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Capa: O Gritador-do-Nordeste (*Cichlocolaptes mazarbarnetti*) pousado na bromélia *Hohenbergia pernambucensis*, ambas espécies endêmicas da Floresta Atlântica de Alagoas e Pernambuco. Fotoarte preparada por Rolf Grantsau baseado em fotografias detalhadas do holótipo (MN 34530).

Cover: Cryptic Treehunter (*Cichlocolaptes mazarbarnetti*) in a bromeliad *Hohenbergia pernambucentris,* both endemic of Alagoas and Pernambuco Atlantic Forest. Photoart made by Rolf Grantsau on the basis of detailed photos of the holotype (MN 34530).

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Juan Mazar Barnett (1975-2012)

Do not stand at my grave and weep,
I am not there; I do not sleep.
I am a thousand winds that blow,
I am the diamond glints on snow,
I am the sunlight on ripened grain,
I am the gentle autumn rain.
When you awaken in the morning's hush
I am the swift uplifting rush
Of quiet birds in circled flight.
I am the soft stars that shine at night.
Do not stand at my grave and cry,
I am not there; I did not die.

Mary Elizabeth Frye

Preface

It was during the XIX meeting of the Brazilian Ornithological Society (SBO), on 20 November 2012, that the appalling news of Juan's untimely departure arrived. The unexpected and sad news spread virally among the participants of the meeting in Maceió. A few hours after the message had arrived in my cell phone, the entire society was in shock. For the rest of the meeting, Juan's premature death was the subject of every table; messages of condolences were politely extended to me and Juan's closest friends; pictures of him appeared in many talks, and a minute of silence was offered during the meeting's closing plenary. It was very clear to me at that moment that Neotropical ornithology had just lost not only one of its most talented ornithologists, but also one of the most beloved and respected members of our society. It was immediately apparent that this guy had a bunch of friends. It was particularly touching that all this occurred in Brazil. Despite the fact that Juan was born in Argentina, where he lived most of his life, it can be said that Juan was half Brazilian. If not in blood and documentation, in spirit and ornithological interests. He simply loved everything that Brazil represented. He had probably spent more time birding in Brazil than in any other country in the world, besides Argentina.

It was during the meeting that the idea of a special volume honoring Juan came to mind. It seemed the most obvious way to pay our respects to a gifted scientist and dear friend, someone who had made a lasting contribution on both Neotropical and Brazilian ornithology. Many important members of the SBO, such as Carla Fontana, Luis Pedreira Gonçaga, Luis Fabio Silveira, and Marcos Raposo, immediately supported the idea, and Alexandre Aleixo, editor in Chief of the Revista Brasileira de Ornitologia (RBO), swiftly accepted the proposal of having a special volume honoring Juan.

This volume represents the efforts of many of us, including the co-editor of this volume, Catherine L. Bechtoldt, whose Obsessive Compulsive Disorder (OCD) was put to shine in reviewing and editing every paper submitted to us. Each one of the papers presented in this special issue has been peer reviewed by at least two anonymous reviewers, and we hope the quality of the papers will represent a new standard for the journal of our society. I also would like to thank the many reviewers, many of which had to read and comment on the manuscripts within ridiculously short deadlines. I am also particularly grateful to Santiago Claramunt, who discussed with me many matters concerning this special issue. I am fully aware that many of Juan's close friends could not contribute papers to this special issue, mostly due to their busy agendas, loaded with fieldwork and other duties. I am sure, however, that many other articles, in this and other journals, will pay tribute to Juan in the following years. I would like to extend my gratitude to the many professionals that devoted their precious time in reviewing and commenting on the articles here presented. I would also like to thank Suzany Menezes for helping on the final editing of some of the articles. I am particularly grateful to Regina Bueno, who was responsible for creating the final art, dealing with the drawings, and the many last minutes requests to build the PDFs.

As expected, most of the papers presented in this special volume had something to do with Juan. In fact, five of the contributions were posthumously authored or co-authored by Juan himself. Some of the manuscripts were almost ready and had been waiting in Juan's computer to see the light. Others were just on Juan's to-do list, and the efforts of his co-authors made sure they would see the light. Articles where submitted by 56 authors from eight different countries, including Argentina (20), Belgium (1), Brazil (23), England (5), Holland (1), Paraguay (3), USA (3), and Uruguay (1). The current volume is divided into three main themes, all of which were Juan's favorites, and include taxonomy and systematics, inventories and distribution, and natural history.

The first article possibly represents one of Juan's most important discoveries; a new species of *Cichlocolaptes* Treehunter (Furnariidae) that inhabits the vanishing patches of Atlantic Forest in the Brazilian northeast. A cryptic species that is already on the brink of extinction (if not already extinct), this new species has been under study for more than 10 years by Juan and Dante Buzzetti (co-author of the article, and responsible for dealing with the final versions of the manuscript, and for naming the new species after his dear friend). Juan's delay in submitting his amazing discovery laid in the fact that no specimen was available, and there was a consensus among conservation leaders that collecting one individual of an already tiny population would be unwise. Fortunately, Juan and Dante found a specimen lying in the drawers of the Museu Nacional in Rio de Janeiro, labeled as the very similar Alagoas Foliage-gleaner (*Phylidor novaesi*), which they were allowed to study and measure. Although that was great news, they remained with only two specimens, which has always been problematic for science. Unfortunately, getting DNA samples from those specimens (the most obvious step to make the final point) was not possible at the time. Juan and Dante remained solely with their observations, recordings, and two specimens at the museum. Despite a general skepticism on part of the ornithological community, Juan and Dante were convinced of their discovery and decided to inform the world, raising a hypothesis that can be easily tested using molecular tools and making the best use possible of a museum specimen. As an editor of this volume, I believe the publication of their manuscript (even if based on two specimens) will boost our scientific knowledge and rapidly encourage other scientists to obtain the molecular and/or anatomical data needed to test whether there are indeed two distinct species involved in the original series of *Phylidor novaesi*.

The second article, authored by Santiago Claramunt, represents an independent assessment of the morphometrics of the specimens of *Phylidor novaesi* at the Museu Nacional, including the alleged new Treehunter, giving support to the existence of a *Cichlocolaptes* within the series. The last article in the systematics and taxonomy section is authored by Victor Piacentini and Fernando Pacheco and deals with the correct scientific name for the Glittering-bellied Emerald (*Chlorostilbon lucidus*), and represents a topic that Juan and Victor had discussed previously.

The following six articles report avian inventories and new distributional data from regions as diverse as the dry Caatinga woodlands, the Amazon forest, the Andes, the Paraguayan Chaco, and Patagonia. The first of these articles, led by Alex Lees and co-authored by some of the most important figures in Brazilian ornithology, including the curators of the largest bird collections in the country, is a call for attention and a roadmap for improvement of avian inventories. This article was envisioned many years ago, even before Alex had visited the Neotropics and was influenced by a chat with Juan about the importance of avian inventories in *The Fat Cat* pub, in Norwich, UK. The second article is about the avifauna of Curaçá (Mazar Barnett *et al.* 2014a) and reports the findings of two research groups in what used to be the "land of the Spix" (*a terra da ararinha-azul*), the last stronghold of *Cyanopsitta spixii*. This paper was long due, and it has a very special meaning for some of us, who shared an unforgettable summer with Juan in the field. It took 17 years to get these data published, and is particularly encouraging that the observations obtained in 1997 were complemented by new generations of ornithologists that visited Curaçá in 2011. Juan's summer in Curaçá was a defining moment in his life, and a source of fond memories. One can only be touched by the memory of Juan running through the Caatinga after having seen *Cyanopsitta* for the first time. This paper shows the importance of documenting our field observations. The bulk of the records presented in that paper came from Juan's careful notes and tape recordings. These previously unpublished notes include the description of unknown breeding behaviors, daily observations, and some of the last observations of a species that can no longer be found in the wild. These observations of the last Spix's Macaw in Curaçá represent a piece of history that could have been lost forever, were not by the careful notes taken by Juan; notes that were written in the dark with the help of a gas lamp, after long days in the field.

Laranjeiras and collaborators (2014) present their study of what must be now the most species-rich National Park in Brazil. Their inventory of Viruá National Park and neighboring areas is the result of 13 years of fieldwork. Juan was one of the first ornithologists to step into that park in 2001, when inventories at Viruá NP began.

We then have yet another new country record for Argentina coauthored by Juan and some of his greatest friends (Mazar Barnett *et al.* 2014b). They present the first records of *Orochelidon andecola* in Argentina, including nothing less than 40 localities for the country. This study was organized by Nacho Areta, who had the difficult task of compiling data from 14 authors.

Paul Smith and collaborators (Smith *et al.* 2014) present distributional and habitat preference data on five species of Doraditos (*Pseudocolopteryx* spp.) that occur in Paraguay, including a new species for the country. Rob Clay, the senior author of the article, was one of Juan's closest friends, and he remembers vividly how some of the data presented in their article were the topic of their last conversation together.

The last distributional article, authored by Ignacio (Kini) Roesler and collaborators (2014), also includes some of Juan's closest friends in Argentina. In their paper, they update the distributional knowledge for 21 species from Santa Cruz, including five new to the Province. Santa Cruz was one of Juan's favorites places in the world, and he had spent several months conducting fieldwork in southern Patagonia. It was in Santa Cruz that he made one of his finest ornithological findings, rediscovering the Austral Rail (*Rallus antarcticus*) after decades without records.

Finally, we present seven articles dealing with the natural history of Neotropical birds, including breeding and behavioral data. The first article, posthumously authored by Juan (Mazar Barnett *et al.* 2014c) and organized by myself, deals with the breeding biology of the Pygmy Nightjar (*Nyctipolus hirundinaceus*) in the Caatinga of Bahia. This article is based on data collected 17 years ago and a first draft of it was sent by Juan to me a couple of years ago. Therefore, this article also represents unfinished business for us, and I am particularly happy that these data finally see the light. This old dataset was complemented by the observations of new generations of ornithologists, which greatly improved the geographical scope of the manuscript. Finally, this article shows the importance of online data resources, such as Wikiaves (wikiaves.com.br), from which we were able to reveal the seasonal breeding patterns of the Pygmy Nightjar. The article is accompanied by a second one, which deals with the habitat preference of this species (Ingels *et al.* 2014) and demonstrates the importance of long-distance data sharing. This paper is authored by four researchers from different countries, and it also presents data obtained in Curaçá some 17 years ago by Juan.

The next article, published by Rob Clay, Juan, and Estela Esquivel (Clay *et al*. 2014), also represents the redemption of data collected 17 years ago. A few months after going to Curaçá, Juan spent several months in Paraguay in 1997, as an intern of the Proyecto Aguara Ñu. Juan was instrumental in the re-discovery of the White-winged Nightjar (*Eleothreptus candicans*), "the phantom of the *Cerrado*," in Paraguay. Their studies on this species were so important, that Rob Pople, also an intern at the project decided to devote several years of his life to study the White-winged Nightjar. The article presented by Pople (2014) reports the first comprehensive description of the breeding biology of the White-winged Nightjar, based on data collected during three years in Paraguay. This possibly represents the most authoritative study on the breeding biology of any Neotropical nightjar, and I am sure Juan would be delighted to see the fruits of his earlier discovery.

We then, need to move from the Paraguayan *Cerrado* to the *Chaco*, where Dan Brooks (2014) studied seriemas. A group of animals that has always fascinated Juan. We are fortunate to have this note ornamented by his beautiful painting.

The following article, by Rosendo Fraga and Santo D'Angelo (2014), is about the natural history of the Pale Baywing (*Agelaioides fringillarius*), a Brazilian endemic that inhabits the *Caatinga*. Fraga and D'Angelo show that this species presents cooperative breeding, an observation made 17 years ago by Juan, and briefly mentioned in Mazar Barnett *et al*. (2014a).

Finally, Juan Klavins and co-authors (2014) describe the 'anting' behavior of the White-throated Woodcreeper (*Xiphocolaptes albicollis*), but involving millipedes instead of army ants. These kind of data fascinated Juan, whose notebooks are full of such observations. Many of those observations are part of the more than 50 peer-reviewed articles that he has published, but many others will need collaborators to see the light.

I am deeply indebted to Cristina Ollua, Juan's mother, for sharing Juan's notebooks, photographs, and memories with me. Many of his friends swiftly responded to my request of localities, including Germán Pugnali, Hernán Casañas, Santiago Imberti, Rob Clay, Ricardo Clark, and Weber Girão. Together with the many authors that contributed with their studies. I would like to dedicate this entire volume to Juan, who has inspired many of us, and will continue to do so, as long as his memory remains with us.

Luciano Nicolás Naka

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ARTICLE

The legacy of Juan Mazar Barnett (1975–2012) to Neotropical ornithology

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ABSTRACT: Juan Mazar Barnett was an Argentinean scientist, considered by many as one of the most talented ornithologists of his generation. His untimely death at the early age of 37 shocked the Neotropical ornithological community. Here, I briefly present highlights of his ornithological career, from his early days in Argentina to his last research interests in NE Brazil. Juan's areas of research included five South American countries: Argentina, Brazil, Bolivia, Paraguay, and Chile, where he visited and conducted research in more than 300 localities. He was a prolific writer, having published 51 peer-reviewed articles and short communications, 12 book reviews, 2 audio guides, a book, and a bird identification guide. I present a list of all his publications organized in chronological order, and comment on his most important ornithological findings. Most of his research was conducted in Brazil (23 publications), followed by Argentina (19), and Paraguay (10). Most of his published research was conducted in the Atlantic Forest (13 publications), followed by the Andes and the *Cerrado* (7 publications each), the *Caatinga* (6), Patagonia and the *Yungas* (5 publications each). His preferred topics of research were: i) biogeography and avian distributions (17 publications); ii) breeding biology and natural history (9); iii) new country records for Argentina, Brazil, or Paraguay (8 publications); iv) taxonomy, including the description of a species new to science (7); v) conservation (5), and vi) rediscoveries of species thought to be extinct or lost to science (4). Since his death in 2012, he has been a co-author on 7 publications (five of them as first author), showing that his legacy cannot be fully appraised yet. I hope this work will show the amazing legacy left by Juan to other Neotropical ornithologists, particularly for his many friends, who through different initiatives are keeping his memory alive. Hopefully, the new generations will see that conducting fieldwork in the Neotropics is among the most rewarding experiences a biologist can have.

KEY WORDS: Argentina, Brazil, Neotropics, ornithologist, field notes, field research.

Juan Mazar Barnett was born in Buenos Aires, Argentina, in March 1975, and was probably one of the most talented ornithologists born in the Neotropics. Juan had several attributes that turned him into an outstanding field ornithologist, even as a young boy. With an almost pathological interest in birds, he was not only familiar with the species in the field, including their vocalizations, behavior, field marks, and habitat preferences, but also with their distribution patterns, taxonomy, systematics, and evolutionary history. These features rapidly transformed him in an ornithological guru for novices and seasoned ornithologists alike, particularly in Argentina.

Juan's field's experience was difficult to match. During his early years he visited every corner of Argentina in search of birds, and as a young man he travelled widely in other South American countries, particularly Brazil, Paraguay, and Bolivia (Figure 1). Overall, he conducted research in more than 300 localities in eastern and southern South America (Figure 2). Most of his observations and trips are well described in his more than 20 field catalogues (particularly for the 1989 – 2002 period). Along with bird lists and descriptions of sites, his field notes are filled with beautiful drawings, careful behavioral notes, descriptions of nests, eggs, chicks, and anything that drew the attention to the young naturalist (Figures 3 and 4). His most impressive quality, however, was how well he understood birds. He somehow knew where to look for them, and where even avian ghosts lost for decades should be found.

He was only 37 years old when he passed away, following a long disease that kept him at home for months at a time during the last eight years of his life. His untimely departure left many of us finishing the projects we had started together, and with the difficult task of trying to tell his story, as a way of paying tribute to a dear friend and great ornithologist. Several independent tributes have been launched already, including two long-term ornithological research grants ("Conservar la Argentina: Juan Mazar Barnett" implemented through Aves Argentinas, and the "Juan Mazar Barnett Conservation Award" established by the Neotropical Bird Club), three memorial articles (Naka 2013a and b; Lowen and Kirwan 2014), and two entire volumes honoring Juan (Neotropical Birding and this one at the Revista Brasileira de Ornitologia). Many other tributes are on their way, and these need to be seen not only as recognition of his ornithological expertise, but mostly as a celebration of his friendship that has touched so many souls. Additionally, in June 2014 a new avian genus honoring Juan was established: *Mazaria propinqua* is a unique bird that dwells on Amazonian river islands (Claramunt 2014). In the current volume, Dante Buzzetti (Juan's long-time friend) decided to name a new species (discovered by both authors) after him (Mazar Barnett and Buzzetti 2014). Therefore, *Mazaria* and *mazarbarnetti* are names that will likely stay with us for a long time, reminding us of Juan's legacy to Neotropical ornithology.

