroat): C.L.R. found a male and female at the same location on 05 and 10 August 2015, respectively, along the edge of a small cattle pond in an overgrown pasture. These birds could have originated from either of two populations: local residents from nearby *várzea* (*G. a. aequinoctialis*) or austral migrants from southern Brazil and neighboring countries (*G. a. velata*). However, the limited extent of gray in the male's crown, blending to olive in the hindcrown, suggests locally expanding *G. a. aequinoctialis* (Curson 2010). This species typically occupies damp thickets or grasses in pastures, fields, marshes, or along woodland borders (Hilty & Brown 1986, Hilty 2002, ML51348521).

Cacicus cela (Yellow-rumped Cacique): first encountered at the study site about ten years ago, there have been a total of only three records: once at a continuous forest site (26 August 2006) and twice from forest fragments (10 and 100 ha) at widely separated *fazendas*, both in 2007 (P.C.S., E.I.J., and C.F.V.). *Cacicus cela* inhabits *várzea*, gallery forest, forest borders, second-growth, and other settings with scattered trees, including towns and villages (Hilty & Brown 1986, Ridgely & Tudor 1989, Fraga 2011). It is common in the Manaus area in flooded forests and in the city. As this species prefers edge habitats, it has likely benefited from human-created habitats caused by road construction or deforestation (Corwin 2012).

Identification revisions

Penelope jacquacu (Spix's Guan): this widespread species is virtually identical in plumage to the guan of the Guianan Shield, *P. marail*, although the two differ in size. Willis (1977) included only *P. jacquacu* on the list of the birds of Reserva Ducke, but subsequent checklists for the BDFFP contain both species, although each time *P. marail* is listed as more abundant (Stotz & Bierregaard-Jr. 1989, Cohn-Haft *et al.* 1997). This difficult field identification has never been fully resolved, although we should note that early ornithologists at the BDFFP (including, notably, Ted Parker) believed that two species were present. To date, however, we still lack any physical evidence that *P. jacquacu* has been registered at the BDFFP. It may be that confusion between these two species is simply the perpetuation of a misidentification that has never since been corrected, a scenario that is not uncommon elsewhere in the Neotropics (Willis 2003). Further

collecting or a closer look at regional specimens, if they exist, could help to elucidate this situation, because there is apparently no overlap in tarsus length between these two species (*P. marail jacupeba* = 53–60 mm; *P. jacquacu orienticola* = 72–84 mm; Blake 1977). In the absence of evidence to the contrary, we are removing *P. jacquacu* from the BDFFP list.

Celeus grammicus (Scale-breasted Woodpecker): similar to the case of the guans, *C. grammicus* and *undatus* are similar in plumage, but they are not usually sympatric. Although both Stotz & Bierregaard-Jr. (1989) and Cohn-Haft *et al.* (1997) list both species as occurring at the BDFFP, there are no specimens or diagnostic photos to establish this, and vocalizations appear to be identical (Hilty 2002, Benz & Robbins 2011). The two are sister species that show the typical Amazonian pattern of geographic replacement on opposite sides of major rivers (Haffer 1997, Naka *et al.* 2012). Furthermore, they exhibit minimal genetic (0.2–0.3%), morphological, and behavioral differentiation, and indeed may best be treated as a single species (Benz & Robbins 2011). Differences in the presence and extent of barring on the rump, tail, and head are often used to separate them, and observed variability in these traits at the BDFFP led to the inference of co-occurrence. Alternatively, however, this variability may represent a hybrid population or actually be typical of *C. undatus*, the expected species east of the lower Rio Negro and the one whose plumage characteristics have most unequivocally been observed. We now believe that careful documentation of these woodpeckers through collecting should be provided before either co-occurrence or hybridization are inferred. Meanwhile, we are removing *C. grammicus* from the site list.

DISCUSSION

A total of 409 bird species have now been documented at the BDFFP site. This takes into account 21 species added and 6 removed due either to redefinition of the area covered (*Avocettula recurvirostris*, *Chrysolampis mosquitus*, *Tachyphonus phoenicius*), reidentification (*Penelope jacquacu*, *Celeus grammicus*), or taxonomic changes (*Icterus chrysocephalus* is currently treated as a subspecies of *I. cayanensis*, but both are found at the site; Remsen-Jr. *et al.* 2017). Despite continued and intensive fieldwork over twenty years by numerous skilled field ornithologists (particularly from 2007–2017), representing many thousands of person-hours in the field, the overall change has been an increase of only 4%. This study confirms that the local avifauna at the BDFFP has been historically well characterized (Stotz & Bierregaard-Jr. 1989, Cohn-Haft *et al.* 1997).

Although the BDFFP avifauna does appear to be well characterized and gradual additions over time of vagrants or very rare species to lists should be expected, additions due to increased knowledge or to changes in the landscape are important to distinguish. These additions may represent processes likely to affect bird populations over the long term. Of the 21 additions, three (*Bartramia longicauda*, *Pachyramphus polychopterus*, and *Tyrannus albogularis*) are non-breeding migrants and appear to be vagrants. Similarly, a number of species listed as "casual" by Cohn-Haft *et al.* (1997), have not been detected subsequently (*e.g.*, *Pipile cumanensis*, *Pionites melanocephalus*, *Pharomachrus pavoninus*, *Sclateria naevia*, *Phyllomyias griseiceps*, *Euphonia chlorotica*, *Tersina viridis*, and *Conirostrum speciosum*), reinforcing that status.

Another two species added (*Touit huetii* and *Hemitriccus josephinae*) are typical of primary *terra firme* forest and are considered rare at our site, where they probably have always occurred. Thus, they appear to represent cases of improved knowledge and detection ability. Although their local status is unclear, even if they are treated as integral parts of the site's primary *terra firme* avifauna (previously listed as 264 species), this would represent an increase of 0.8%, consistent with the prediction that the "core avifauna" had already been characterized to >99% precision (Cohn-Haft *et al.* 1997).

The great majority (16 species, 76%) of the species added are birds that prefer *várzea*, second-growth, disturbed, or edge habitats. This suggests that the farm and fragment matrix of the BDFFP continues to accumulate non-primary forest species. A similar pattern has been described from other Amazonian sites (*e.g.*, Borges *et al.* 2017), and many of the recent additions to the Santarém area and Alta Floresta lists were associated with anthropogenic habitat alteration (Lees *et al.* 2013a, b). However, some of these may also be vagrants, expected to appear rarely and at a more or less constant rate as they disperse through or over primary forest. Others may represent permanent additions to the local avifauna. Furthermore, the colonization process by non-primary forest species may be changing over time with changes either at the study site itself or in the surrounding landscape, increasing the likelihood of colonization (via increases in deforestation or dispersal along roads, for example). Distinguishing among these possibilities, however, would require a temporal landscape analysis.

The BDFFP continues to have the most thoroughly documented avifauna in all of central Amazonia. This updated list, replete with extensive, recent fieldwork at the BDFFP, likely reflects local and regional land-use changes that have accumulated during the past two decades and serves as one of the few complete, longitudinal avian inventories available in all of lowland Amazonia. Although other intensive lists have been published at a variety of Amazonian sites (*e.g.*, Terborgh *et al.* 1984,

Karr *et al.* 1990, Parker-III *et al.* 1994), we look forward to updates to those inventories as well as other published lists to become available, which will be even more useful to make comparisons across the biogeographically diverse Amazon.

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APPENDIX I

Bird species recorded at the Biological Dynamics of Forest Fragments Project in the state of Amazonas, Brazil. Taxonomy and order follow the South American Classification Committee (9 March 2017). Abundance codes are: c – common, u – uncommon, r – rare, x – casual; followed by seasonality codes if not year-round resident: a – austral migrant, b – boreal migrant, m – unspecified movements. Habitat codes are: 1 – primary *terra firme* forest, 2 – secondary forest, p – pasture, w – water bodies, c – *campinarana*.

Families and species	**English name**	**Abundance, seasonality**	**Habitat**
TINAMIDAE			
Tinamus major	Great Tinamou	c	1
Crypturellus soui	Little Tinamou	u	2, 1
Crypturellus variegatus	Variegated Tinamou	c	1
Crypturellus brevirostris	Rusty Tinamou	u	1
ANATIDAE			
Cairina moschata	Muscovy Duck	x	w
Nomonyx dominicus	Masked Duck	r	w
CRACIDAE			
Penelope marail	Marail Guan	c	1
Pipile cumanensis	Blue-throated Piping-Guan	x	1
Ortalis motmot	Variable Chachalaca	c	2
Crax alector	Black Curassow	u	1
ODONTOPHORIDAE			
Odontophorus gujanensis	Marbled Wood-Quail	u	1, 2
PODICIPEDIDAE			
Tachybaptus dominicus	Least Grebe	u	w
COLUMBIDAE			
Patagioenas speciosa	Scaled Pigeon	r	2
Patagioenas plumbea	Plumbeous Pigeon	c	1
Patagioenas subvinacea	Ruddy Pigeon	c	1, 2
Geotrygon montana	Ruddy Quail-Dove	cm	1
Leptotila verreauxi	White-tipped Dove	c	2, p
Columbina passerina	Common Ground Dove	r	2, p
Columbina talpacoti	Ruddy Ground Dove	r	2, p
CUCULIDAE			
Crotophaga major	Greater Ani	x	1
Crotophaga ani	Smooth-billed Ani	c	p, 2
Dromococcyx pavoninus	Pavonine Cuckoo	x	1
Piaya cayana	Squirrel Cuckoo	u	2
Piaya melanogaster	Black-bellied Cuckoo	c	1
Coccyzus melacoryphus	Dark-billed Cuckoo	xa	2
Coccyzus euleri	Pearly-breasted Cuckoo	ra	1
NYCTIBIIDAE			
Nyctibius grandis	Great Potoo	r	2, 1
Nyctibius aethereus	Long-tailed Potoo	r	1, 2
Nyctibius griseus	Common Potoo	u	2, 1
Nyctibius leucopterus	White-winged Potoo	u	1
Nyctibius bracteatus	Rufous Potoo	u	1