Juan's biography, personal life, and motivations had been reviewed elsewhere (Naka, 2013a and b), and will not be discussed in detail in this article. Here, I will face

FIGURE 1. Clockwise from upper left. Juan at the Ilhas Moleques do Sul, Santa Catarina, Brazil; Exploring the high Andes at Abra de Lizoite (4.400 m), Jujuy Province, Argentina; Juan, with a Sickle-winged Nightjar (*Eleothreptus anomalus*) at Isla Yaciretá, Paraguay (December, 2001); Enjoying the best grape juice in Bonito, Mato Grosso do Sul; posing with the Wandering Albatross (*Diomedea exulans*) at Prion Island, Antarctica in 2010.

the difficult task of presenting Juan's major contributions to Neotropical ornithology. To do so, I gathered data from several sources, including his published articles and notes, his detailed field catalogues, audio recordings, online databases, and photographs. Much of the data presented here was obtained from his closest friends and family. In this article, I provide a map with the localities where Juan conducted ornithological research in the Neotropics (Figure 2). It is very likely that many other localities visited by Juan went unnoticed by his friends or me. Therefore, the map here presented represents a conservative estimate of the amount of fieldwork he has endured in the Neotropics. I also analyzed his publications to report the geographical biases of his studies in terms of countries and biomes explored, and present a quantitative assessment of the main research topics on which he published ornithological data. I will then divide this article into the main topics that directed his research as a way to organize his lasting contribution to Neotropical ornithology.

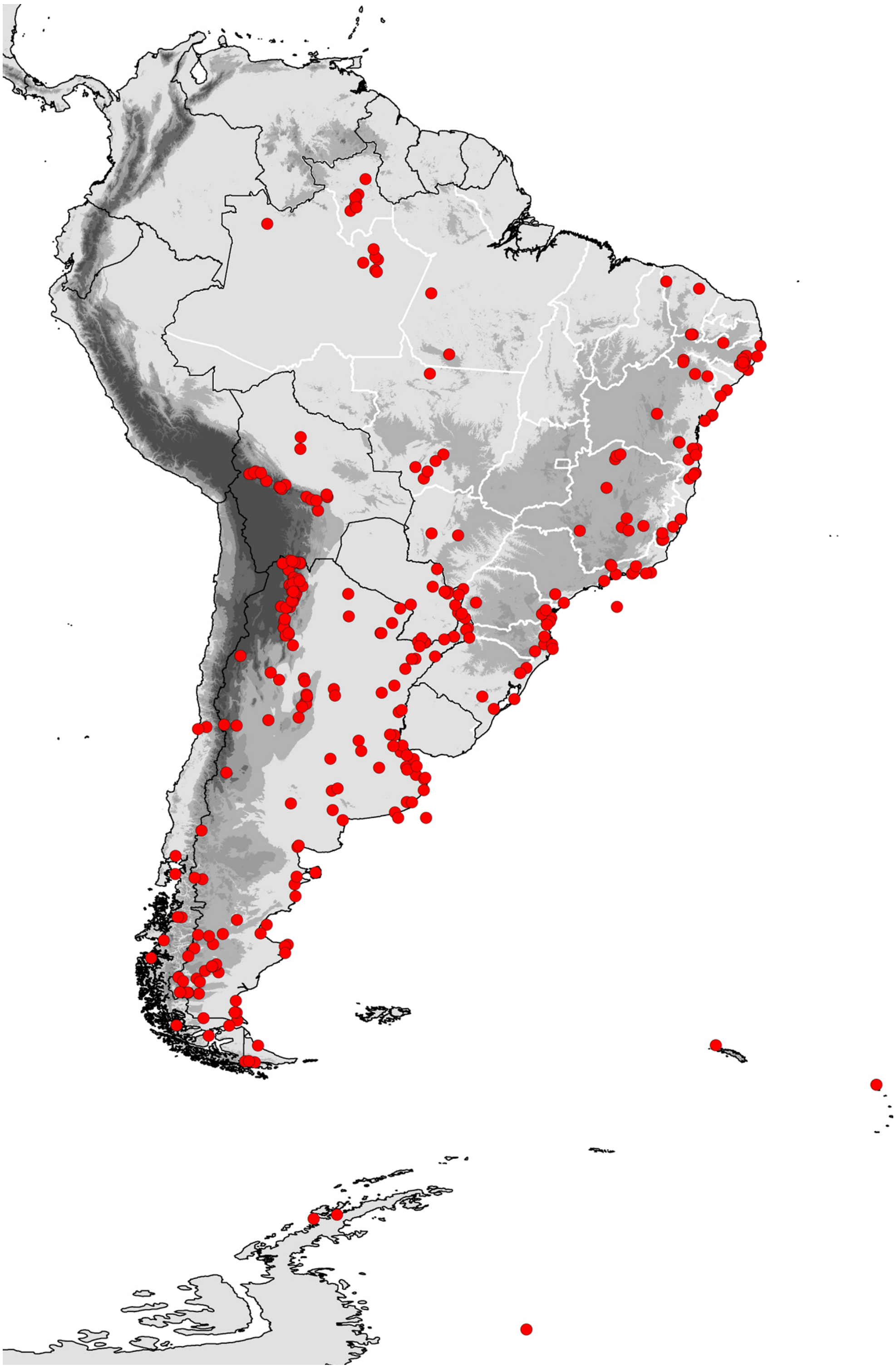

FIGURE 2. Localities were Juan Mazar Barnett conducted ornithological fieldwork in South America and Antarctica, between 1985 and 2012.

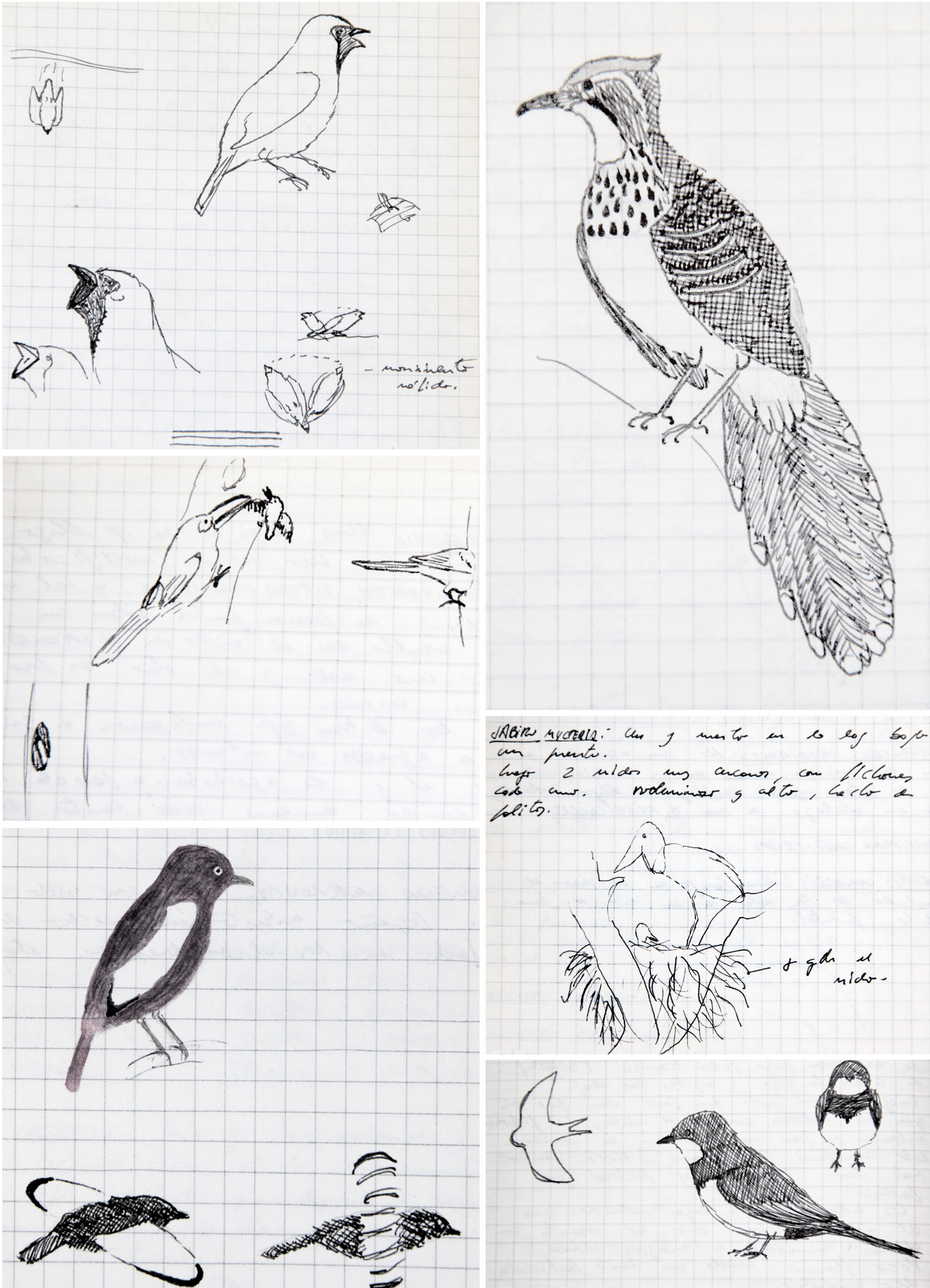

FIGURE 3. Art by Juan Mazar Barnett. Photographs taken from his field catalogues. Field sketches depicting interesting behaviors. Clockwise from top left. Male display of the Bare-throated Bellbird (*Procnias nudicollis*); Pheasant Cuckoo (*Dromococcyx phasianellus*); nesting Jabiru (*Jabiru mycteria*); Black-collared Swallow (*Pygochelidon melanoleuca*) Parque Nacional Iguazú, Misiones, Argentina (19 Sept, 1994); White-winged Cotinga (*Xipholena atropurpurea*) Reserva Biologica Linhares, Espirito Santo, Brazil (18 March, 1997); Saffron Toucanet (*Pteroglossus bailloni*) trapped in a hole.

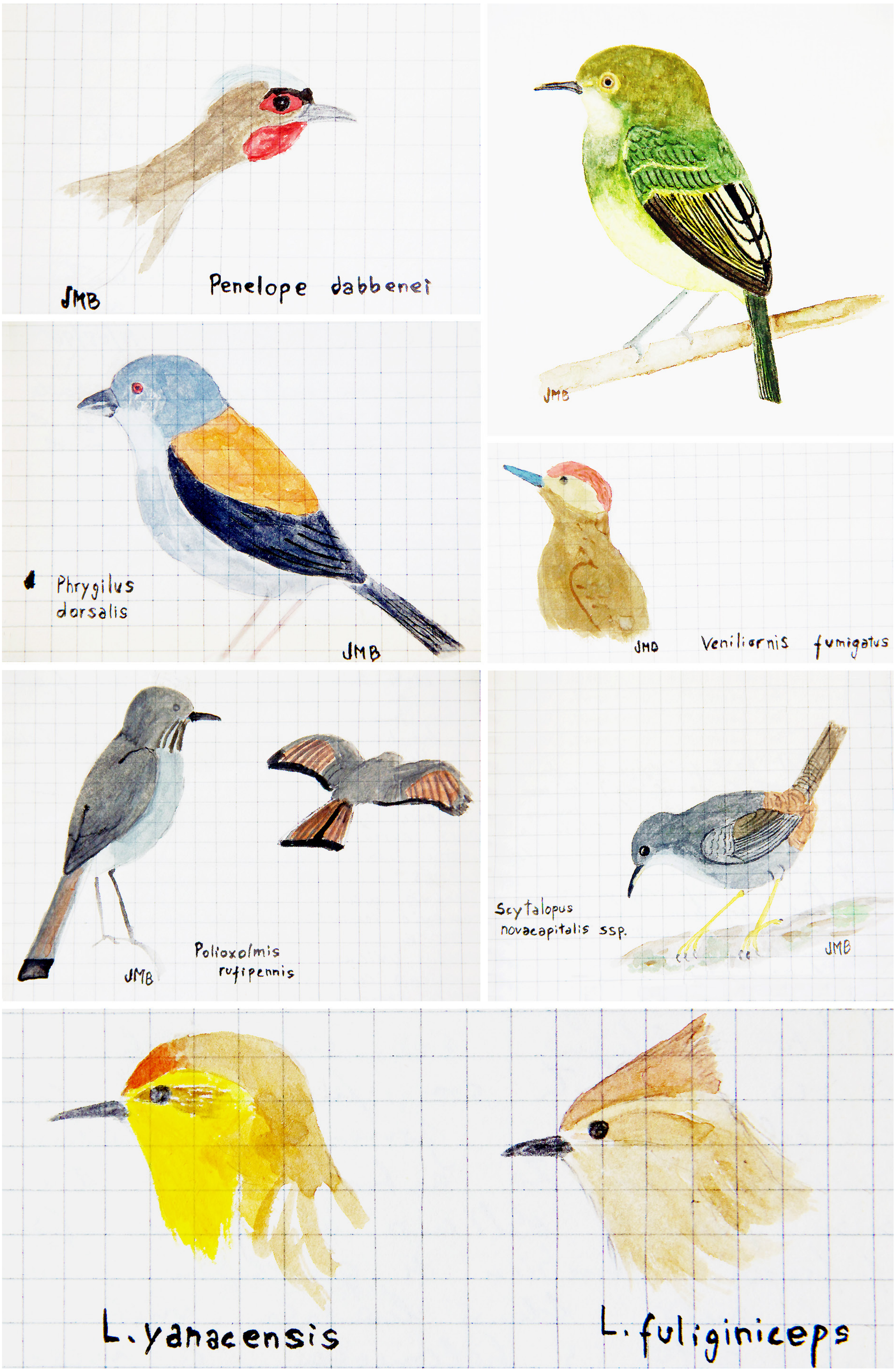

FIGURE 4. Art by Juan Mazar Barnett. Photographs taken from his field catalogues. Clockwise from top left: Red-faced Guan (*Penelope dabbenei*), Alto Calilegua, Jujuy, Argentina (10 July, 1996); Kaempfer's Tody Tyrant (*Hemitriccus kaempferi*), Santa Catarina, Brazil; Smoky-brown Woodpecker (*Veniliornis fumigatus*), Parque Nacional Calilegua, Jujuy, Argentina (26 July, 1996); Brasilia Tapaculo (*Scytalopus novacapitalis*), Parque Nacional Serra da Canastra, Minas Gerais, Brazil (17 December, 1996); Tawny Tit-spinetail (*Leptasthenura yanacensis*) and brown-capped Tit-spinetail (*L. fuliginiceps*), Alto Calilegua, Jujuy (10 August, 1996); Rufous-webbed Bush Tyrant (*Polioxolmis rufipennis*) and Red-backed Sierra Finch (*Phrygilus dorsalis*), NW Argentina.

Scientific legacy

Juan was a prolific writer. With more than 50 scientific articles published, he was among the most active ornithologists of his generation. He was particularly good at documenting his discoveries, and his research has been published in 13 peer-reviewed scientific journals (see references). His ornithological interests were broad, but most of his published research involved articles on biogeography and avian distribution (17 articles), breeding biology and natural history (9), new country records (8), taxonomic studies (7), conservation, and (5) rediscovery of species lost to science (4; Figure 5). Besides his peer-reviewed work, he has published a book, co-authored two audio guides, wrote a field guide, and made more than 12 book reviews, all of which are full of sharp comments.

Although he was born and lived most of his life in Argentina, the majority of his published research was conducted in Brazil (23 publications), followed by Argentina (19), and Paraguay (10; Figure 6). He was a versatile ornithologist, capable of conducting accurate avian inventories in virtually all Neotropical ecosystems in the countries he had visited. Most of his publications reported on his findings from the Atlantic Forest (13 publications), followed by the Andes and the *Cerrado* (7 publications each), the *Caatinga* (6), and Patagonia and the *Yungas* (5 publications each; Figure 7). Amazonia, the Pampas, and marine ecosystems contributed with 2 publications each.

It is noteworthy that Juan published more on Brazilian birds than any other country, including his own, Argentina. Brazil not only represented the country with the highest numbers of publications, but Brazilian habitats ranked among the three biomes from where he published the most data: the Atlantic Forest, the *Cerrado*, and the *Caatinga* (although most of his research in the *Cerrado* was conducted in Paraguay). Juan simply loved Brazil. This country, like no other, offered him super-diverse tropical habitats, great friends, delicious tropical fruits, and the most amazing birds.

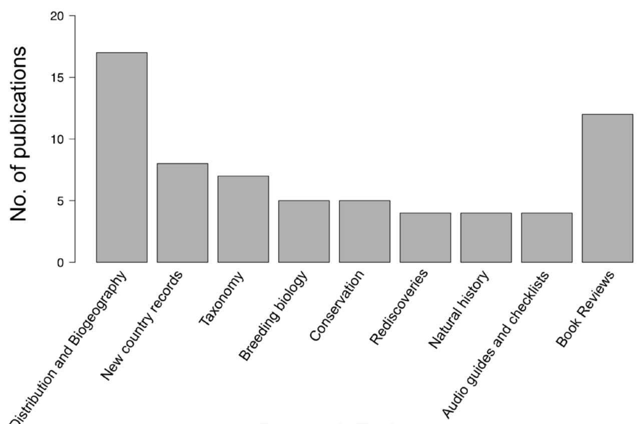

FIGURE 5. Number of publications authored by Juan Mazar Barnett between 1996 and 2014 organized by topic of research.