Families and species	English name	Abundance, seasonality	Habitat
CAPRIMULGIDAE			
Chordeiles acutipennis	Lesser Nighthawk	x	p
Chordeiles minor	Common Nighthawk	rb	1, p
Lurocalis semitorquatus	Short-tailed Nighthawk	u	1
Nyctipolus nigrescens	Blackish Nightjar	u	2, 1
Nyctidromus albicollis	Common Pauraque	c	2, p
APODIDAE			
Streptoprocne zonaris	White-collared Swift	rm	1, 2, p
Chaetura spinicaudus	Band-rumped Swift	c	1, w, p
Chaetura chapmani	Chapman's Swift	u	1, w
Chaetura brachyura	Short-tailed Swift	r	2, w, p
Tachornis squamata	Fork-tailed Palm-Swift	r	p
Panyptila cayennensis	Lesser Swallow-tailed Swift	r	1, 2
TROCHILIDAE			
Topaza pella	Crimson Topaz	r	1, 2
Florisuga mellivora	White-necked Jacobin	u	1, 2
Glaucis hirsutus	Rufous-breasted Hermit	x	2
Phaethornis ruber	Reddish Hermit	r	2
Phaethornis bourcieri	Straight-billed Hermit	c	1, 2
Phaethornis superciliosus	Long-tailed Hermit	c	1, 2
Heliothryx auritus	Black-eared Fairy	c	1, 2
Polytmus theresiae	Green-tailed Goldenthroat	x	p
Anthracothorax nigricollis	Black-throated Mango	r	1
Discosura longicaudus	Racket-tailed Coquette	r	1, 2
Campylopterus largipennis	Gray-breasted Sabrewing	c	1, 2
Thalurania furcata	Fork-tailed Woodnymph	c	1, 2
Amazilia versicolor	Versicolored Emerald	r	2
Amazilia fimbriata	Glittering-throated Emerald	x	1
Hylocharis sapphirina	Rufous-throated Sapphire	u	1, 2
PSOPHIIDAE			
Psophia crepitans	Gray-winged Trumpeter	u	1
RALLIDAE			
Aramides cajaneus	Gray-necked Wood-Rail	r	1, 2
Anurolimnas viridis	Russet-crowned Crake	u	p
Laterallus melanophaius	Rufous-sided Crake	x	w
HELIORNITHIDAE			
Heliornis fulica	Sungrebe	x	w
CHARADRIIDAE			
Pluvialis dominica	American Golden-Plover	rb	w
Charadrius collaris	Collared Plover	x	w, p
SCOLOPACIDAE			
Bartramia longicauda	Upland Sandpiper	xb	p
Calidris himantopus	Stilt Sandpiper	xb	w
Calidris minutilla	Least Sandpiper	xb	w
Calidris fuscicollis	White-rumped Sandpiper	ub	w

Families and species	English name	Abundance, seasonality	Habitat
Calidris melanotos	Pectoral Sandpiper	rb	w
Gallinago paraguaiae	South American Snipe	x	w
Actitis macularius	Spotted Sandpiper	ub	w
Tringa solitaria	Solitary Sandpiper	ub	w
Tringa melanoleuca	Greater Yellowlegs	ub	w
Tringa flavipes	Lesser Yellowlegs	rb	w
JACANIDAE			
Jacana jacana	Wattled Jacana	c	w
EURYPYGIDAE			
Eurypyga helias	Sunbittern	r	1
CICONIIDAE			
Mycteria americana	Wood Stork	x	p
ANHINGIDAE			
Anhinga anhinga	Anhinga	x	p
ARDEIDAE			
Tigrisoma lineatum	Rufescent Tiger-Heron	r	1, w
Cochlearius cochlearius	Boat-billed Heron	x	1
Nycticorax nycticorax	Black-crowned Night-Heron	x	1
Butorides striata	Striated Heron	x	1
Bubulcus ibis	Cattle Egret	x	p, w, 1
Ardea cocoi	Cocoi Heron	r	w
Ardea alba	Great Egret	r	w
Pilherodius pileatus	Capped Heron	x	w
THRESKIORNITHIDAE			
Mesembrinibis cayennensis	Green Ibis	x	1
CATHARTIDAE			
Cathartes aura	Turkey Vulture	u	p, 2
Cathartes melambrotus	Greater Yellow-headed Vulture	c	1, p
Coragyps atratus	Black Vulture	u	p
Sarcoramphus papa	King Vulture	u	1, p
PANDIONIDAE			
Pandion haliaetus	Osprey	xb	w
ACCIPITRIDAE			
Gampsonyx swainsonii	Pearl Kite	r	p
Chondrohierax uncinatus	Hook-billed Kite	x	1
Leptodon cayanensis	Gray-headed Kite	x	1
Elanoides forficatus	Swallow-tailed Kite	um?	1, 2
Morphnus guianensis	Crested Eagle	r	1
Harpia harpyja	Harpy Eagle	r	1
Spizaetus tyrannus	Black Hawk-Eagle	r	1, 2
Spizaetus melanoleucus	Black-and-white Hawk-Eagle	x	1, 2, p
Spizaetus ornatus	Ornate Hawk-Eagle	u	1
Harpagus bidentatus	Double-toothed Kite	u	1
Ictinia plumbea	Plumbeous Kite	um?	1, 2
Accipiter poliogaster	Gray-bellied Hawk	x	1

Families and species	English name	Abundance, seasonality	Habitat
Accipiter superciliosus	Tiny Hawk	r	1
Accipiter bicolor	Bicolored Hawk	r	1
Buteogallus meridionalis	Savanna Hawk	u	p
Buteogallus urubitinga	Great Black Hawk	u	1, 2
Rupornis magnirostris	Roadside Hawk	u	p, 2
Geranoaetus albicaudatus	White-tailed Hawk	r	p
Pseudastur albicollis	White Hawk	c	1, 2
Leucopternis melanops	Black-faced Hawk	r	1
Buteo nitidus	Gray-lined Hawk	c	2, p
Buteo platypterus	Broad-winged Hawk	ub	2, 1
Buteo brachyurus	Short-tailed Hawk	u	2, p
TYTONIDAE			
Tyto alba	Barn Owl	r	2, p
STRIGIDAE			
Megascops choliba	Tropical Screech-Owl	r	2
Megascops watsonii	Tawny-bellied Screech-Owl	c	1, 2
Lophostrix cristata	Crested Owl	c	1
Pulsatrix perspicillata	Spectacled Owl	c	1
Ciccaba virgata	Mottled Owl	r	2, 1
Ciccaba huhula	Black-banded Owl	u	1, 2
Glaucidium hardyi	Amazonian Pygmy-Owl	c	1, 2
Athene cunicularia	Burrowing Owl	x	p
TROGONIDAE			
Pharomachrus pavoninus	Pavonine Quetzal	x	1
Trogon melanurus	Black-tailed Trogon	c	1
Trogon viridis	Green-backed Trogon	c	1, 2
Trogon violaceus	Guianan Trogon	c	1
Trogon rufus	Black-throated Trogon	c	1
ALCEDINIDAE			
Megaceryle torquata	Ringed Kingfisher	r	w
Chloroceryle amazona	Amazon Kingfisher	x	w
Chloroceryle americana	Green Kingfisher	x	1
Chloroceryle inda	Green-and-rufous Kingfisher	r	1
Chloroceryle aenea	American Pygmy Kingfisher	r	1
MOMOTIDAE			
Momotus momota	Amazonian Motmot	c	1
GALBULIDAE			
Galbula albirostris	Yellow-billed Jacamar	c	1, 2
Galbula leucogastra	Bronzy Jacamar	r	c, 1, 2
Galbula dea	Paradise Jacamar	c	1, 2
Jacamerops aureus	Great Jacamar	c	1
BUCCONIDAE			
Notharchus macrorhynchos	Guianan Puffbird	c	1
Notharchus tectus	Pied Puffbird	u	1, 2
Bucco tamatia	Spotted Puffbird	u	1, 2

Families and species	English name	Abundance, seasonality	Habitat
Bucco capensis	Collared Puffbird	u	1
Malacoptila fusca	White-chested Puffbird	u	1
Nonnula rubecula	Rusty-breasted Nunlet	r	1
Monasa atra	Black Nunbird	c	1, 2
Chelidoptera tenebrosa	Swallow-winged Puffbird	r	p, 2
CAPITONIDAE			
Capito niger	Black-spotted Barbet	c	1
RAMPHASTIDAE			
Ramphastos tucanus	White-throated Toucan	c	1
Ramphastos vitellinus	Channel-billed Toucan	c	1
Selenidera piperivora	Guianan Toucanet	u	1
Pteroglossus viridis	Green Aracari	u	1, 2
PICIDAE			
Picumnus exilis	Golden-spangled Piculet	u	1, 2
Melanerpes cruentatus	Yellow-tufted Woodpecker	c	2, 1
Veniliornis cassini	Golden-collared Woodpecker	c	1
Piculus flavigula	Yellow-throated Woodpecker	c	1
Piculus chrysochloros	Golden-green Woodpecker	r	1
Celeus torquatus	Ringed Woodpecker	u	1
Celeus undatus	Waved Woodpecker	c	1
Celeus flavus	Cream-colored Woodpecker	x	1
Celeus elegans	Chestnut Woodpecker	u	1
Dryocopus lineatus	Lineated Woodpecker	c	2, 1, p
Campephilus rubricollis	Red-necked Woodpecker	c	1
FALCONIDAE			
Micrastur ruficollis	Barred Forest-Falcon	c	1, 2
Micrastur gilvicollis	Lined Forest-Falcon	c	1
Micrastur mirandollei	Slaty-backed Forest-Falcon	u	1, 2
Micrastur semitorquatus	Collared Forest-Falcon	u	1, 2
Caracara plancus	Southern Caracara	r	p
Ibycter americanus	Red-throated Caracara	c	1
Daptrius ater	Black Caracara	r	1
Milvago chimachima	Yellow-headed Caracara	u	p
Falco rufigularis	Bat Falcon	c	1, 2, p
PSITTACIDAE			
Touit huetii	Scarlet-shouldered Parrotlet	r	1, 2
Touit purpuratus	Sapphire-rumped Parrotlet	u	1
Brotogeris chrysoptera	Golden-winged Parakeet	c	1
Pyrilia caica	Caica Parrot	u	1
Pionus fuscus	Dusky Parrot	um	1
Pionus menstruus	Blue-headed Parrot	cm	1
Amazona autumnalis	Red-lored Parrot	cm	1
Amazona farinosa	Mealy Parrot	cm	1
Forpus sp.	Parrotlet species	x	1, 2
Pionites melanocephalus	Black-headed Parrot	x	1

Families and species	English name	Abundance, seasonality	Habitat
Deroptyus accipitrinus	Red-fan Parrot	c	1
Orthopsittaca manilatus	Red-bellied Macaw	u	p, 1
Ara ararauna	Blue-and-yellow Macaw	c	1
Ara macao	Scarlet Macaw	r	1
Ara chloropterus	Red-and-green Macaw	c	1
Psittacara leucophthalmus	White-eyed Parakeet	r	1, 2, p
THAMNOPHILIDAE			
Euchrepomis spodioptila	Ash-winged Antwren	c	1
Cymbilaimus lineatus	Fasciated Antshrike	c	1, 2
Frederickena viridis	Black-throated Antshrike	r	1, 2
Thamnophilus murinus	Mouse-colored Antshrike	c	1, 2
Thamnophilus punctatus	Northern Slaty-Antshrike	u	2, c
Thamnomanes ardesiacus	Dusky-throated Antshrike	c	1
Thamnomanes caesius	Cinereous Antshrike	c	1
Isleria guttata	Rufous-bellied Antwren	r	1
Epinecrophylla gutturalis	Brown-bellied Antwren	c	1
Myrmotherula brachyura	Pygmy Antwren	c	1, 2
Myrmotherula axillaris	White-flanked Antwren	c	1, 2
Myrmotherula longipennis	Long-winged Antwren	c	1
Myrmotherula menetriesii	Gray Antwren	c	1
Herpsilochmus dorsimaculatus	Spot-backed Antwren	c	1
Hypocnemis cantator	Guianan Warbling-Antbird	c	1, 2
Cercomacroides tyrannina	Dusky Antbird	u	2
Cercomacra cinerascens	Gray Antbird	c	1
Hypocnemoides melanopogon	Black-chinned Antbird	x	1
Sclateria naevia	Silvered Antbird	x	1
Percnostola rufifrons	Black-headed Antbird	c	1, 2
Myrmelastes leucostigma	Spot-winged Antbird	u	1
Myrmoderus ferrugineus	Ferruginous-backed Antbird	c	1
Myrmophylax atrothorax	Black-throated Antbird	r	2, 1
Myrmornis torquata	Wing-banded Antbird	r	1
Pithys albifrons	White-plumed Antbird	c	1
Gymnopithys rufigula	Rufous-throated Antbird	c	1
Hylophylax naevius	Spot-backed Antbird	r	1, 2
Willisornis poecilinotus	Common Scale-backed Antbird	c	1
CONOPOPHAGIDAE			
Conopophaga aurita	Chestnut-belted Gnateater	u	1
GRALLARIIDAE			
Grallaria varia	Variegated Antpitta	c	1
Hylopezus macularius	Spotted Antpitta	u	1
Myrmothera campanisona	Thrush-like Antpitta	c	1, 2
FORMICARIIDAE			
Formicarius colma	Rufous-capped Antthrush	c	1
Formicarius analis	Black-faced Antthrush	c	1