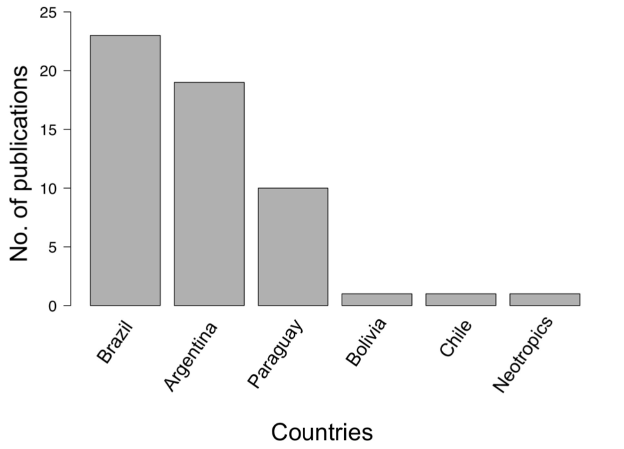

FIGURE 6. Number of publications authored by Juan Mazar Barnett between 1996 and 2014 organized by country were research was conducted.

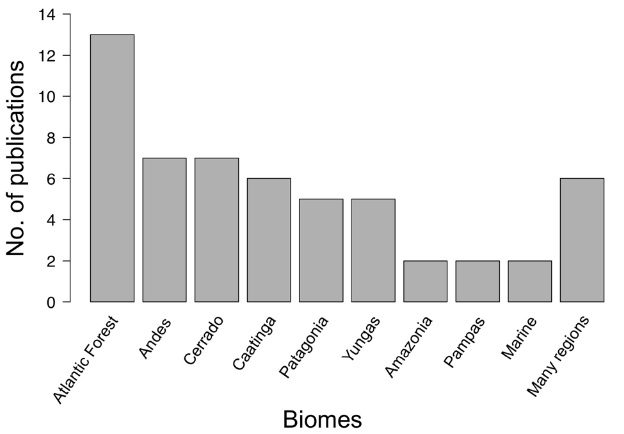

FIGURE 7. Number of publications authored by Juan Mazar Barnett between 1996 and 2014 organized by Biome were research was conducted.

New country records

Juan started his scientific career at the age of 21, when he published his first article reporting a new country record for Argentina: the Sooty Grassquit (*Tiaris fuliginosa*) found in Misiones (Mazar Barnett and Herrera 1996). Then, he documented the presence of Terek Sandpiper (*Xenus cinereus*) in Brazil (Mazar Barnett 1997b). In the following years, he published another three new country records for Argentina: the Giant Conebill (*Oreomanes fraseri*) in the Andes (Mazar Barnett *et al.* 1998d), the Pink-footed Shearwater (*Puffinus creatopus*) from coastal Patagonia (but found in the drawers of the Museo Argentino de Ciencias Naturales in Buenos Aires; Mazar Barnett and Navas 1998), and the Bolivian Warbling-finch (*Poospiza boliviana*) in NW Argentina (Mazar Barnett *et al.* 2001). Then followed Paraguay, where he discovered two new species for the country, including the globally threatened Lesser Nothura (*Nothura minor*) (Capper *et al.* 2001b; Mazar Barnett *et al.* 2004a). Besides those first country records, Juan had always paid attention to unusual findings, and in 1998 he reported extra-limital records for the Rough-legged Tyrannulet (*Phyllomyias burmeisteri*) in Argentina (Mazar Barnett 1999b), and the Ocellated Crake (*Micropygia schomburgkii*) in coastal São Paulo, Brazil (Mazar Barnett 1999b). In the present volume, Juan authors posthumously yet another avian discovery for Argentina: the Andean Swallow (*Orochelidon andecola*; Mazar Barnett *et al.* 2014c).

Biogeography and avian distribution

Juan has always been fascinated by avian distribution patterns, and most of his publications deal with this kind of data. His first biogeographical studies included Argentinean birds, most notably birds form the Andes. Juan first co-authored notes on the rare Plushcap (*Catamblyrhynchus diadema*; Di Giacomo *et al.* 1997), a bird with just a handful of previous records in Argentina. Subsequently he described the ghostly presence of the Lyre-tailed Nightjar (*Uropsalis lyra*) in Argentina (Mazar Barnett *et al.* 1998c), and published notes on other rare Andean birds (Mazar Barnett et al. 1998a, 2001), several of which were previously known in Argentina from just one or two records. Those initial papers were followed by many others, including a range expansion for the White-sided Hillstar (*Oreotrochilus leucopleurus*; Mazar Barnett 2001b); comments on the migratory status of the Patagonian population of the Striped Woodpecker (*Picoides lignarius*; Mazar Barnett 2003b); data on the Broad-Winged Hawk (*Buteo platypterus*), considered a rare visitor in Argentina (Roesler and Mazar Barnett 2004); the first nesting evidence of the Wedge-tailed Hillstar (*Oreotrochilus adela*) in Argentina (Areta *et al.* 2006); and new distributional data for the Magellanic Plover (*Pluvianellus socialis*) and the Crested Doradito (*Pseudocolopteryx sclateri*) in Buenos Aires (Lowen *et al.* 2009). All his experience in Argentina was then put to service in one of Juan's most important contributions, an "Annotated Checklist of the Birds of Argentina" (Mazar Barnett and Pearman 2001), the most comprehensive work of the Argentinean avifauna, later updated online (Mazar Barnett and Pearman 2009) and still a fundamental source for any ornithologist interested in Argentinean birds.

Studies in Argentina were followed by those in other countries, most notably Paraguay, where Juan conducted intensive research between 1995 and 1998. He was part of an important era for the Paraguayan avifauna, following two very successful research projects: Proyecto Jacutinga and Proyecto Aguará Ñu, both lead by British ornithologists (Clay *et al.* 1998). Juan was a very active part of these projects and participated in their publications, which included many avian novelties and range extensions for Paraguay (Lowen *et al.* 1997a, b; Capper *et al.* 2001a, b). Additionally, a trip to the Argentinean-Paraguayan border resulted in the first nesting record of the South American Bittern (*Botaurus pinnatus*) in Paraguay (Mazar Barnett *et al.* 2002). Many of Juan's publications from Paraguay were related to the rediscovery, display description, and nesting behavior of the White-winged Nightjar (*Eleothreptus candicans*; see below). His studies in Paraguay culminated with a field guide "Aves de la Reserva Natural del Bosque Mbaracayú: Guía para la Identificación de 200 especies,"published by the Fundación Moisés Bertoni (Mazar Barnett and Madroño 2003).

After Paraguay, Juan began exploring Brazil, working his way north, from the south to the northeast. His first visits to Brazil were to the southern edge of the Atlantic Forest, in the states of Rio Grande do Sul, Santa Catarina, and Paraná. Some of his first contributions were from Santa Catarina, where he spent a good amount of time (Naka *et al.* 2000, 2001, Mazar Barnett *et al.* 2004b). As he gained experience with Brazilian birds, he intensively explored eastern Brazil, including the *Caatinga* and the Atlantic forest. His explorations of interior Minas Gerais and Bahia resulted in several publications, particularly those from the middle São Francisco Valley, at the southern tip of the *Caatinga* (Kirwan and Mazar Barnett 2001; Kirwan *et al.* 2004; Raposo *et al.* 2002).

The Brazilian northeast was a special place for Juan, both within the *Caatinga* realms in the semi-arid interior and the vanishing Atlantic Forest. During the summer of 1997 he visited Curaçá, in the dry interior of the state of Bahia (Figure 8), in order to work with the *Ararinha Azul Project*. His goal was to survey the region, which was the last stronghold of Spix's Macaw (*Cyanopsitta spixi*), a species at the brink of extinction and one of Juan's most wanted birds to see. During several weeks, he walked the dry woodlands of the region, and made detailed observations including records of almost 200 bird species, which are being reported in this volume (Mazar Barnett *et al.* 2014d). Additionally, he documented the presence of 98 bird species in more than 300 min of tape recordings, most of which remain the only documentation of those species in the area. Juan returned to Curaçá in January 2000, and his observations of the last Spix's Macaw were among the last ones made on the species in the wild (Barnett *et al.* 2014d). The Curaçá avian inventory took more than 16 years to be completed and published, but it was only possible because of Juan's careful notes and field effort obtained during that summer. Juan was also a generous soul, and readily shared the information that he gathered so meticulously. His observations of the behavior of the Pygmy Nightjar also resulted in two additional publications from Curaçá, also published in this volume (Ingels *et al.* 2014; Mazar Barnett *et al.* 2014a).

The Atlantic Forest of the Brazilian northeast captivated Juan like no other place, and from 2000 to

2004 he made several trips to this region. His first papers from the Brazilian northeast included data on a handful of poorly known birds from Alagoas, Sergipe, and Ceará (Kirwan and Mazar Barnett 2001), but soon he started paying attention to the highly endangered avifauna of the Pernambuco Area of Endemism (see Conservation). At that time, he also visited the Amazon, in the states of Amazonas, Pará, and Roraima, where he embarked on a three-week expedition along the Rio Branco (Naka *et al.* 2007). Part of the ornithological findings of that memorable trip are also being published in this volume (Laranjeiras *et al.* 2014).

FIGURE 8. Juan after pulling the car out of the mud in Curaçá (Bahia) in the Summer of 1997, with his friends and colleagues Yara de Melo Barros (on the wheel), Luciano N. Naka, and Andrei Langeloh Roos.

Lost birds to science: the science of rediscovery

Lost birds, or birds that lacked formal record for decades, have always attracted Juan's attention. As mentioned above, he first co-authored notes on rare Andean birds, many of which were very rare in Argentina at the time (Di Giacomo *et al.* 1997; Mazar Barnett *et al.* 1998a, c, 2001). His most important records, however, included those birds "lost to science" or even considered extinct. One of these was the Austral Rail (*Rallus antarcticus*), which remained unseen for nearly 40 years until Juan and his friends Santiago Imberti, Marco Della Seta, and Germán Pugnali rediscovered it in the marshes of southern Patagonia in Argentina (Mazar Barnett *et al.* 1998b) and Chile (Imberti and Mazar Barnett 1999). Juan also played a role in locating a new population of the extremely rare White-winged Nightjar, which remained elusive in the Paraguayan savannas, until its rediscovery in 1995 (Clay *et al.* 1998, 2001; Capper *et al.* 2001a). In Brazil, Juan was instrumental in documenting the rediscovery of another lost bird, Kaempfer's Tody-Tyrant (*Hemitriccus kaempferi*), an understory species previously unknown in life. Its existence rested solely in the type specimen collected by Kaempfer himself in 1929 and a second bird collected by H. F. Berla in 1950, but noticed by scientists only in the early 1990s (Mazar Barnett *et al.* 2000; Buzzetti *et al.* 2003a, b). With these credentials, Juan was optimistic about the survival in Paraguay of a small population of the Glaucous Macaw (*Anodorhynchus glaucus*), a bird that has been considered extinct since the mid-19th century. Two unidentified blue macaws seen and tape-recorded in flight during his fieldwork in Paraguay ignited this hope. Further expeditions to find these ghosts, however, proved unsuccessful.

Taxonomy

After being hooked on avian biogeography, Juan began to pay attention to taxonomy and systematics. He was particularly interested in patterns of geographic variation, and soon in his career he discussed the presence of different avian forms in Argentina, as was the case of the Wren-like Rushbird (*Phleocryptes melanops schoenobaenus*) in NW Argentina (Mazar Barnett 1999a). His studies in Minas Gerais showed a clear turn in Juan's interests when, together with a team of international researchers, he discussed the taxonomic relationships of the Minas Gerais Tyrannulet (*Phylloscartes roquettei*; Raposo *et al.* 2002), and a year later pointed out the need to reassign *Chordeiles vielliardi* to the genus *Nyctiprogne* (Whitney *et al.* 2003). He then described the nest of the Striated Softtail (*Thripophaga macroura*), a rare endemic bird of the Brazilian NE, but did so also analyzing other nests in the genus and studying the relationships of the genus based on nest architecture (Mazar Barnett and Kirwan 2004). By then, Juan had spent a good amount of time in Bolivia, where together with his friend and colleague Sebastian Herzog, he realized that there was an undescribed species of *Serpophaga* Tyrannulet in Bolivia and central Argentina (Herzog and Mazar Barnett 2004). His interest in taxonomy and systematics was growing fast; he conducted a pioneering molecular study to assess the "Taxonomy and biogeography of the South American species of the genus *Picoides*", a study that rendered him to graduate with first class honors in Ecology and Biology in 2001 at the University of East Anglia.

Breeding biology and natural history

Since Juan was a young ornithologist, he had been interested in natural history. Despite his interest in rare birds, Juan could spend hours looking at common birds in uncommon situations. One of his drawings ornamenting his field notes include a Saffron Toucanet (*Pteroglossus bailloni*) getting stuck in a hole, as it was trying to reach the content of a putative nest (Figure 3)! One aspect of bird behavior that have always attracted Juan's attention was breeding. Only a handful of nests described in his notebooks actually made it into print. One of the most memorable ones included a broken arm after falling from a Caracara's nest near Buenos Aires. One of his first articles mentioned above was actually entitled "Natural history notes on some little known birds in north-west Argentina" (Mazar Barnett *et al.* 1998a). Many of his notes were about nocturnal birds, such as owls and nightjars. Following his fieldwork in Paraguay, where he was part of the team that re-discovered the White-winged Nightjar, it was time to describe the reproductive display of this species (Clay *et al.* 2001). It took another 15 years to describe the eggs, chick, and nest-site of this species, which is finally being done in the current volume (Clay *et al.* 2014). In 2003, together with Dante Buzzetti, they described "the nest and eggs of two *Myrmeciza* antbirds endemic to the Atlantic Forest of Brazil" (Buzzetti and Mazar Barnett 2003). His field catalogues from Curaçá include detailed breeding information on more than 30 different species, including two undescribed nests, which are also being described in this volume: those of the Pygmy Nightjar (*Nyctipolus hirundinaceus*; Mazar Barnett *et al.* 2014a) and the Scarlet-throated Tanager (*Compsothraupis loricata*; Mazar Barnett *et al.* 2014b). Besides describing the nest of the Scarlet-throated Tanager, Juan's careful observations denoted that not only this species uses helpers to feed the young in the nest, but that they also use false nests to deceive possible predators. Mazar Barnett *et al.* (2014b) also described the amusing pantomimes of this tanager, as the male visited the false nest and moved its head as if feeding a non-existing young. In that same paper, Juan and collaborators also described the social and reproductive behavior of another *Caatinga* endemic, the Pale Baywing (*Agelaioides fringillarius*), providing evidence of the use of helpers as well, which came to be confirmed by Fraga and D'Angelo (2014), also in this volume.

Conservation

Besides obtaining a bachelor's degree at the University of East Anglia, his three years in the UK had a strong influence on his professional life. During his time in Europe, Juan worked in the Threatened Birds of the World Program of BirdLife International at Cambridge. Although conservation was not his main area of expertise, many of his projects were conservation-related, either in Paraguay (Clay *et al.* 1998), the Pampas (Lowen and Marzar Barnett 2010), Patagonia (Mazar Barnett *et al.* 2014b), or elsewhere in the Neotropics (Stouffer *et al.* 2011). Juan's interests in conservation were far beyond the academic exercise of modeling species lost. He could get overwhelmingly irritated, frustrated, and personally offended when witnessing the disastrous human management of nature.

Once he was back from Europe, Juan worked on several conservation projects in both Argentina and Brazil. In collaboration with the Sociedade para a Conservação das Aves (SAVE) he conducted fieldwork in NE Brazil, in Pernambuco and Alagoas between 1999 and 2003, where he witnessed the almost complete destruction of the Atlantic forests of the Pernambuco Area of Endemism. Possibly one of his largest contributions to conservation followed his discovery of "A new site for the Alagoas endemics" (Mazar Barnett *et al.* 2003), where he highlighted the presence of many endemic and endangered species in a forest fragment that had been overlooked until then. This discovery ignited "Renewed hope for the threatened avian endemics of northeastern Brazil" (Mazar Barnett *et al*. 2005), and his activities at the forest fragment were vital for the establishment of a privately owned reserve at Frei Caneca, in Pernambuco.

Avian vocalizations

Juan had always paid special attention to avian vocalizations, and was among the first in Argentina to embrace bioacoustics to conduct avian surveys in the early 1990s. He quickly built a very substantial collection of recordings. When he was in the field (which represented most of the time) he would hardly ever be seen without his tape recorder. He co-authored two audio guides, including "Sonidos de aves de Calilegua" (Krabbe et al. 2001), and "Bird sounds of Argentina and adjacent areas" (Imberti *et al*. 2009). Juan's generosity in sharing his data is apparent from his many recordings available in "Birds of Bolivia" (Mayer 2000), or freely available through xeno-canto (www.xeno-canto.org). His entire collection is currently being digitized and archived at the Macaulay Library, the largest avian audio repository in the world, and hopefully will be available for research purposes in the near future.

Concluding remarks

Looking at the map of the localities he visited, one can only recall his first steps in Patagonia when he was 9 years old, or in the *Yungas* of Calilegua. He has been a bright star since he was 12 years old, and he will continue to shine as long as we remember him with pride and love. Even in a relatively short life, he was able to leave a strong legacy to Neotropical ornithology, not only through his vast portfolio of publications, but mostly through the friendship and character that he has shown along the years. Many words have been said about his life, and the things that motivated him to spend several months in the field at a time. He simply never got tired of spending his time in the field. He never had enough birds. For those of us that outlived him, we can read his notes and hear his comments recorded on tape to have him back with us. I believe Juan lived his life the way he wanted to. He had an exceptional life; he was a master of his time and he will not be forgotten.