Families and species	English name	Abundance, seasonality	Habitat
FURNARIIDAE			
Sclerurus mexicanus	Tawny-throated Leaftosser	u	1
Sclerurus rufigularis	Short-billed Leaftosser	c	1
Sclerurus caudacutus	Black-tailed Leaftosser	r	1
Certhiasomus stictolaemus	Spot-throated Woodcreeper	c	1
Sittasomus griseicapillus	Olivaceous Woodcreeper	c	1, 2
Deconychura longicauda	Long-tailed Woodcreeper	c	1
Dendrocincla merula	White-chinned Woodcreeper	c	1
Dendrocincla fuliginosa	Plain-brown Woodcreeper	c	1, 2
Glyphorynchus spirurus	Wedge-billed Woodcreeper	c	1, 2
Dendrexetastes rufigula	Cinnamon-throated Woodcreeper	u	1
Dendrocolaptes certhia	Amazonian Barred-Woodcreeper	c	1
Dendrocolaptes picumnus	Black-banded Woodcreeper	u	1
Hylexetastes perrotii	Red-billed Woodcreeper	u	1
Xiphorhynchus pardalotus	Chestnut-rumped Woodcreeper	c	1
Campylorhamphus procurvoides	Curve-billed Scythebill	u	1
Lepidocolaptes albolineatus	Guianan Woodcreeper	c	1
Xenops minutus	Plain Xenops	c	1
Microxenops milleri	Rufous-tailed Xenops	c	1
Philydor erythrocercum	Rufous-rumped Foliage-gleaner	c	1
Philydor pyrrhodes	Cinnamon-rumped Foliage-gleaner	u	1
Clibanornis rubiginosus	Ruddy Foliage-gleaner	u	1, 2
Automolus ochrolaemus	Buff-throated Foliage-gleaner	c	2, 1
Automolus infuscatus	Olive-backed Foliage-gleaner	c	1
Synallaxis rutilans	Ruddy Spinetail	r	1
TYRANNIDAE			
Phyllomyias griseiceps	Sooty-headed Tyrannulet	x	2
Tyrannulus elatus	Yellow-crowned Tyrannulet	c	1, 2
Myiopagis gaimardii	Forest Elaenia	c	1
Myiopagis caniceps	Gray Elaenia	c	1
Elaenia flavogaster	Yellow-bellied Elaenia	x	2
Elaenia parvirostris	Small-billed Elaenia	ra	2
Elaenia chiriquensis	Lesser Elaenia	xm	2, p
Ornithion inerme	White-lored Tyrannulet	u	1
Camptostoma obsoletum	Southern Beardless-Tyrannulet	x	2
Phaeomyias murina	Mouse-colored Tyrannulet	r	2
Corythopis torquatus	Ringed Antpipit	u	1
Zimmerius acer	Guianan Tyrannulet	c	1, 2
Phylloscartes virescens	Olive-green Tyrannulet	c	1
Mionectes oleagineus	Ochre-bellied Flycatcher	r	2
Mionectes macconnelli	McConnell's Flycatcher	c	1, 2
Sublegatus sp.	Scrub-Flycatcher species	x	2
Myiornis ecaudatus	Short-tailed Pygmy-Tyrant	u	1, 2
Lophotriccus vitiosus	Double-banded Pygmy-Tyrant	c	1, 2
Lophotriccus galeatus	Helmeted Pygmy-Tyrant	r	2