ACKNOWLEDGEMENTS

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ARTICLE

A new species of *Cichlocolaptes* Reichenbach 1853 (Furnariidae), the *'gritador-do-nordeste'*, an undescribed trace of the fading bird life of northeastern Brazil

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ABSTRACT: A new species of treehunter, *Cichlocolaptes mazarbarnetti sp. nov.*, is described from a specimen that for many years had been confused with *Philydor novaesi*. The morphology of this specimen, collected in 1986 at Pedra Branca, Murici, Alagoas, at 550 m elevation (currently the Murici Ecological Station), suggests its allocation in the genus *Cichlocolaptes*. The new species differs from *P. novaesi* by its considerably larger size, heavier body-mass, darker and more uniform forehead and crown, absence of buffy periocular-feathers, and a pale orange-rufous tail that contrasts with the rump and the rest of the dorsal plumage. It also has a flat-crowned appearance and a larger, deeper-based, and generally stouter bill. Behavioral specialization on bromeliads and vocal repertoire also suggest that the new species belongs in the genus *Cichlocolaptes*. The song of this species is markedly different from that of *P. novaesi*, and it closely matches that of *Cichlocolaptes leucophrus*. The new species is endemic to the 'Pernambuco Center' of endemism, where it inhabits dense, humid forests in hilly terrain. It is known from only two localities in northeastern Brazil, one each in the states of Alagoas and Pernambuco. Taken together, these areas contain less than 3,000 ha of suitable habitat for the species, where we estimate the population during our studies to have numbered no more than 10 individuals. We propose that this species should be categorized as Critically Endangered at a national and global level, and we consider the situation of its conservation to be critical in that it will require urgent action to avoid its global extinction.

KEY WORDS: Atlantic Forest, Conservation, Ovenbirds, *Philydor*, Taxonomy, Treehunter.

INTRODUCTION

Northeastern Brazil was the first area in the country to be settled by Europeans, when the Dutch arrived and established a colony that thrived along the coast between Maranhão and Sergipe in the period 1630-1654 (Rodrigues 1949, Cascudo 1956). The area that had been covered by extensive forests soon gave way to sugar-cane plantations, a habitat modification that is now five centuries old, and which may perhaps represent one of the oldest, large-scale habitat modifications produced by European colonies in South America. Despite its early economic exploitation, northeastern Brazil has been one of the most neglected areas in the country for biological exploration. Ornithological attention was drawn to this region, perhaps too late, as recently as the 1970s, when expeditions by the Museu Nacional do Rio de Janeiro (MN hereafter) resulted in the description of four new, endemic taxa in the state of Alagoas, from Fazenda Serra Branca (currently part of the Murici Ecological Station): Alagoas Foliage-gleaner *Philydor novaesi* (Teixeira & Gonzaga 1983a), Orange-bellied Antwren *Terenura sicki* (Teixeira & Gonzaga 1983b), Alagoas Antwren *Myrmotherula snowi* (Teixeira & Gonzaga 1985), and Alagoas Tyrannulet *Phylloscartes ceciliae* (Teixeira 1987). Even by the 1970s, forested areas throughout northeastern Brazil had already been much reduced, and they were found mostly on remote mountaintops (Teixeira & Gonzaga 1983a, Teixeira 1987). The present situation is even more desperate, in that only 1,907 km^2, or less than 2% of the original forests, remain (Silva & Tabarelli 2001). Despite the near total removal of natural habitats in this region, the forests still support undescribed bird taxa, as demonstrated by the recent description of a new pygmy-owl (Silva *et al.* 2002). Recent fieldwork at the Murici Ecological Station (hereafter Murici) by field ornithologists supported the extreme rarity of *P. novaesi* (Roda 2011; IUCN, 2012), which has been by far the rarest and most difficult to find element of the endemic avifauna of Murici, and which, until recently, was known exclusively from this one locality. During fieldwork at Murici on 12 October 2002, we observed and tape-recorded a bird that largely fit the plumage description of *P. novaesi*. This bird, however, differed from *P. novaesi* (or at least from *P. atricapillus*, its supposedly closely allied sister-taxon (Teixeira & Gonzaga 1983a, Remsen 2003) and with which we were familiar) in its behavior, general morphology and, most strikingly, in its voice. In fact, these characteristics suggested instead affinities with the genus *Cichlocolaptes*. These similarities were so striking that we quickly became convinced that *P. novaesi* had been wrongly described in the genus *Philydor*, and that it belonged instead in the genus *Cichlocolaptes*. We later learned that several colleagues had already reached this same conclusion some time before us (e.g., Andrew Whittaker and Kevin Zimmer). Nevertheless, in February 2003, we found *P. novaesi* in montane forests of the state of Pernambuco, at the Reserva Particular do Patrimônio Natural Frei Caneca (hereafter Frei Caneca) (Mazar Barnett *et al*. 2003, 2004), along with the other three endemic species of the 'Pernambuco Center' of endemism (Roda 2003). The behavior, morphology, and vocalizations of this bird were reminiscent of *P. atricapillus*, yet they contrasted strikingly with the ovenbird we had seen and heard at Murici. We realized that the bird seen in Pernambuco may represent the true *P. novaesi*, described by Teixeira & Gonzaga (1983a), and that the ovenbird we observed at Murici represented an undescribed species. Teixeira *et al.* (1987) mentioned a particularly large and heavy female specimen of *P. novaesi* secured at Murici, and our subsequent examination of the series of *P. novaesi* at MN further confirmed our hypothesis, as we found that the particularly large female specimen mentioned above represented an undescribed taxon distinct from *P. novaesi*.

MATERIAL AND METHODS

Morphology

We examined all specimens of *Philydor novaesi* at MN, which represents the entire available collection of the species, 35 specimens of the morphologically similar *P. atricapillus*, and 30 specimens of *Cichlocolaptes leucophrus* at MN, Museu de Zoologia da Universidade de São Paulo (MZUSP), and Museo Argentino de Ciencias Naturales (MACN) (Appendix 1). We measured the exposed culmen, wing chord, tail, and tarsus length of the specimens examined using a dial caliper to the nearest 0.1 mm. We took additional measurements on specimens of *P. novaesi:* distance from the commissure to the external nares, distance from the commissure to the bill tip, and the length of the 10th primary. Body mass, total length, bill coloration, wingspan, and gonad conditions were obtained from specimen labels. Remiges and rectrices were counted. Color names used in the description follow Smithe (1981) and Munsell (1994). Field observations were made using Zeiss and Swarovski 10 × 40 binoculars and a 15-45× spotting scope. Photographs of the specimens at MN were taken under natural light.

Vocalizations

We recorded vocalizations with Sony TCM 5000EV tape-recorders using Sennheiser ME66 and ME67 microphones. Original recordings are in the Arquivo Sonoro Dante Buzzetti (ASDCB), maintained by the second author. These recordings have been deposited at xeno-canto (www.xeno-canto.org). Additional recordings are available at other online collections, IBC/Lynx (http://ibc.lynxeds.com), the Macaulay Library (http://macaulaylibrary.org), and on Minns *et al.* (2009). Other recordings made by colleagues are listed in Appendix 2. Tape-recordings were digitized at 44.1 kHz with a 16 bit word-size. Spectrograms were produced in Cool Edit 2000 using a Blackman window with a resolution of 512 bands. Vocal variables were measured using screen cursors from the fundamental signals of the spectrograms. The variables measured were: total phrase duration, duration of intervals between notes, note length and frequency (defined as frequency at the point of highest amplitude) (*sensu* Isler *et al*. 1998). Note shape descriptions were made from spectrograms at the same scale as those in the figures. The name applied to each vocalization type in the repertoire of suboscines is not standardized, but we always attempted to compare homologous vocalizations (as indicated by their overall similarity) regardless of the name applied. Digitized recordings used to make sonograms and additional recordings are available at the second author's website: www.dantebuzzetti.com.br.

RESULTS

We propose to name the new species:

Cichlocolaptes mazarbarnetti sp. nov.

Cryptic Treehunter

gritador-do-nordeste

Holotype: Specimen N° 34530, study skin of an adult female deposited at the Museu Nacional do Rio de Janeiro (MN), collected on 16 January 1986 by Dante M. Teixeira at Serra Branca, Murici (currently Murici Ecological Station), 09° 15' S, 35° 50' W, 550 m above sea level, Alagoas State, Brazil.

Diagnosis: Differs from *Philydor novaesi* in its considerably heavier and longer body (Figure 1, Table 1), uniformly blackish crown, forehead and lores (speckled with light brown in *P. novaesi*, Figure 2); dark periocular-feathers (buffy eyering in *P. novaesi*); buffy supraloral-stripe (indistinct in *P. novaesi*, Figure 3); dark patches on sides of neck (absent in *P. novaesi*); longer and paler orange-rufous rectrices that contrast with the brown rump (upper-tail coverts are rufous like the rectrices in *P. novaesi*, Figure 4) and have rounded tips (mucronate in *P. novaesi*); larger, deeper-based, and more heavily built bill; a flat-crowned appearance (smaller bill and rounded head in *P. novaesi*, Figure 3). Differs from *Cichlocolaptes leucophrus* in having a uniform plumage that lacks buffy stripes on the ventral and dorsal regions of the body (Figure 5).

FIGURE 1. Adult female *Philydor novaesi* (MN 33873, left) and *Cichlocolaptes mazarbarnetti* (MN 34530, right).

FIGURE 2. Upper view of the heads of adult female *Philydor novaesi* (MN 33873, left) and *Cichlocolaptes mazarbarnetti* (MN 34530, right), showing differences in bill length and the coloration of the crown, forehead and lores.

FIGURE 3. Lateral view of the heads of adult female *Philydor novaesi* (MN 33873, left) and *Cichlocolaptes mazarbarnetti* (MN 34530, right), showing differences in the eyering, extension of the supercilium, head shape, and bill length and shape.

FIGURE 4. From left to right male and female *Philydor novaesi* (MN 33872 and 33873), female *Cichlocolaptes mazarbarnetti* at the center (MN 34530), and two male *Philydor novaesi* at right (MN 32028 and 32029, the latter the holotype), showing the differences in contrast between tail and rump color.

FIGURE 5. From left to right *Philydor atricapillus* (MN 39355), *P. novaesi* (MN 33873), *Cichlocolaptes mazarbarnetti* (MN 34530) and *C. leucophrus leucophrus* (MN 9021).

TABLE 1: Measurements of specimens of *Cichlocolaptes mazarbarnetti* and *Philydor novaesi* housed at MN. The values are presented in millimeters, with the exception of body mass, which was measured in grams.

Measurements	***Cichlocolaptes mazarbarnetti*** **Female *** **MN 34530**	***Philydor novaesi*** **Female**** **MN 33873**	***Philydor novaesi*** **Males** **MN 32028** **MN 32029** **MN 33872**	***Cichlocolaptes mazarbarnetti*** **Juvenile** **MN 34531**
body mass	48.0	30.0	32.0-34.0	36.0
exposed culmen	15.5	12.9	12.3-13.0	12.8
bill depth	6.8	6.3	6.3-6.7	6.6
bill width	5.0	4.7	4.0-4.3	4.6
nares to commissure	14.9	9.8	10.1-11.4	-
commissure to tip	28.9	22.6	22.2-22.7	-
wing chord	96.5	83.5	91.4-94.9	90.1
wingspan	320.0	280.0	-	305.0
length of 10th primary	80.2	64.5	72.6-75.4	73.8
tail	82.0	76.1	80.0-84.8	83.9
tarsus	22.9	20.7	22.2-22.6	22.6
total length	221.0	195.0	193.0-205.0	207.0

* The female *C. mazarbarnetti* had an ossified skull and a globulous ovary with one ovum > 2 mm (based on the specimen tags). We therefore treat it as an adult.
** The female *P. novaesi* had an ossified skull and a granular ovary (based on the specimen tags), and is thus treated as an adult.

Description of the Holotype: Crown and forehead Jet-Black (3.2PB 1.6/0.5). Back of the neck, back, and rump Cinnamon-Brown (7.0YR 4.0/4.0). Tail Pale Orange-Rufous (2.5YR 5.0/8.0), with the central rectrices darker dorsally. Throat, sides of head, supercilium and supraloral-stripe Pinkish-Buff (0.4Y 7.5/4.3). Auriculars and moustachial region Pinkish-Buff, with dusky streaking. Lower throat and sides of neck Cinnamon-Brown (7.0YR 4.0/4.0). Breast, belly, and underwing coverts Cinnamon (8.7YR 5.0/6.0). Thighs, flanks and undertail coverts Prout's Brown (6.5YR 3.5/3.0). Remiges Vandyke Brown (5.0YR 3.5/2.5), with Cream-colored (3.5Y 8.5/5.5) fringes, wing-coverts darker than the remiges. Irides brown (from specimen label). Tarsi and toes in the dried skin Grayish-Olive (5.0 Y 4.8/2.5). Upper mandible black, lower mandible paler, and both with sides grayish in the dried skin. Total length 221.0 mm (from specimen label), exposed culmen 15.5 mm, wing chord 96.5 mm, tail 82.0 mm (but R1 and R2 were still growing), tarsus 23.2 mm, and body mass 48.0 g (from specimen label).

Etymology: The second author dedicates the name of the new species to the first author, a good friend and colleague who suddenly passed away before this manuscript was finished, in recognition of his important contributions to the conservation of the Atlantic Forest in northeastern Brazil and its declining avifauna. For the English name we propose Cryptic Treehunter because it is difficult to find and, particularly, to separate from *Philydor novaesi* in the field. We propose naming this species gritador-do-nordeste in Portuguese. 'Gritador' (meaning 'screamer') is an apt name given the loudness of its vocalizations, but it also represents a figure in Brazilian folklore. The story of the 'Gritador' is that of two brothers who went hunting and one accidentally shot the other. In desperation, he shot himself, and now his soul sometimes can be heard as it wanders through the forest in the top of the hills, screaming in pain while searching for his brother. A parallel can be drawn with the story of the 'Gritador', as *C. mazarbarnetti* can be heard 'screaming' while wandering through the hilltop forest searching in vain for his 'brothers', in this case due to the scarcity of the species.

Additional specimen: Immature female MN 34531 collected on 20 January 1986. This specimen is larger than *P. novaesi*, even the males, though it does not approach the size and body mass of MN 34530 (see Table 1). It measured 207 mm in total length and 36 g. Like the holotype of *C. mazarbarnetti*, this specimen has the rump and sides of neck browner, the plumage more orange than any *P. novaesi*, and the crown and lores unmarked and blackish, and it lacks the buffy eyering (Figure 6). Although collected four days later, this specimen was presumed to be the same bird seen accompanying the holotype when it was collected (Dante M. Teixeira *pers. com.*, 2004). Therefore, it is possible that MN 34531 represents the offspring of MN 34530.

GEOGRAPHIC DISTRIBUTION

Cichlocolaptes mazarbarnetti is known from only two sites, the type locality at Murici in the state of Alagoas, and Frei Caneca (08º 43' S, 35º 51' W), Jaqueira, in the state of Pernambuco. The 6,116 ha of Murici presently has less than a 2,000 ha covered by forests that are suitable for this species. In recent years, *C. mazarbarnetti* has been found at this site only in the vicinity of an area known as Poço d'Anta, at Fazenda Bananeiras (09º 12' S, 35º 52' W, 500–600 m). The species could potentially occur in the forests of the nearby Fazenda São José (09º 13' S, 35º 54' W) and perhaps in certain tracts of forest at Serra do Ouro (09º 14' S, 35º 50' W). *Cichlocolaptes mazarbarnetti* has been found at Frei Caneca, and it could potentially be present in the forests of the contiguous Fazenda Pedra D'Anta (08º 39' S, 35º 53' W), comprising together about 1,000 ha of forest (SAVE Brasil 2013). We did not find the species at various other highland localities, or at two lowland sites, in the states of Alagoas and Pernambuco (Appendix 3).

HABITAT AND BEHAVIOR

The Cryptic Treehunter is endemic to the 'Pernambuco Center' of endemism, where it inhabits dense, humid forests in hilly terrain with rainfall higher than at nearby lowland sites. The areas at Fazenda Bananeiras and Frei Caneca where the species and its co-endemics have been found are forests near the hilltops, and especially those in deep, forested ravines. The steep slopes and ravines present taller and better-preserved forest, where a few emergent trees reach over 25 m. These forests have been selectively logged, but some areas have suffered from more severe logging. Most of these areas were not logged, and have recovered some of the original structure with multiple strata and a relatively open understory. The best-preserved patches have a profusion of vine tangles and they are densely laden with bromeliads, mosses, and orchids (Figure 7). A great number of these epiphytes, mainly bromeliads, are also restricted to the 'Pernambuco Center' of endemism (Siqueira-Filho & Leme 2006). *Cichlocolaptes mazarbarnetti* can be found alone or in pairs, sometimes on their own, but usually in association with large, mixed-species flocks. They move between the

FIGURE 6. Juvenile *Cichlocolaptes mazarbarnetti* (MN 34531), showing the dark crown, the absence of a buffy eyering, and browner sides of neck.

mid-levels and the subcanopy (mostly 8–20 m). A bird seen by the authors on 12 October 2002 was foraging actively in the lower part of an open tree-crown. It visited bromeliads exclusively, searching deeply within them. On one occasion, a bird was seen entering and almost disappearing into one large bromeliad, leaving only its upward pointing tail visible. This bird removed and threw away dead leaves from the bromeliad's interior while searching for food. Another individual was observed on 21 January 1998 foraging at 12–15 m in the subcanopy and again inside a large bromeliad cluster on a canopy branch off the main trunk (A. Whittaker *in litt*. 2004). A bird seen in January 1999 was foraging 12–15 m up in the sub-canopy by 'rummaging around in bromeliads, with just its tail and hind-parts sticking out' (K. Zimmer and A. Whittaker *in litt*. 2004). A bird was also seen foraging about 15 m up in a bromeliad on 23 February 2003 (W. Silva *in litt*. 2004). The pair seen and tape-recorded by DCB at Frei Caneca on 3 October 2003 was searching a large bromeliad 15 m up. A bird observed on 19 April 2007 at Murici was attracted with playback after natural vocalizations were heard. It flew through the subcanopy 18 m up and then stopped at a branch covered by moss 15 m up, where it started to sing again for a few minutes before flying away. Probably the same bird was heard and tape-recorded in the same area on 20 April 2007 at dawn, when it gave non-stop songs for at least 12 minutes from a large concentration of bromeliads 8 m above the ground on the top of a hill. One individual seen on 12 October 2002 was in a flock with *Veniliornis affinis*, *Picumnus exilis*, *Automolus lammi*, *Xiphorhynchus atlanticus*, *Thamnophilus aethiops*, *Thamnomanes caesius*, *Myrmotherula axillaris*, *Myrmotherula snowi*, *Herpsilochmus rufimarginatus*, *Terenura sicki*, *Myrmoderus ruficaudus*, *Conopophaga melanops*, *Myiopagis gaimardii*, *Rhynchocyclus olivaceus*, *Hemitriccus griseipectus*, *Caryothraustes canadensis*, and *Saltator maximus*. The mixed-species flock joined by the individual observed on 21 January 1998 included *X. atlanticus*, *T. caesius*, *M. snowi*, *T. sicki*, and *Myiobius atricaudus*. This bird was in heavy wing and tail molt, including both the primaries and secondaries (A. Whittaker *in litt*. 2004).

VOCAL REPERTOIRE

Vocalizations of birds that match the morphological characteristics of the type of *C. mazarbarnetti* were recorded at Murici and Frei Caneca. Most of the songs analyzed were spontaneous, and from recordings made between March 2001 and April 2007, in the months of January, February, March, April and October, by four different recordists on five occasions. Given that all of these recordings were made at Fazenda Bananeiras and Frei Caneca, it is also possible that only five or six individuals are represented. In the following description, we compare *C. mazarbarnetti*'s vocalizations with those of *C. leucophrus*, *Philydor novaesi*, and *P. atricapillus*,

FIGURE 7. Detail of primary forest at Frei Caneca, showing the profusion of epiphytes (and in particular bromeliads) in the canopy. Photo by DCB.

showing their differences and homologies. Examination of the complete vocal repertoire of *C. mazarbarnetti* would be necessary for a thorough analysis, yet we feel that the available material is sufficient to document our assertion that *C. mazarbarnetti* and *Philydor novaesi* represent different species. What we regard as Song Type 1 of *C. mazarbarnetti* is a fast, dry rattle of 0.38–2.81 s followed closely by a series of 4–8 loud, raspy notes delivered at a regular pace (Figure 8A). Each of these raspy notes, lasting 0.12-0.23 s, increases slightly in frequency before decreasing suddenly at the end. The initial rattle is a rapid series of 9–62 notes at a pace of 21.1–24.7 notes/s in spontaneous songs, but it is faster following playback. This initial rattle maintains a constant frequency throughout and it may escape detection if the bird is distant. Sometimes the song includes a shorter rattle after the series of harsh notes, and this occurs mostly when the number of harsh notes is fewer. In response to playback, and spontaneously at dawn, we observed a modified version of Song Type 1 that we refer to as Song Type 2: the initial rattle increases to 1.8–3.2 s and the number of following notes is reduced to 1–3; the first note is lower pitched than the second, and the second is lower than the third (if present) (Figure

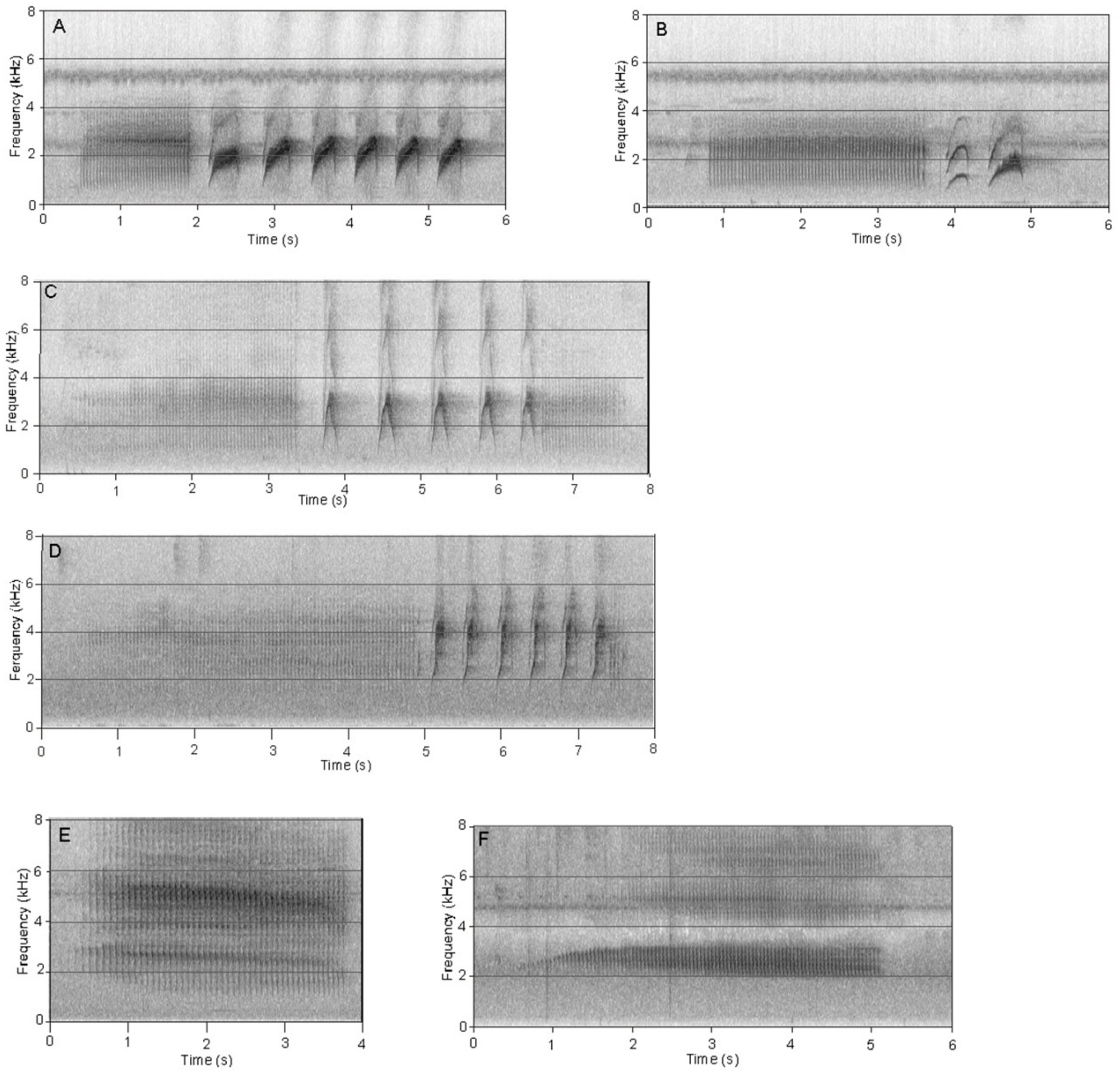

FIGURE 8. A. Song Type 1 of *Cichlocolaptes mazarbarnetti* recorded on 20 April 2007 at Murici Ecological Station, municipality of Murici, Alagoas (DCB, XC180893). **B.** Song Type 2 of *Cichlocolaptes mazarbarnetti*, recorded in same take as A. **C.** Song of *Cichlocolaptes leucophrus leucophrus* recorded on 3 May 1997 in the municipality of Vargem Alta, Espírito Santo (Ricardo Parrini). **D**. Song of *Cichlocolaptes leucophrus holti*, recorded on 28 June 2003 at Rio Vermelho, municipality of Bananal, São Paulo (DCB, XC180863). **E**. Song of *Philydor novaesi* recorded on 15 February 2003 at Frei Caneca, municipality of Jaqueira, Pernambuco (JMB, XC181063). **F.** Song of *Philydor atricapillus* recorded on 16 October 1993 in the municipality of Ubatuba, São Paulo (Andrew Whittaker).

8B). On one occasion, we recorded a spontaneous vocalization at dawn that was delivered for 12½ minutes, and that comprised 10 phrases of the first song-type, 64 phrases of the second song-type, and one isolated rattle. The interval between songs was shorter at dawn, when the number of phrases of Song Type 2 was greater than that of Song Type 1, but most spontaneous songs made throughout the day matched Song Type 1, and Song Type 2 was given almost exclusively in response to playback. Analysis of 123 phrases of song (including both types 1 and 2) shows only limited variation. In addition to songs, birds may deliver a fast rattle without the following notes, at a rate of 21.7–24.0 notes/s, and lasting up to 8.5 s (Figure 11A). Isolated rattles may be delivered among songs, as was heard at dawn, or after playback, when the bird is excited, but it is unusual to hear them given spontaneously during the day. Calls recorded in response to playback are a fast, staccato series of three dry notes that have an ascending and then a descending shape, and which are delivered at 2.0–2.4 kHz (Figure 9A; Table 2). Single-note calls are reminiscent of the raspy notes of the song, but without the upward and downward inflections, and they are delivered at 1.7-2.7 kHz (see Table 2). A presumed alarm-call was recorded once, and possibly related to an agonistic behavior, given that two birds were involved. It consisted of 1-3 notes, the first a fast and sharply descending modulation, followed by a fast upward and slow downward modulation, and finally, a raspy note at the end. Sometimes two notes were delivered after the raspy note, and sometimes only the raspy notes were delivered (Figure 10A). The song of *C. leucophrus leucophrus* consists of a fast, dry rattle of 2.2-3.6 s followed closely by a series of 5-8 loud, short notes delivered at a regular pace (Figure 8C). The structure of the song is similar to that of *C. mazarbarnetti*, but the timbre and shape of the short notes are different. Like *C. mazarbarnetti*, *C. l. leucophrus* sometimes delivers a faster rattle of about 1.0 s at the end of the phrase, and sometimes in response to playback, isolated rattles at a rate of 19.5–22.2 notes/s, with the rattle lasting up to 9.2 s (Figure 11C). The song of *C. leucophrus holti* is similar in pattern to that of *C. l. leucophrus* and *C. mazarbarnetti*, in that it is a fast, dry rattle of 0.5-4.3 s followed closely by a series of 4-8 loud, short notes delivered at a regular pace (Figure 8D). Each of the short notes begins by increasing in frequency, but unlike the songs of C. *mazarbarnetti* and *C. l. leucophrus*, the decrease at the end is not so evident. The initial rattle maintains a constant frequency throughout. Like *C. mazarbarnetti* and *C. l. leucophrus*, *C. l. holti* sometimes delivers a shorter (0.3 s) and more rapid rattle at the end of the phrase. Possibly because of its smaller body size, all notes in the song of *C. l. holti* are given at a higher frequency than those of the other taxa (see Table 2). The song of *C. mazarbarnetti* is closer to that of *C. l. leucophrus* than *C. l. holti* in the range and frequency of the initial rattle and raspy notes. Some homologies in the calls and rattles were also noted between *C. mazarbarnetti* and *C.*

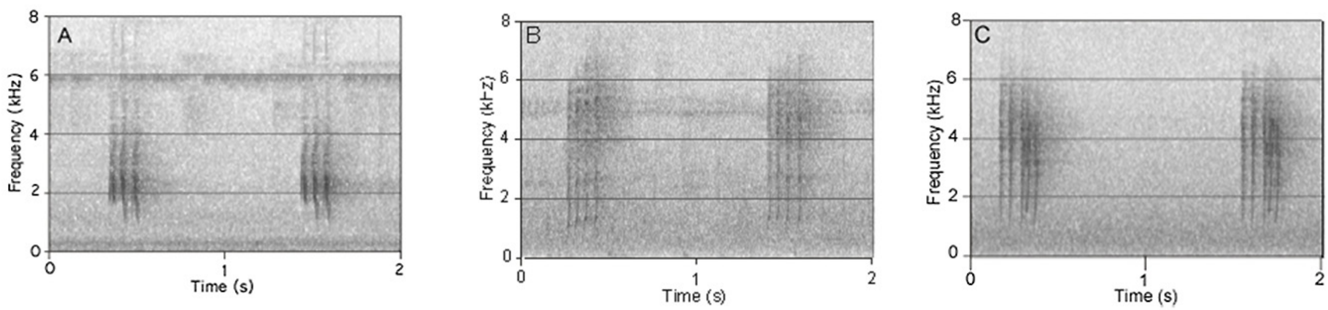

FIGURE 9. A. Three-note calls of *Cichlocolaptes mazarbarnetti* recorded on 5 March 2001 at Murici, Alagoas. (Curtis Marantz, LNS/Macaulay Library #128035). **B**. Calls of *Philydor novaesi* recorded on 3 October 2003 at Frei Caneca, Jaqueira, Pernambuco (DCB, XC181036). **C.** Calls of *Philydor atricapillus* recorded on 17 July 1994 at Serra da Cantareira, municipality of Guarulhos, São Paulo (DCB, XC180995).

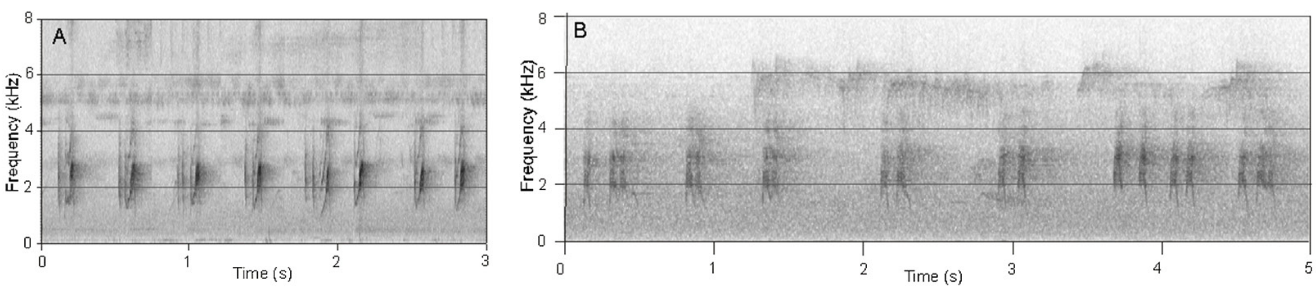

FIGURE 10. A. Alarm calls of *Cichlocolaptes mazarbarnetti* recorded on 3 October 2003 at Frei Caneca, municipality of Jaqueira, Pernambuco (DCB, XC180906). **B**. Alarm calls of *Cichlocolaptes leucophrus leucophrus* recorded on 11 May 1999 in the municipality of Boa Nova, Bahia (Ricardo Parrini).