Families and species	English name	Abundance, seasonality	Habitat
Hemitriccus josephinae	Boat-billed Tody-Tyrant	r	1
Hemitriccus zosterops	White-eyed Tody-Tyrant	c	1, 2
Todirostrum pictum	Painted Tody-Flycatcher	c	1, 2
Rhynchocyclus olivaceus	Olivaceous Flatbill	c	1
Tolmomyias assimilis	Yellow-margined Flycatcher	c	1
Tolmomyias poliocephalus	Gray-crowned Flycatcher	c	1, 2
Neopipo cinnamomea	Cinnamon Manakin-Tyrant	x	1, 2
Platyrinchus saturatus	Cinnamon-crested Spadebill	u	1
Platyrinchus coronatus	Golden-crowned Spadebill	c	1
Platyrinchus platyrhynchos	White-crested Spadebill	u	1
Onychorhynchus coronatus	Royal Flycatcher	u	1
Myiophobus fasciatus	Bran-colored Flycatcher	x	p
Myiobius barbatus	Sulphur-rumped Flycatcher	c	1
Terenotriccus erythrurus	Ruddy-tailed Flycatcher	c	1, 2
Contopus cooperi	Olive-sided Flycatcher	rb	2, 1
Contopus virens	Eastern Wood-Pewee	rb	2, 1
Pyrocephalus rubinus	Vermilion Flycatcher	xa	2
Legatus leucophaius	Piratic Flycatcher	u	2, 1
Myiozetetes cayanensis	Rusty-margined Flycatcher	c	2, p
Myiozetetes luteiventris	Dusky-chested Flycatcher	x	2
Pitangus sulphuratus	Great Kiskadee	r	2, p
Conopias parvus	Yellow-throated Flycatcher	c	1
Myiodynastes maculatus	Streaked Flycatcher	ra?	2, p
Megarynchus pitangua	Boat-billed Flycatcher	r	2
Tyrannopsis sulphurea	Sulphury Flycatcher	u	1
Empidonomus varius	Variegated Flycatcher	um?	2
Empidonomus aurantioatrocristatus	Crowned Slaty Flycatcher	ra	1
Tyrannus albogularis	White-throated Kingbird	x	w
Tyrannus melancholicus	Tropical Kingbird	cm	2, p
Tyrannus savana	Fork-tailed Flycatcher	ua?	2, p
Tyrannus tyrannus	Eastern Kingbird	xb	p
Rhytipterna simplex	Grayish Mourner	c	1, 2
Sirystes subcanescens	Todd's Sirystes	c	1
Myiarchus tuberculifer	Dusky-capped Flycatcher	u	2, 1
Myiarchus ferox	Short-crested Flycatcher	u	2
Myiarchus tyrannulus	Brown-crested Flycatcher	r	2
Ramphotrigon ruficauda	Rufous-tailed Flatbill	u	1
Attila cinnamomeus	Cinnamon Attila	x	w
Attila spadiceus	Bright-rumped Attila	c	1
COTINGIDAE			
Phoenicircus carnifex	Guianan Red-Cotinga	u	1
Haematoderus militaris	Crimson Fruitcrow	r	1, 2
Perissocephalus tricolor	Capuchinbird	u	1
Cotinga cotinga	Purple-breasted Cotinga	x	1
Cotinga cayana	Spangled Cotinga	u	1

Families and species	English name	Abundance, seasonality	Habitat
Lipaugus vociferans	Screaming Piha	c	1
Xipholena punicea	Pompadour Cotinga	c	1
PIPRIDAE			
Tyranneutes virescens	Tiny Tyrant-Manakin	c	1
Neopelma chrysocephalum	Saffron-crested Tyrant-Manakin	u	c
Corapipo gutturalis	White-throated Manakin	c	1, 2
Lepidothrix serena	White-fronted Manakin	c	1, 2
Heterocercus flavivertex	Yellow-crowned Manakin	x	2
Manacus manacus	White-bearded Manakin	u	2
Dixiphia pipra	White-crowned Manakin	c	1, 2
Ceratopipra erythrocephala	Golden-headed Manakin	c	1, 2
TITYRIDAE			
Tityra cayana	Black-tailed Tityra	c	1, 2
Schiffornis olivacea	Guianan Schiffornis	c	1, 2
Laniocera hypopyrra	Cinereous Mourner	u	1
Iodopleura fusca	Dusky Purpletuft	xm?	1
Pachyramphus rufus	Cinereous Becard	x	2
Pachyramphus polychopterus	White-winged Becard	x	2
Pachyramphus marginatus	Black-capped Becard	c	1
Pachyramphus surinamus	Glossy-backed Becard	c	1
Pachyramphus minor	Pink-throated Becard	u	1
INCERTAE SEDIS			
Piprites chloris	Wing-barred Piprites	c	1
VIREONIDAE			
Cyclarhis gujanensis	Rufous-browed Peppershrike	c	2, 1
Hylophilus semicinereus	Gray-chested Greenlet	x	2
Hylophilus thoracicus	Lemon-chested Greenlet	r	1
Vireolanius leucotis	Slaty-capped Shrike-Vireo	c	1
Tunchiornis ochraceiceps	Tawny-crowned Greenlet	c	1
Pachysylvia muscicapina	Buff-cheeked Greenlet	c	1
Vireo olivaceus	Red-eyed Vireo	ub	1, 2
Vireo altiloquus	Black-whiskered Vireo	rb	1
HIRUNDINIDAE			
Atticora tibialis	White-thighed Swallow	u	2, 1, w
Stelgidopteryx ruficollis	Southern Rough-winged Swallow	u	2, p
Progne tapera	Brown-chested Martin	xa	p
Progne subis	Purple Martin	rb	1, 2, p
Progne chalybea	Gray-breasted Martin	u	p, 2
Riparia riparia	Bank Swallow	xb	p
Hirundo rustica	Barn Swallow	ub	p
TROGLODYTIDAE			
Microcerculus bambla	Wing-banded Wren	c	1
Troglodytes aedon	House Wren	u	p, 2
Pheugopedius coraya	Coraya Wren	c	2, 1
Cantorchilus leucotis	Buff-breasted Wren	x	2