l. leucophrus, these mainly in the rattle and alarm calls. Alarm calls of *C. mazarbarnetti* and *C. l. leucophrus* have a similar pattern (Figs. 10A and 10B). Unlike those of the taxa described above, the song of *P. novaesi* is a high-pitched rattle that combines two simultaneous notes as it descends slightly in pitch through the song (Figure 8E). Each component note decreases sharply in pitch, the whole rattle is longer than that of *C. mazarbarnetti*, and it is delivered at a slower pace (see Table 2). The length of the phrases varies relative to the bird's level of excitement. The song is usually delivered at intervals of 5–15 s, but occasionally at longer intervals. The analysis of 75 phrases of the *P. novaesi* song, including an abnormal type (see below), showed only limited variation in frequency and pace. The songs analyzed were, for most part, spontaneous, and they were made between February 2003 and November 2010, in the months of February, March, June, October, November and December, by six different recordists on nine occasions. Given that all of these recordings were made at Frei Caneca, it is possible that only three or four individuals were represented. The song of *P. atricapillus* is similar to that of *P. novaesi*, in that it consists of a high-pitched rattle that descends slowly in frequency (Figure 8F). Each note has a simple, descending shape that is quite similar to that of the lower frequency notes of songs of *P. novaesi*. Each component note decreases sharply in pitch as well, and the whole song is delivered at 18.2–21.6 notes/s, and thus somewhat faster than *P. novaesi* (see Table 2). The duration of the phrases likewise varies based on the bird's level of excitement. One call of *P. novaesi* and *P. atricapillus* is similar in both structure and pace, and it consists of four, ascending notes given in a series (Figs. 9B and 9C). Although the vocal repertoire of *P. novaesi* is poorly known, we feel that the similarities in the songs and calls of *P. novaesi* and *P. atricapillus* show a clear homology, making a compelling case for a close relationship between them. The vocalizations of *P. atricapillus* tend to be 'softer' and higher in frequency than those of *P. novaesi*, which probably reflects its smaller size. By contrast, the fast rattle that begins the song of *C. mazarbarnetti* is different from that of the song of *P. novaesi* in structure, pace, frequency, and duration. It reaches 21.1–24.6 notes/s versus 12.2–16.3 notes/s and its frequency is 2.5 kHz compared to 5.2 kHz. The duration of 1.6 s is also markedly shorter than the 3.8 s of *P. novaesi* (see Table 2). It is important to note that the initial rattle of *C. mazarbarnetti*, *C. l. leucophrus*, and *C. l. holti* all maintain a constant frequency from beginning to end, whereas the frequency of the songs of *P. novaesi* and *P. atricapillus* fall steadily throughout the vocalization. Equally importantly, the raspy notes are absent in the song of both *P. novaesi* and *P. atricapillus*, yet they are present and conspicuous in the songs of *C. mazarbarnetti*, *C. l. leucophrus*, and *C. l. holti*. Calls of *C. mazarbarnetti* consist of series of three rapidly ascending and descending modulations at 2.0–2.4 kHz (see Figure 9A). *Philydor novaesi* has a similar sounding call, but it consists of 3–6 ascending notes

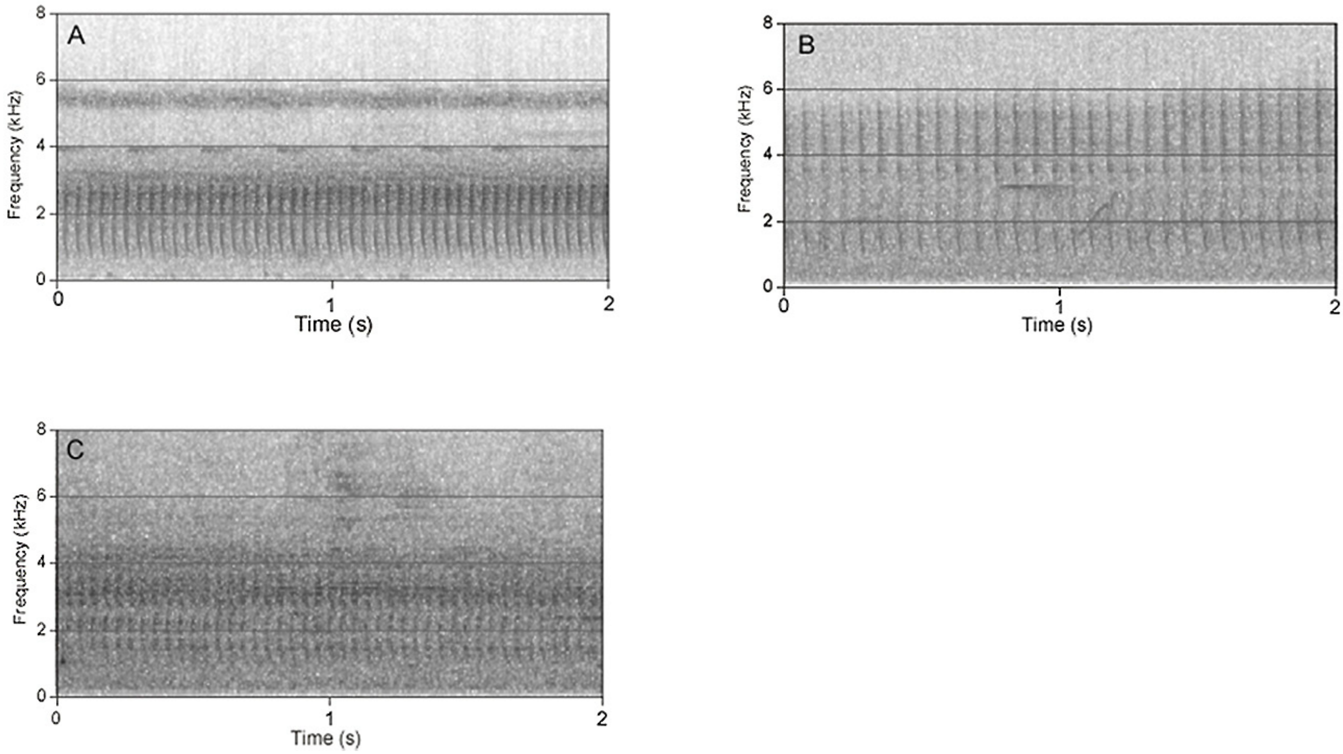

FIGURE 11. A. Rattle of *Cichlocolaptes mazarbarnetti* recorded on 20 April 2007 at Murici, Alagoas. (DCB, XC 180893). **B.** Rattle of *Philydor novaesi*, recorded in response to playback on 12 April 2003 at Frei Caneca, Jaqueira, Pernambuco (JMB, XC181072). **C.** Rattle of *Cichlocolaptes leucophrus leucophrus* recorded on 03 May 1997 at Reserva Biológica Augusto Ruschi, Espírito Santo (Andrew Whittaker).

delivered at 4.6-5.6 kHz (see Figure 9B; Table 2). The isolated rattle of *C. mazarbarnetti* is delivered at a rate of 21.7–24.0 notes/s and with a duration of 1.2-8.5 s, whereas the rattle of *P. novaesi* is 7.2-13.6 s in length and it is delivered at a rate of 13.8-15.8 notes/s (Figure 11B). These vocalizations also differ in frequency and note shape (Figure 12A). It is interesting to compare the rattle of *C. mazarbarnetti,* whether as the initial part of the song or as a stand-alone vocalization, with the song of *P. novaesi*, which is also a rattle. The rattle of *C. mazarbarnetti* is both quicker (21.1–24.6 notes/s for the initial part of the song and 21.7-24.0 notes/s for a stand-alone rattle versus 12.2-16.3 notes/s) and lower in frequency (2.5 kHz versus 5.2 kHz). These vocalizations also differ in frequency and shape of the notes (Figure 12B). A playback experiment was carried out at Murici to test the

TABLE 2: Comparison of songs and calls of *Cichlocolaptes leucophrus holti, C. l. leucophrus, C. mazarbarnetti, Philydor novaesi*, and *P. atricapillus*. The values presented are range, mean ± standard deviation (in parentheses) and sample size for songs and calls (in italics).

	Cichlocolaptes leucophrus holti	***Cichlocolaptes leucophrus leucophrus***	***Cichlocolaptes mazarbarnetti***	***Philydor novaesi***	***Philydor novaesi****	***Philydor atricapillus***
Rattle/Song *length (s)*	0.51-4.30 (2.35 ± 1.17) *n = 14*	2.25-3.65 (2.95 ± 0.70) *n = 3*	0.38-2.81 (1.62 ± 0.35) *n = 27*	2.45-5.64 (3.83 ± 0.63) *n = 35*	2.8	2.64-4.76 (3.64 ± 0.55) *n = 15*
number of notes	10-89 (47.07 ± 23.08) *n = 14*	50-77 (63.66 ± 13.50) *n = 3*	9-62 (38.03 ± 14.49) *n = 27*	32-76 (53.60 ± 9.9) *n = 35*	45	56-103 (71.93 ± 12.19) *n = 15*
notes per second	16.94-21.78 (20.09 ± 1.22) *n = 14*	21.10-22.22 (21.62 ± 0.56) *n = 3*	21.11-24.66 (23.44 ± 0.83) *n = 27*	12.28-16.34 (13.98 ± 1.16) *n = 35*	16.07	18.28-21.64 (19.77 ± 1.24) *n = 15*
frequency (kHz)	3.55-4.10 (3.72 ± 0.13) *n = 14*	2.87-3.13 (2.98 ± 0.13) *n = 3*	2.34-2.98 (2.53 ± 0.15) *n = 27*	4.82-5.52 (5.29 ± 0.16) *n = 35*	3.83	2.48-3.07 (2.76 ± 0.18) *n = 15*
Raspy notes *length of note (s)*	0.12-0.23 (0.20 ± 0.02) *n = 101*	0.19-0.37 (0.25 ± 0.05) *n = 18*	0.12-0.23 (0.35 ± 0.05) *n = 129*	-	0.18-0.20 (0.18 ± 0.01) *n = 4*	-
number of notes	4-8 (6.31 ± 1.01) *n = 16*	5-8 (6.00 ± 1.73) *n = 3*	4-8 (3.55 ± 1.63) *n = 31*	-	4	-
frequency (kHz)	3.50-4.31 (3.80 ± 0.16) *n = 88*	2.87-3.58 (3.07 ± 0.23) *n = 18*	1.13-2.64 (2.07 ± 0.29) *n = 129*	-	1.62-1.95 (1.83 ± 0.14) *n = 4*	-
Calls with one note *frequency (kHz)*	3.82-5.50 (4.53 ± 0.31) *n = 71*	2.93-3.48 (3.24 ± 0.18) *n = 68*	1.75-2.72 (2.29 ± 0.19) *n = 84*	3.54-4.23 (3.75 ± 0.22) *n = 13*	-	3.31-5.00 (4.41 ± 0.57) *n = 34*
Calls with 3-6 notes *frequency (kHz)*	-	-	2.09-2.47 (2.28 ± 0.10) *n = 33*	4.68-5.69 (5.26 ± 0.31) *n = 25*	-	3.87-5.73 (4.61 ± 0.51) *n = 14*

*abnormal song of *P. novaesi* after playback of *C. mazarbarnetti*'s song (n = 1 phrase)

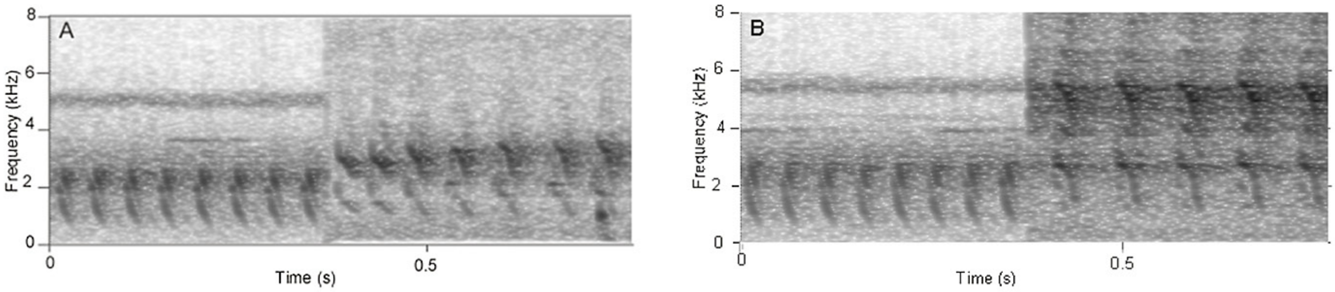

FIGURE 12. A. Comparison between the rattles of *C. mazarbarnetti* and *P. novaesi*, showing differences in frequency, pace, and shape of the notes. **B.** Comparison between the rattle of *C. mazarbarnetti* and the song of *P. novaesi*, showing differences in frequency, pace, and shape of the notes.

reaction of *C. mazarbarnetti* to the song of *P. novaesi*. The individual of *C. mazarbarnetti* recorded on 20 April 2007 at dawn (see Habitat and Behavior) had sung spontaneously for at least 12 minutes. Immediately after it stopped singing, we played a single song of *P. novaesi* several times, at intervals of one or two minutes. No vocal or visual reaction by *C. mazarbarnetti* was observed. This was probably the same individual that was recorded in the same area on the previous afternoon, when it was attracted immediately by playback of its own song, clearly demonstrating territorial defense behavior. The bird recorded on 12 October 2002 at Murici also showed strong territorial defense behavior after playback of its own song, first flying back-and-forth overhead several times and then singing for some minutes. The same behavior was noted by Curtis Marantz when he recorded *C. mazarbarnetti* at Murici in March 2001 (http://macaulaylibrary.org/audio/128037). *Cichlocolaptes mazarbarnetti*'s behavior on these occasions led us to conclude that it did not recognize the song of *P. novaesi* as part of its own species' repertoire. An abnormal song of *P. novaesi* was recorded at Frei Caneca on November 2010 (www.xeno-canto.org/65550) with simultaneous photos and observations made following extended playback of the song of both *C. mazarbarnetti* and *P. novaesi* (Ciro Albano *in litt*. 2010). This vocalization consisted of an initial rattle followed by four short notes, and in this respect if superficially resembled a song by *C. mazarbarnetti*. This song has been considered by some colleagues to be the same as the song of *C. mazarbarnetti*, thus leading them to conclude, based on this recording and the concomitant observation of a bird that visually matches *P. novaesi*, that only one species is involved. We therefore analyzed this recording and compared it with the songs of both *P. novaesi* and *C. mazarbarnetti*. The initial rattle of the abnormal song is similar to the song of *P. novaesi* in length, pace, and in the number and shape of the notes, and it descends in frequency throughout. It differs from the song of *C. mazarbarnetti* in all these parameters (see Table 2). The four terminal notes of the abnormal song are softer than the loud and raspy notes of *C. mazarbarnetti*, and their shape and timbre are quite different. In the recording, the abnormal song is followed by three typical songs of *P. novaesi*, which are closely similar to the initial rattle of the abnormal song. We therefore conclude that this phrase was delivered by an excited *P. novaesi* during an unusual behavioral context, as opposed to by *C. mazarbarnetti*.

DISCUSSION

Evidence for a new species

The differences between *C. mazarbarnetti* and *P. novaesi* in morphology and plumage noted on museum skins, combined with vocalizations and observations of foraging behavior made in the field, provide strong evidence that two different species are involved. These differences are at odds with variation within a single population (see also Claramunt [2014] regarding morphometric evidence). Aspects of the plumage that aided our diagnosis of the new species from *P. novaesi* in the field were noted, most notably characters of the facial pattern and color of the upper-tail coverts. There is a photo available at Lees *et al.* (2014), where the buffy eyering and the rufous upper-tail coverts of *P. novaesi* are shown simultaneously, and we can see at Figure 4 the different facial pattern and the dark rump color of *C. mazarbarnetti*. A video made at Frei Caneca on 11 October 2008, available at http://ibc.lynxeds.com/video/alagoas-foliage-gleaner-philydor-novaesi/bird-tree-singing-several-times-flying-away, shows a singing bird with a buffy eyering. The four phrases of the song presented in this video have the same pattern of the song of *P. novaesi* shown in Figure 8E in duration, pace, number and shape of the notes, and the descending frequency. The facial pattern and the domed head of this bird match the four unambiguous skins of *P. novaesi* by comparison (see Figs. 3 and 5). Another video made at Frei Caneca on 5 November 2010, available at http://ibc.lynxeds.com/video/alagoas-foliage-gleaner-philydor-novaesi/one-adult-bird-singing, shows a singing bird with a bill that appears both larger and stouter than that of the bird in the first video. The large bill in particular suggests *C. mazarbarnetti*. Although we noted little variation in bill size in the type series of *P. novaesi*, representing one female and three males (see Table 1), individual variation in bill size in ovenbirds and sexual dimorphism in *Philydor* are both expected (see Claramunt 2014). The bird recorded on 5 November 2010 does have a buffy eyering, and the six phrases of the song heard in this video have the same pattern as those in the first video, and they are again like that shown in Figure 8E. We therefore conclude that this bird also represents *P. novaesi*, and that the most important features to separate *P. novaesi* from *C. mazarbarnetti* in the field are the facial pattern, in particular the presence versus absence of buffy eyering, respectively, rufous upper-tail coverts versus brown rump, and a song that represents a long, descending rattle in *P. novaesi* versus a rattle that maintains a constant frequency throughout followed by some raspy notes in *C. mazarbarnetti*. There are many other cases in which vocalizations provided the first insight that a new species was present, to be corroborated only later by morphological or molecular evidence (such as, for a few recent examples, *Herpsilochmus sellowi* (Whitney *et al*. 2000), *Suiriri islerorum* (Zimmer *et al.* 2001), and *Formicivora grantsaui* (Gonzaga *et al*. 2007)). Our observations suggest that foraging behavior differs in *C. mazarbarnetti* and *P. novaesi*. The *Philydor* forages in the lower strata, up into the canopies of mid-sized trees, where it forages along branches and in tangles. Of the four unambiguous specimens of *P. novaesi*, two were mist-netted in the understory and one was shot in the mid-levels (based on information contained on the specimen labels). It also adopts a variety of postures when foraging, with its head down, or hanging with the belly upwards, even from suspended branches, or perching on vertical branches. These birds search the edges of green leaves, they inspect dead leaves that have fallen or those that have accumulated in clusters, they rummage in balls of detritus, they creep along surfaces of trunks, and they even lift bark. These birds also hammer thick and rotten branches in the manner of a *Xenops* (Teixeira & Gonzaga 1983a). Birds seen at Frei Caneca in February 2003 and in September–October 2003 (Mazar Barnett *et al.* 2004) moved along thin horizontal branches in the lower to middle levels among the crowns of small trees (*ca*. 4 m). *P. novaesi* was also seen foraging on bromeliads in the mid-levels, searching mainly the edges of the leaves and clusters, but not 'entering' bromeliads leaving only its tail visible, as does *C. mazarbarnetti* when foraging. *Philydor novaesi* fanned their tails, as described by Teixeira & Gonzaga (1983a), which resulted in the tail appearing broad and rounded, and thus much like *P. atricapillus*. Foraging maneuvers observed included a bird pecking at a dead leaf that was hanging from a small clump of mosses in a fork, and another bird that systematically investigated clumps of hanging, dead leaves (Mazar Barnett *et al.* 2004; see also *Philydor novaesi* photos #6-8 in Minns *et al.* [2009]). Despite the paucity of data on the foraging behavior of *P. novaesi*, similarities with *P. atricapillus* were noted by us and by other researchers (Gussoni *et al*. 2011), yet consistent and marked differences were noted between *P. novaesi* and *C. mazarbarnetti*. *Philydor atricapillus* has been regarded as a dead-leaf-searching specialist (Remsen & Parker 1984, Parrini *et al*. 2010) that frequently assumes acrobatic postures, such as hanging upside-down vertically. It also uses substrates such as bits of rotten wood, hanging debris, vine tangles, living foliage and epiphytes (especially bromeliads), though more often these birds inspect clusters of dead leaves (Mallet-Rodrigues 2001). *Philydor atricapillus* has also been seen foraging in a *Xenops*-like manner (Fontana *et al.* 2003), as described above for *P. novaesi*. We have noted in *P. atricapillus* the typical and characteristic movement of the fanned tail, identical to that described above for *P. novaesi*. The behavior of *C. mazarbarnetti* is notably different from that described above for *P. novaesi* and *P. atricapillus* as a result of its clear preference for foraging at bromeliads, and by inhabiting the middle to upper strata of the forest (see Habitat and Behavior). In these respects, the behavior noted closely matches that of *C. leucophrus*. It is also important to note that the holotype of *C. mazarbarnetti* (MN 34530) was shot near the canopy and that it was searching a bromeliad at the time (based on the specimen label; D. M. Teixeira *pers. comm*. 2004). Our requests for permission to X-ray skulls and take samples for molecular analysis from the specimens of *C. mazarbarnetti* and *P. novaesi* at MN were denied in September 2004, November 2008, and June 2013. Our conclusions, based on morphology, plumage, vocalizations, and foraging behavior, could be corroborated in the future using molecular methods.