Families and species	English name	Abundance, seasonality	Habitat
Cyphorhinus arada	Musician Wren	u	1
POLIOPTILIDAE			
Microbates collaris	Collared Gnatwren	c	1
Ramphocaenus melanurus	Long-billed Gnatwren	c	1
Polioptila guianensis	Guianan Gnatcatcher	r	1
TURDIDAE			
Catharus fuscescens	Veery	rb	1, 2
Catharus minimus	Gray-cheeked Thrush	rb	1
Turdus albicollis	White-necked Thrush	c	1
THRAUPIDAE			
Lamprospiza melanoleuca	Red-billed Pied Tanager	c	1
Tachyphonus cristatus	Flame-crested Tanager	c	1
Tachyphonus surinamus	Fulvous-crested Tanager	c	1, 2
Tachyphonus rufus	White-lined Tanager	x	p
Lanio fulvus	Fulvous Shrike-Tanager	u	1
Ramphocelus carbo	Silver-beaked Tanager	c	2, p
Cyanicterus cyanicterus	Blue-backed Tanager	r	1
Thraupis episcopus	Blue-gray Tanager	u	2, p
Thraupis palmarum	Palm Tanager	u	2, p
Tangara varia	Dotted Tanager	r	1
Tangara punctata	Spotted Tanager	c	1, 2
Tangara mexicana	Turquoise Tanager	r	2, 1
Tangara chilensis	Paradise Tanager	c	1
Tangara velia	Opal-rumped Tanager	u	1
Tangara gyrola	Bay-headed Tanager	r	1
Tersina viridis	Swallow Tanager	xm	1
Dacnis lineata	Black-faced Dacnis	c	1
Dacnis cayana	Blue Dacnis	c	1
Cyanerpes nitidus	Short-billed Honeycreeper	u	1
Cyanerpes caeruleus	Purple Honeycreeper	c	1
Cyanerpes cyaneus	Red-legged Honeycreeper	c	1, 2
Chlorophanes spiza	Green Honeycreeper	c	1, 2
Hemithraupis flavicollis	Yellow-backed Tanager	c	1
Conirostrum speciosum	Chestnut-vented Conebill	x	2, 1
Saltator maximus	Buff-throated Saltator	r	2
Saltator grossus	Slate-colored Grosbeak	c	1, 2
Volatinia jacarina	Blue-black Grassquit	u	p, 2
Sporophila bouvronides	Lesson's Seedeater	xm	p
Sporophila lineola	Lined Seedeater	xm	p
Sporophila castaneiventris	Chestnut-bellied Seedeater	u	p
Sporophila angolensis	Chestnut-bellied Seed-Finch	u	2, p
Coereba flaveola	Bananaquit	c	1, 2
EMBERIZIDAE			
Ammodramus aurifrons	Yellow-browed Sparrow	u	p, 2
Arremon taciturnus	Pectoral Sparrow	r	1

Families and species	English name	Abundance, seasonality	Habitat
CARDINALIDAE			
Piranga rubra	Summer Tanager	xb	2
Caryothraustes canadensis	Yellow-green Grosbeak	c	1, 2
Cyanoloxia cyanoides	Blue-black Grosbeak	u	1, 2
PARULIDAE			
Geothlypis aequinoctialis	Masked Yellowthroat	x	p
Setophaga fusca	Blackburnian Warbler	xb	2, 1
Setophaga petechia	Yellow Warbler	xb	1
Setophaga striata	Blackpoll Warbler	rb	2, 1
Myiothlypis rivularis	Riverbank Warbler	u	2, 1
ICTERIDAE			
Psarocolius viridis	Green Oropendola	c	1
Cacicus cela	Yellow-rumped Cacique	x	2, 1
Cacicus haemorrhous	Red-rumped Cacique	c	1, 2
Icterus cayanensis	Epaulet Oriole	r	1, 2
Molothrus oryzivorus	Giant Cowbird	u	p, 2, 1
Molothrus bonariensis	Shiny Cowbird	u	p, 2
Sturnella militaris	Red-breasted Meadowlark	u	p
FRINGILLIDAE			
Euphonia plumbea	Plumbeous Euphonia	x	1, 2
Euphonia chlorotica	Purple-throated Euphonia	x	2
Euphonia chrysopasta	Golden-bellied Euphonia	r	1, 2
Euphonia minuta	White-vented Euphonia	u	1, 2
Euphonia cayennensis	Golden-sided Euphonia	c	1

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SHORT-COMMUNICATION

First records of European Starling *Sturnus vulgaris* in Brazil

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ABSTRACT: We present the first records of *Sturnus vulgaris* in Brazil. Here we report the occurrence of the species at three localities of Rio Grande do Sul state. We photographed and recorded five juvenile specimens feeding in grasslands at the municipality of Santa Vitória do Palmar, 30 specimens at the municipality of Chuí and a single adult in breeding plumage at the municipality of Lavras do Sul. Our most recent record reveals the probable establishment of this species in the country.

KEY-WORDS: Common Starling, conservation, ecology, exotic birds, invasive species.

The European Starling *Sturnus vulgaris* Linnaeus, 1758 belongs to the Sturnidae family, native from Europe and Asia. It is regarded as a highly successful invader, currently introduced in Africa, the Americas and Oceania (Feare 1984, Ifran & Fiorini 2010). In Latin America, its southernmost distribution is documented to the southern portion of Uruguay (Mazzulla 2013) and central and northeast of Argentina (Peris *et al*. 2005).

Its size can range between 20.5 and 25 cm. It has an elongated bill, short tail and reddish legs (Howell & Webb 1995, de la Peña & Rumboll 1998, Azpiroz 2012). Its plumage is quite variable, presenting distinct characteristics between adults/breeding and adults/non-breeding. During non-breeding season (fall-winter) the bill is dark and the plumage presents white dots all over the body which will disappear, totally or partially, as the breeding season approaches. At breeding season (spring–summer), the bill is yellow. The plumage is black with violet shades on the head and greenish on the rest of its body. The youngsters have a totally grayish brown plumage, with back darker than the belly, white throat and dark bill. The tail is shorter compared to adults (Howell & Webb 1995, Azpiroz 2012). Its vocalization is a sequence of sharp notes, rough and noisy (Aspiroz 2012). Its diet is essentially omnivorous, eventually feeding on small invertebrates, fruits and cereals (Wood 1924, Feare 1984).