Affinities of *C. mazarbarnetti*

Morphometric features that link *C. mazarbarnetti* to *Cichlocolaptes* were presented by Claramunt (2014). What little is known of the behavior of the new species also links it to *Cichlocolaptes*. The tendency of *C. mazarbarnetti* to remain in the subcanopy or higher strata is shared with *C. leucophrus*, even though both species do frequent lower strata on occasion. *Cichlocolaptes leucophrus* is known to be highly dependent on bromeliads, and while foraging, it searches deep within leaf clusters, sometimes almost disappearing altogether (Pizo 1994, Ridgely & Tudor 1994, Fontana *et al*. 2003). We have noticed a similar foraging behavior and dependency on bromeliads for *C. mazarbarnetti*, and our data are supported by observations by others (e.g., K. Zimmer and A. Whittaker *in litt*. 2004). The rather slow and deliberate movements of *C. mazarbarnetti* while foraging also recalled those of *C. leucophrus* to A. Whittaker (*in litt*. 2004). Above all, we think that the undeniable similarity of the vocalizations of *C. mazarbarnetti* and *C. leucophrus* suggests better than anything else that the two are closely related. The differences in plumage between *C. mazarbarnetti* and *C. leucophrus* are considerable; however, there are other examples of sister species of foliage-gleaners in which one has a plain plumage and the other has a strongly streaked one: *Simoxenops ucayalae* and *S. striatus*, *Syndactyla rufosuperciliata* and *S. dimidiata*, and *Automolus subulatus* and *A. cervicalis* (Remsen 2003, Robbins & Zimmer 2005, Derryberry *et al.* 2011, Claramunt *et al.* 2013). The difference in plumage pattern and color between *C. mazarbarnetti* and the southern forms *C. l. leucophrus* and *C. l. holti* could indicate that the latter two heavily streaked taxa are more closely related to each other. The extent to which these plumage features indicate relationships is hard to determine, and as such, a molecular analysis of *Cichlocolaptes* will likely be necessary to determine the true affinities of the new species.

Biogeography

The forests of northeastern Brazil, north of the São Francisco River, have long been recognized as a center of endemism. The 'Pernambuco Center' (Prance 1982, Coimbra-Filho & Câmara 1996, Silva & Casteleti 2005) is well-known to harbor endemic plants (Prance 1987, Tabarelli & Santos 2004), butterflies (Brown 1987), and birds (Cracraft 1985, Stattersfield *et al.* 1998, Roda 2003). The endemic avifauna of this area is composed of two sets of taxa with different biogeographical affinities. One set has affinities with the Atlantic Forest, and the other is related to Amazonian taxa (Teixeira 1986, Roda 2003). Taxa with Atlantic Forest affinities include *Philydor novaesi*, *Automolus lammi*, *Dendrocincla taunayi, Xiphorhynchus atlanticus, Synallaxis infuscata*, *Myrmotherula snowi*, *Terenura sicki*, *Phylloscartes ceciliae*, and *Tangara fastuosa* (Roda *et al.* 2011). Treatments of these taxa as either species or subspecies reflect uneven taxonomic studies of the region's birds.

CONSERVATION

The existence of a cryptic taxon resembling *P. novaesi* render past records of this species uncertain if not accompanied by a recording or detailed morphological or behavioral data. There are no recent observations of *P. novaesi* at Murici. It went unrecorded September 2002-October 2003 despite the near constant presence of a resident ornithologist. DCB searched for *P. novaesi* in April and December 2007 at Murici, but found only *Cichlocolaptes mazarbarnetti*. We have searched for both *C. mazarbarnetti* and *P. novaesi* at many other sites (see Appendix 3), and failed to find it. Since the discovery of *P. novaesi* at Frei Caneca (Mazar Barnett *et al.* 2003, 2004), the species was seen frequently there until September 2011 (Carlos Gussoni *in litt.* 2014), but there have been no subsequent reports, and its conservations status in the area is considered critical (Pedro Develey, SAVE Brasil, *in litt*. 2014, Lees *et al.* 2014). There is only one record of *P. novaesi* at the contiguous area Fazenda Pedra D'Anta, municipality of Lagoa dos Gatos, close to the border of Frei Caneca (Roda 2011). *Cichlocolaptes mazarbarnetti*, like *P.* novae*si*, is certainly one of the rarest birds in the world. It is known from only two localities. At Murici, less than 3,000 ha remain forested (Goerck 2001a), and probably no more than 1,500–2,000 ha are suitable for the species. Frei Caneca and Fazenda Pedra D'Anta comprise together about 1,000 ha of contiguous forest (SAVE Brasil, 2013). We propose that *C. mazarbarnetti* should be categorized as Critically Endangered at both national and global levels. Criteria for such categorization are the small range (Extent of Occurrence estimated at <100 km^2, in only two localities), and a population of <50 individuals (BirdLife International 2000, IUCN 2012). We suspect that no more than two pairs each survive at sites from which all recent reports have been made. Based on intensive fieldwork at Murici by JMB and W. Silva as part of the conservation project of BirdLife International Brazil Programme, we estimated that a maximum of 5-10 pairs may have existed in the entire reserve in 2004; however, the number of birds remaining is likely lower. At Frei Caneca, we estimate that no more than one or two pairs survive. Murici has been a mythical spot among birdwatchers because of the presence of several range- restricted species. It is likewise a key place for conservationists, due to the difficulty of implementing measures to protect its remaining bits of natural habitat (e.g., BirdLife International 2000: 357). Ironically, Teixeira & Gonzaga (1983a) argued for the declaration of an ecological station in the forests of Murici when they described the first endemic bird from the site, 18 years before its designation as such. Goerck (2001b) stated that the official designation of Murici's protected area status 'should ensure the survival of its many threatened species.' Sadly, we doubt that this is the case, as most land is still in private hands, and troubling levels of small to medium-scale deforestation were detected during September–October 2002-2007. Most unsettling then was the felling of much of the forest on the entire slope opposite the ravine that holds all recent records of *C. mazarbarnetti*, with evidence of further logging occurring between visits during the above period. This area appeared to be ideal habitat for *C. mazarbarnetti*, given the profusion of bromeliads and other epiphytes that remained in the now broken and very open canopy. Most of the cleared land on steep slopes is being converted into grazing areas for cattle. The lower slopes, valley bottoms, and adjacent lowlands were long ago converted to sugarcane plantations, though some fields are now used for cattle grazing. The specialization of *C. mazarbarnetti* on bromeliads, as is known for *Cichlocolaptes leucophrus* (Pizo 1994), is a very important aspect of its conservation. Secondary forests have lower densities of epiphytes, including bromeliads (Dettke *et al.* 2008, Mania & Monteiro 2010). We suspect that *C. mazarbarnetti* can survive only in primary or mature secondary forests where bromeliads are abundant. This habitat is disappearing from the remnant forests in Alagoas and Pernambuco. We have searched unsuccessfully for the species at both Fazenda Riachão da Serra and Fazenda Branca dos Tavares, on patches of mature secondary forest with tracts of primary forest at the neighborhood of Murici. The more inaccessible forests of Fazenda São José and the remnant forest at Serra do Ouro, on the lands of the University of Alagoas, both at Murici, should also be surveyed. Usina Serra Grande, with *ca*. 3,500 ha of forests, is situated almost directly between Murici and Frei Caneca (Mazar Barnett *et al*. 2004). Although the species has never been recorded there (Roda *in litt*. 2004, Roda *et al*. 2008, Marantz *in litt*. 2014), specific searches in the area of Engenheiro Coimbra should be undertaken. Similar patches of forest at the complex of mountains known as 'Serra Grande', or 'Complexo Catende' (Ministério do Meio Ambiente 2000) should be identified and surveyed. Searches for *C. mazarbarnetti* should be undertaken in the most humid tracts of primary or mature secondary forests, which is where the forests have a high density of bromeliads. Searches should be undertaken between March and October, when the birds are most vocal. Sadly our expectations for the long-term survival of this species are not high, and we may now be witnessing its passage through the temporal window representing the time-lag between deforestation and extinction (Brooks & Balmford 1996). Conservation efforts at Murici have been undermined by political and bureaucratic problems since the ornithological discovery of the area. Without the political will to design and implement environmental policies and the commitment of private interests and stakeholders in Murici, little will be achieved for the conservation of its damaged forests (Mazar Barnett *et al*. 2004). An educational program targeting local communities is also essential. Such a program should focus on the biological uniqueness of the region's forests, their value, and the results of habitat deterioration by human activities. The current popularity of Murici with birders, which we now expect will increase, makes the choice of an ecotourism enterprise a valuable option to develop in the area. Murici and Frei Caneca are of maximum priority for the conservation of birds in the Atlantic Forest (see Goerck 2001a), and continent-wide (Collar *et al*. 1992, Goerck 2002), and the presence of this new species is a renewed reason to take actions for their preservation. The story of this discovery is unique, and it provides a crude testimony of how such remarkable phenomena can be missed, even when right before our eyes. Vocalizations once again provided the main lead in solving a twisted riddle in Neotropical ornithology. It was only after additional fieldwork that *C. mazarbarnetti* was 'discovered', and the 'true' *P. novaesi* was rediscovered. If all the factors of this complicated case had not taken place the way they did, *C. mazarbarnetti* could have remained forever overlooked.

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APPENDIX 1:

Specimens examined:

Cichlocolaptes mazarbarnetti: Brazil, Alagoas: Murici, Serra (=Pedra) Branca, one female (MN 34530, holotype) and one juvenile (MN 34531).

Cichlocolaptes leucophrus leucophrus: Brazil, Rio de Janeiro: Teresópolis, two males and two females (MZUSP 20263, 20438, 20196, and MN 38390); Fazenda Campestre, Nova Friburgo, one male (MN 36129). Brazil, Minas Gerais: Rio Doce, two males (MZUSP 25609, 25610). Brazil, Espírito Santo: Cupido, one male (MN 27152); Água Boa, Santa Cruz, one female (MN 19197); Chaves, one male and one female (MZUSP 28507, 28506); Pau Gigante, one female (MZUSP 9358); Rio São José, one male (MZUSP 28508); Itaúnas, one male (MZUSP 34530).

Cichlocolaptes leucophrus holti: Brazil, São Paulo: Iporanga, one male and one female (MZUSP 2864, 49761); São Paulo, Rio Ipiranga, one male (MZUSP 47838); Quadro Penteado, one male (MZUSP 49762); Rio das Corujas, one male (MZUSP 56751); Salesópolis, one male and one female (MZUSP 64439, 64591); Estação Engenheiro Ferraz, one male and two females (MZUSP 60716, 54949, 60714); Rocha, two males (MZUSP 49690, 49760); Boracéia, three males (MZUSP 31491, 31665, 31667); Juquiá, one female (MZUSP 32147). Brazil, Paraná: Guaratuba, one male (MZUSP 35397).

***Cichlocolaptes leucophrus* (intermediate specimens)**: Brazil, Rio de Janeiro: Visconde de Mauá, Rio Maromba, one male (MZUSP 36443). Brazil, São Paulo: Serra da Bocaina, two males and one unsexed bird (MZUSP 27132, 29544, 11048).

Philydor novaesi: Brazil, Alagoas: Murici, Serra (=Pedra) Branca, three males (MN 32028 paratype, 32029 holotype and 33872) and one female (MN 33873).

Philydor atricapillus: Brazil, Bahia: Cachoeira Grande do Sul, Rio Jacurucú, one male (MZUSP 14188). Brazil, Espírito Santo, one male (MZUSP 6327); Rio São José, one female (MZUSP 28525); Conceição da Barra, Rio Itaúnas, four females (MZUSP 34526–34529). Brazil, São Paulo, Iguape, two males and one female (MZUSP 62815, 62821, 62818); Iguape, Icapara da Serra, one female (MZUSP 62817); Iguape, Rio Ribeira, one female (MZUSP 66935); Iguape, Barra do Icapava, three males and two females (MZUSP 64951, 66933, 68303, 54940, 66934); Primeiro Morro, three males (MZUSP 49763, 49764, 49784); Rio Ipiranga, one female (MZUSP 47869); Campo Grande, one female (MZUSP 51141); Estação Engenheiro Ferraz, two males and three females (MZUSP 60684, 60686, 54938, 60687, 60688). Argentina, Misiones: Departamento Frontera, Refugio Piñalitos, nine males and six females (MACN 36748–36762).

APPENDIX 2:

Sound recordings examined

For each set of recordings, general localities are followed by the name of municipalities.

Cichlocolaptes mazarbarnetti – Brazil, Alagoas: Murici Ecological Station, municipality of Murici: Song Type 1 and 2 (n = 35), isolated rattles (n = 24), calls with three notes (n = 11), recorded by Curtis A. Marantz (LNS/ML #128025, 128032, 128034-128037); same locality: Song Type1 and 2 (n = 8), calls with 3 notes (n = 42), angry-calls (n = 147), recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor novaesi* recordings #1-4 and 10-11); same locality: Song Type1 (n = 7), recorded by JMB (XC180942 and 181076); same locality: Song Type 1 and 2 (n = 71), isolated rattle (n = 1), spontaneous calls with one note (n = 59), recorded by DCB (XC 180893,180902, 180909 and 181080). Brazil, Pernambuco: Frei Caneca, municipality of Jaqueira: calls with two and three notes (n = 8), calls with one note (n = 5) recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor novaesi* recording #11); same locality: calls with three notes (n = 1), calls with one note (n = 57), recorded by DCB (XC180906); same locality: Song Type 2 (n = 2), recorded by Braulio Carlos (XC180936).

Cichlocolaptes lecucophrus leucophrus – Brazil, Bahia: Municipality of Boa Nova. song (n = 1), calls (n = 7), recorded by Luiz P. Gonzaga (Gonzaga & Castiglioni 2001: *Cichlocolaptes leucophrus* recording #89); Fazenda Farofa, municipality of Boa Nova, calls (n = 11), alarm call (n = 1), recorded by Ricardo Parrini (Minns *et. al* 2009: *Cichlocolaptes leucophrus* recording #7; same locality, song (n = 5), calls (n = 32) recorded by Jeremy Minns (XC80778, XC80781); same locality, song (n = 1), recorded by Ciro Albano (Minns *et. al* 2009: *Cichlocolaptes leucophrus* recording #2). Brazil, Espírito Santo: Reserva Biológica Augusto Ruschi, municipality of Santa Teresa, rattle (n = 4), song (n = 3), recorded by Andrew Whittaker (Minns *et. al* 2009: *Cichlocolaptes leucophrus* recording #3); municipality of Vargem Alta, song (n = 3), calls (n = 4), recorded by Ricardo Parrini (Minns *et. al* 2009: *Cichlocolaptes leucophrus* recording #4). Brazil, Rio de Janeiro:

Municipality of Guapimirim, angry calls (n = 1), calls (n = 9), recorded by Jeremy Minns (XC180430).