The aim of this study is present the first documented records of *S. vulgaris* in Brazil. A first sighting of *S. vulgaris* in Brazil occurred in Rio Grande do Sul state, on 10 October 2014, at the municipality of Lavras do Sul (30°35'35.56''S; 53°50'17.15''W), available on Wikiaves (Souza 2014). This record was of a single adult in breeding plumage. However, the discovery was not properly documented in the scientific literature.

Our current records of *S. vulgaris* took place on 07–08 December 2016 around 18:30 h at the municipality of Santa Vitória do Palmar (33°37'42.84''S; 53°20'24.06''W). The individuals were photographed, filmed and had their vocalization recorded. The photographs were posted in the Wikiaves image collection (Silva 2016a) and the vocalization record in the Xenocanto digital collection under accession number XC345984 (Silva 2016b). At the first day, the flock with five juvenile specimens flew in circles over a eucalyptus forest while vocalizing (calling) and landed on the trees (Fig. 1). The birds moved in aggregate form to another forest where they remained vocalizing. The next day at 11:10 h the same specimens were detected flying over the field at the same location, landing to feed on the ground. Another flock with 30 juvenile specimens flying in circles and landing to feed on the ground were observed on 29 October 2017 around 8:00 h at the municipality of Chuí (33°40'14.56''S; 53°24'38.68''W).

The native fields of the region where the species was registered foraging was occupied by cattle and sheep and are characterized by the invasive Gorse (*Ulex europaeus*), vegetation native from Europe, in addition to *Eucalyptus* spp. Furthermore, the rice cultivation is the main agricultural activity at this region. When the registers were carried out, the rice crops were 20 cm tall and the species interaction with crops were not detected.

Figure 1. Flock with juvenile Starlings *Sturnus vulgaris* recorded at Santa Vitória do Palmar, Rio Grande do Sul state, Brazil, on 07 December 2016. Photo Author: Josiani M. Pinto.

However, it is known that cereals play an important role on diet of Starlings, and that they cause serious damage to the agriculture in the United States and Europe (Feare 1984, 1989, Feare *et al.* 1992, Pimentel *et al.* 2000).

The *S. vulgaris* expansion capacity is alarming. According to Peris *et al.* (2005), in Argentina, the bird had dispersed in a progression of 7.5 km/year. In Australia and Europe, there are several studies and reports addressing the competition problems for nesting sites with native species (*e.g.*, Wood 1924, Pazzucconi 1997, Pell & Tidemann 1997, Wiebe 2003). According to Wood (1924), Starlings show advantage over native species where there was competition, as they can outcompete for nest cavities.

The reproduction of *S. vulgaris* in landscapes such as Santa Vitória do Palmar, in the Pampa Biome, may be harmful to native species, since the Starling builds its nests, preferable, in trunk cavities, *i.e.* as secondary cavity nesters (Wood 1924, Feare 1984, Pazzucconi 1997), similar to several native species in this region.

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Each Table should be on a separate page, numbered in Arabic numerals, with its own heading.

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. Figures should be pooled as composition (Fig. 1A, B, C) always as possible.

As necessary, subsections may be identified and labeled as such, lower case, in bold, central. If another subheading is necessary, please use in italics, left-justified. All pages should be numbered.

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 (milligram), all of them in lowercase (not capitals) and with no "periods" (".”). Use the following *statistical notations: P, n, t, r, F, G, U, df* (degrees of freedom), χ^2, 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), also in figures and tables.

Latin words or expressions should be written in italics (*e.g.*, *i.e.*, *c.*, *et al.*, *in vitro*, *in vivo*, *sensu*, *a priori*). The same rule applies to words in a language distinct from the manuscript language, *i.e.*, English, but does not apply to references, which follow distinct format rules, as indicated below. Numbers one to ten should be written out, unless a measurement (*e.g.*, four birds, 6 mm, 2 min); from 11 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); Two authors are cited in text with "&" (*e.g.* Aleixo & Pacheco 2006). Three or more authors must be presented as the first author followed by *et al.* (*e.g.* Aleixo *et al.* 2013). Avoid multiple citations in text, such as more than 3 references to support an idea or information. Multiple references should be listed in chronological order (*e.g.* Sick 1997; Narosky & Yzurieta 2003; BirdLife International 2015).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, M.Sc. Dissertations and Doctoral Thesis) and *meeting abstracts* should be cited only exceptionally, in cases they are absolutely essential and no alternative source exists. 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*. Brasilia: Editora Universidade de Brasilia.

Book Chapters

Thiollay J.M. 1994. Family Accipitridae (hawks and eagles), p. 52–205. In: del Hoyo J., Elliott A. & Sargatal J. (eds.). *Handbook of birds of the world, v. 2 (New World vultures to guineafowl)*. Barcelona: Lynx Editions.

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. Thesis. Rio Claro: Faculdade de Filosofia, Ciencias e Letras de Rio Claro.

Cavalcanti L.M.P. 2014. *Sazonalidade na estação reprodutiva de aves de uma área de Caatinga e sua relação com a precipitação.* Bachelor's Monograph. Mossoró: Universidade Federal Rural do Semiárido.

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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).

Pinheiro R.T. 2009. [WA589090, *Celeus obrieni* Short, 1973]. http://www.wikiaves.com/589090 (access on 05 March 2012).

Footnotes will not be accepted in the text, but should be used in exceptional cases, or in tables.

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, AI, EPS, WMF or XLS; minimum resolution of 300 dpi) of the original figures will be requested. Tables and figures will receive independent numbering. In the text, mentioning figures and tables must follow the pattern: "(Fig. 2)" or "... in Fig. 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.

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