Cichlocolaptes leucophrus holti – **Brazil, São Paulo.** Bananal Ecological Station, municipality of Bananal, calls (n = 23) recorded by DCB (XC 180870, 180871, 180874 and 180879); Rio Vermelho, municipality of Bananal, song (n = 10) recorded by DCB (XC180863 and 180866); municipality of Ubatuba, song (n = 1), calls (n = 4) recorded by Jeremy Minns (XC180433); Corcovado, municipality of Ubatuba, song (n = 9) recorded by DCB (XC180865); Fazenda Lavrinhas, municipality of Campos do Jordão, calls (n = 19) recorded by DCB (XC180868); Carlos Botelho State Park, municipality of São Miguel Arcanjo, calls (n = 11) recorded by DCB (XC180878). Brazil, Santa Catarina: Reserva Particular do Patrimônio Natural Volta Velha**,** municipality of Itapoá, song variant (n = 2), calls (n = 7), recorded by DCB (XC180867 and 180880); Aparados da Serra National Park, municipality of Jacinto Machado, alarm-calls (n = 3), recorded by DCB (XC180881).

Philydor novaesi – Brazil, Pernambuco: Frei Caneca, municipality of Jaqueira: song (n = 10), calls with 4-6 notes (n = 17), recorded by Ciro Albano (XC16447, 65550); same locality: song (n = 14), calls with one note (n = 2), recorded by Jeremy Minns XC80732; same locality: calls with one note (n = 15), call with four notes (n = 6) recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor novaesi* recordings #9 and 11); same locality: rattle (n = 4), song (n = 11), recorded by JMB (XC181063, 181068 and 181072); same locality: song (n = 26), calls with four notes (n = 35), recorded by DCB (XC181036, 181054, 181056 and 181059); same locality: song (n = 8) recorded by Josep del Hoyo (http://ibc.lynxeds.com/video/alagoas-foliage-gleaner-philydor-novaesi/bird-tree-singing-several-times-flying-away); same locality: song (n = 6), recorded by Carlos Gussoni (XC77752).

Philydor atricapillus – Brazil, Bahia: Una Biological Reserve, municipality of Una: calls with one note (n = 4), recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor atricapillus* recording #5). Brazil, Espírito Santo: Municipality of Santa Teresa: calls with one note (n = 8), recorded by Jeremy Minns (XC180436). Brazil, Rio de Janeiro: Ilha Grande, municipality of Angra dos Reis: song (n = 3), recorded by DCB (XC180950); Serra dos Órgãos National Park, municipality of Guapimirim: scolding-calls (n = 16), recorded by Jeremy Minns (XC80733). Brazil, São Paulo: Fazenda Angelim, municipality of Ubatuba: song (n = 3), calls with one note (n = 1), recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor atricapillus* recording #1); Corcovado, municipality of Ubatuba: song (n = 3), recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor atricapillus* recording #2); Folha Seca, municipality of Ubatuba: song (n = 3), calls with one note (n = 7), recorded by Jeremy Minns (XC80922); Cantareira State Park, municipality of Guarulhos: calls with four notes (n = 11), recorded by DCB (XC180995); Rio Mococa, municipality of Caraguatatuba: scolding-calls (n = 8), recorded by Jeremy Minns (XC80847); Bopiranga, municipality of Itanhaém, scolding-calls (n = 21), calls with one note (n = 7), recorded by DCB (XC181034, 181001 and 181030); Córrego do Engano, municipality of Miracatú, song (n = 14), recorded by DCB (XC181125). Brazil, Santa Catarina: Reserva Particular do Patrimônio Natural Volta Velha**,** municipality of Itapoá: calls with three notes (n = 4) recorded by Andrew Whittaker (Minns *et. al* 2009: *Philydor atricapillus* recording #9); same locality: calls with one note (n = 12), recorded by Jeremy Minns (XC180442); Canyon Fortaleza, municipality of Jacinto Machado: calls with 2-3 notes (n = 19), recorded by DCB (XC180992).

APPENDIX 3:

Fieldwork by one or both authors in search of *C. mazarbarnetti* and later *P. novaesi* was undertaken during the periods: 10 September 2002–15 October 2002 (Murici); 19 January 2003–9 February 2003 (with 19–23 January spent at Murici); 23 September–4 October 2003 (with 23–26 September spent at Murici and 28 September–04 October spent at Frei Caneca); 12-15 November 2003 at Usina Serra Grande, Ibateguara, Alagoas (08º 59' S, 35º 51' W); 18-22 November 2003 at Usina Trapiche, Pernambuco (08º 38' S, 35º 12' W);10-13 March 2004 (Murici); 14 March 2004 at Reserva Particular do Patrimônio Natural Senador Carlos Lyra, Maceió, Alagoas (09° 25' S, 36° 02' W); 17-18 March 2004 at Fazenda Riachão da Serra, União dos Palmares, Alagoas (09° 10' S, 35° 56' W); 19-21 March 2004 at Fazenda Recanto, Chã Preta, Alagoas (09º 17' S, 36º 14' W); 14–15 July 2004 (Murici); 16-22 April 2007 (Murici); 6-10 December 2007 (Murici).

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ARTICLE

Morphometric insights into the existence of a new species of *Cichlocolaptes* in northeastern Brazil

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ABSTRACT: Mazar Barnett & Buzzetti (2014) described a new species, *Cichlocolaptes mazarbarnetti*, from the Atlantic forests of northeastern Brazil. The holotype of the new species is a female that shows remarkable similarities with the sympatric *Philydor novaesi*. Here I analyze eight morphometric variables to assess phenotypic similarities among specimens of *Philydor novaesi, Cichlocolaptes mazarbarnetti* and other species in these two genera. The holotype of *C. mazarbarnetti* differs from *Philydor novaesi* and falls in a region of the morphometric space occupied by specimens of *Cichlocolaptes leucophrus*. Therefore, morphometric data is consistent with other morphological, behavioral, and vocal data that suggest the existence of a new species *Cichlocolaptes* in the northern Atlantic forest.

KEY-WORDS: *Cichlocolaptes mazarbarnetti*, *Philydor novaesi*, Furnariidae, measurements, taxonomy.

INTRODUCTION

The avifauna of the northern stretch of the Atlantic Forest is one of the least known, yet most endangered on Earth. Habitat destruction has outpaced ornithological research and conducting research on some species today is difficult because of their scarcity and vulnerability. The inventory of the taxonomic composition of this avifauna is incomplete, as demonstrated by continuous discoveries of new species in the last decades (e.g. Teixeira 1987; Teixeira & Gonzaga 1983, Silva *et al.* 2002). One such species is the Alagoas foliage-gleaner *Philydor novaesi*, discovered at Pedra Branca, Muricí, a relict of foothill forest in Alagoas State (Teixeira & Gonzaga 1983b), and found later in a small reserve in Pernambuco State (Mazar Barnett *et al.* 2005). The species is considered critically endangered (BirdLife International 2013). In a surprising turn of events, Mazar Barnett & Buzzetti (2014) described yet another new foliage-gleaner from Murici, *Cichlocolaptes mazarbarnetti*, based on field observations and examination of museum specimens. The new species is extremely similar to *P. novaesi* in plumage pattern and color but its behavior and vocalizations resemble those of *Cichlocolaptes leucophrus*. In particular, like *C. leucophrus*, the new species shows a preference for foraging on bromeliads. Upon examination of specimens identified as *P. novaesi* at the Museu Nacional in Rio de Janeiro, Mazar Barnett & Buzzetti (2014) concluded that one specimen originally identified as *P. novaesi* is an exemplar of the new foliage-gleaner; diagnostic characters include a larger body size, a longer beak, absence of buffy orbital feathers, and rounded tail feather tips. Although Mazar Barnett & Buzzetti (2014) measured and discussed some biometric data, comparisons were limited to single variables and few species. As part of a large-scale morphometric analysis of the Furnariidae (Claramunt 2010; Claramunt *et al.* 2013), I examined and measured all specimens identified as *P. novaesi* at the Museu Nacional, including the holotypes of *P. novaesi* and *C. mazarbarnetti*. Here I present a morphometric analysis of those specimens and discuss its implications regarding their taxonomic status.

METHODS

Measurements were taken with a Mitutoyo Digimatic Point Caliper (resolution: 0.01 mm) with an output interface. Variables were the same as in previous morphometric studies of the Furnariidae (Claramunt *et al.* 2010; Claramunt *et al.* 2013). Here, I analyzed only two variables from each body region because some measurements were highly correlated in foliage-gleaners: 1) wing length; 2) wing length to the first secondary feather; 3) tail length to central rectrices; 4) tail length to the most external rectrix; 5) bill length from the anterior border of the nostril to the tip of the bill; 6) bill width at the level of the anterior border of the nostrils; 7) tarsus length; and 8) hallux length with claw (Baldwin *et al.* 1931; Claramunt *et al.* 2010).

All known specimens of *Philydor novaesi* and the holotype of *Cichlocolaptes mazarbarnetti* were examined and measured (Appendix). For comparison, I included in the analysis other *Philydor* and *Cichlocolaptes* taxa. Although DNA sequences of *P. novaesi* are not available, its overall morphology and plumage suggest a close relationship with *P. atricapillus* (Teixeira & Gonzaga 1983b) from southeastern Brazil, which belongs to a clade including *P. pyrrhodes*, *Cichlocolaptes leucophrus*, and *Heliobletus contaminatus* (Derryberry *et al.* 2011; Appendix). I did not include *H. contaminatus* in the analysis because of its small size and very distinctive morphology compared to the other species examined. In addition, I analyzed specimens of *P. fuscipenne* and *P. erythrocercum* (Appendix), which are more distantly related but share several phenotypic similarities with *P. novaesi*, and cannot be discarded as potential close relatives. Finally, I also analyzed specimens of the genus *Pseudocolaptes* (Appendix), another genus of Furnariidae that specialized in bromeliad foraging (Sillet *et al.* 1997, Martínez 2003), to investigate patterns of morphological variation related to bromeliad specialization. I examined scatter plots of all variables obtained and conducted a Principal Components Analysis on the covariance matrix of log-transformed values for all measured specimens.

RESULTS

All species analyzed showed sexual dimorphism in which males are larger than females (Table 1). The size dimorphism is particularly pronounced in wing and tail length, for which males of some species average 10 mm longer than females. Exceptions to this pattern are *Cichlocolaptes* and *Pseudocolaptes*, which show reversed sexual dimorphism in bill length, with females having longer bills (Table 1). *P. novaesi* is larger than other species of *Philydor*. Whereas males are relatively uniform (small standard deviations), females previously assigned to *P. novaesi* (including the holotype of *C. mazarbarnetti*) are unusually heterogeneous, particularly in wing, bill, and tarsus length (Table 1). Female 33873 is about 90% smaller than males' averages in wing, tail, and feet variables. Female 34531 is about the same size as males in all variables. Female 34530, the type of *C. mazarbarnetti*, has long wings and bill, surpassing all specimens of *P. novaesi*, including males. The tail of 34530 is not longer than that of *P. novaesi*, however, rectrices 1 and 2 may not be fully grown, as their rachises still show basal sheaths. It is possible to estimate the expected tail length of 34530 from the length of rectrix 6, using the average ratio between these two measurement among specimens of *Philydor* and *Cichlocolaptes* examined. Given a ratio of 1.32, rectrix 1 should be around 82.6 mm when fully-grown, not much longer than the actual measurement (Table 1).

Two principal components explained 86% of the variance among all specimens measured (Table 2). Principal component 1 is positively correlated with all variables; thus, it is associated with overall size. Principal component 2 is a contrast between variables of the bill and variables of the flight apparatus (wings and tail). The three genera, *Philydor*, *Cichlocolaptes*, and *Pseudocolaptes*, occupy different parts of the morphospace defined by components 1 and 2, with limited overlap (Figure 1). Within each genus, females and males are almost completely segregated. Females tend to have lower scores than males in both components, indicating smaller overall size but relatively larger bills. *P. novaesi* is in an intermediate position among the three genera. The three males of *P. novaesi* are tightly clustered, with intermediate scores on component 1 (intermediate size) and high scores on component 2 (relatively long wings and tail but short bill). Females, in contrast, are heterogeneous. Female 33873 has lower scores in both components, compared to males, and its position matches the relative position of females due to sexual dimorphism. Female 34531, in contrast, is positioned near males *P. novaesi*. Female 34530, the type of *C. mazarbarnetti*, has a slightly larger component 1 score but a considerably lower component 2 score compared to male *P. novaesi*; has a result, it is positioned in a region of the morphospace occupied by *Cichlocolaptes leucophrus*, and closer to females of *Pseudocolaptes* than to males of *P. novaesi*. The use of the estimated fully-grown tail length of 34530 instead of its actual length had a negligible effect on the position of this specimen in the multivariate space.

A simple plot of wing and bill length shows a similar pattern (Figure 2). *P. novaesi* specimens are closer to other species of *Philydor*. Note, again, the nearly complete segregation of males and females along the wing-length axis, and, for *Cichlocolaptes* and *Pseudocolaptes*, along the bill-length axis. Again, female 34530 is closer to *Cichlocolaptes* and *Pseudocolaptes* rather than to other specimens of *P. novaesi* and specimens of *Philydor* in general.

DISCUSSION

The morphometric analysis presented here provides a quantitative assessment of all specimens of *P. novaesi* and *C. mazarbarnetti* (Mazar Barnett & Buzzetti 2014). The analysis indicates that *P. novaesi* is larged compared to the other species of *Philydor*, evident in both univariate and multivariate analyses (Table 1, Fig. 1 and 2). The three male specimens of *P. novaesi* are fairly homogeneous, occupying a small sector of the morphospace, but the three females are unusually heterogeneous. Female 33873

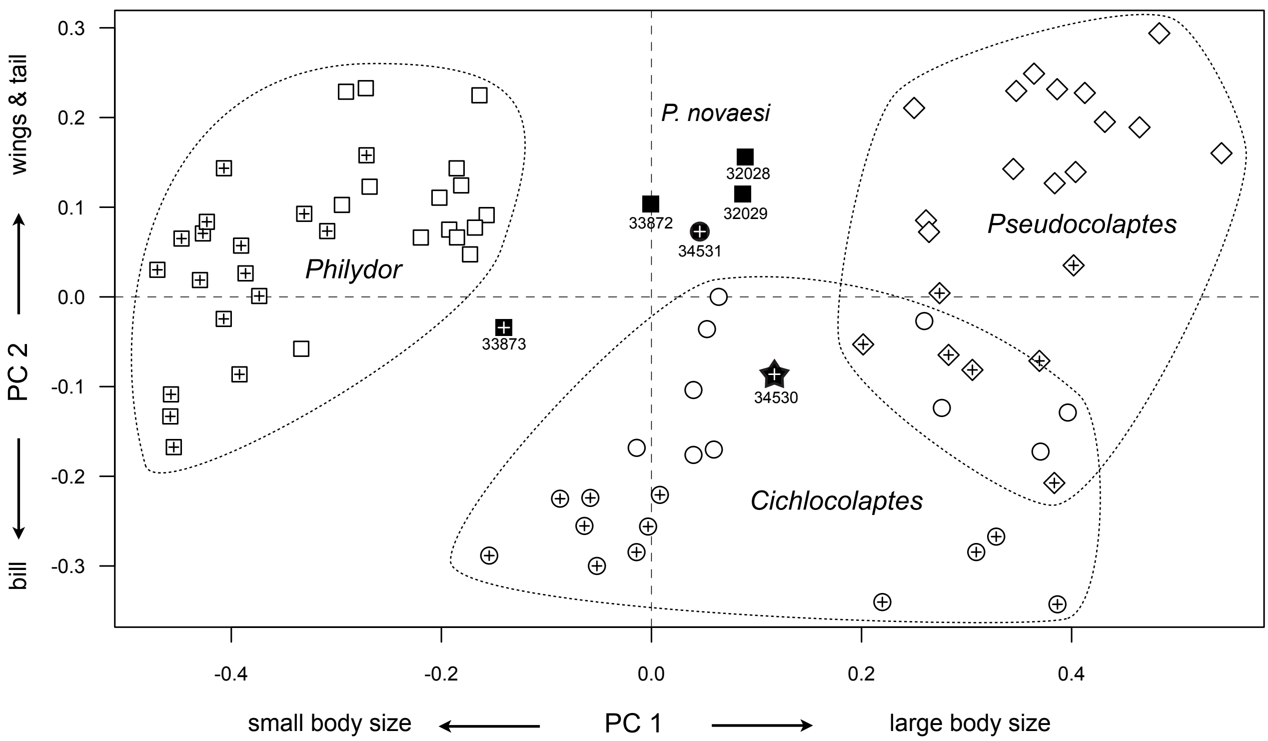

FIGURE 1. Principal component analysis of eight morphometric variables for male (plain symbols) and female (cross) specimens of *Philydor*, *Cichlocolaptes*, and *Pseudocolaptes*, including *Philydor novaesi* (black squares), the holotype of *Cichlocolaptes mazarbarnetti* (black star) and a specimen of uncertain affinities (black circle). Numbers below symbols are Museu Nacional specimen numbers. An approximate interpretation is given for each component but see Table 2 for variable loadings.

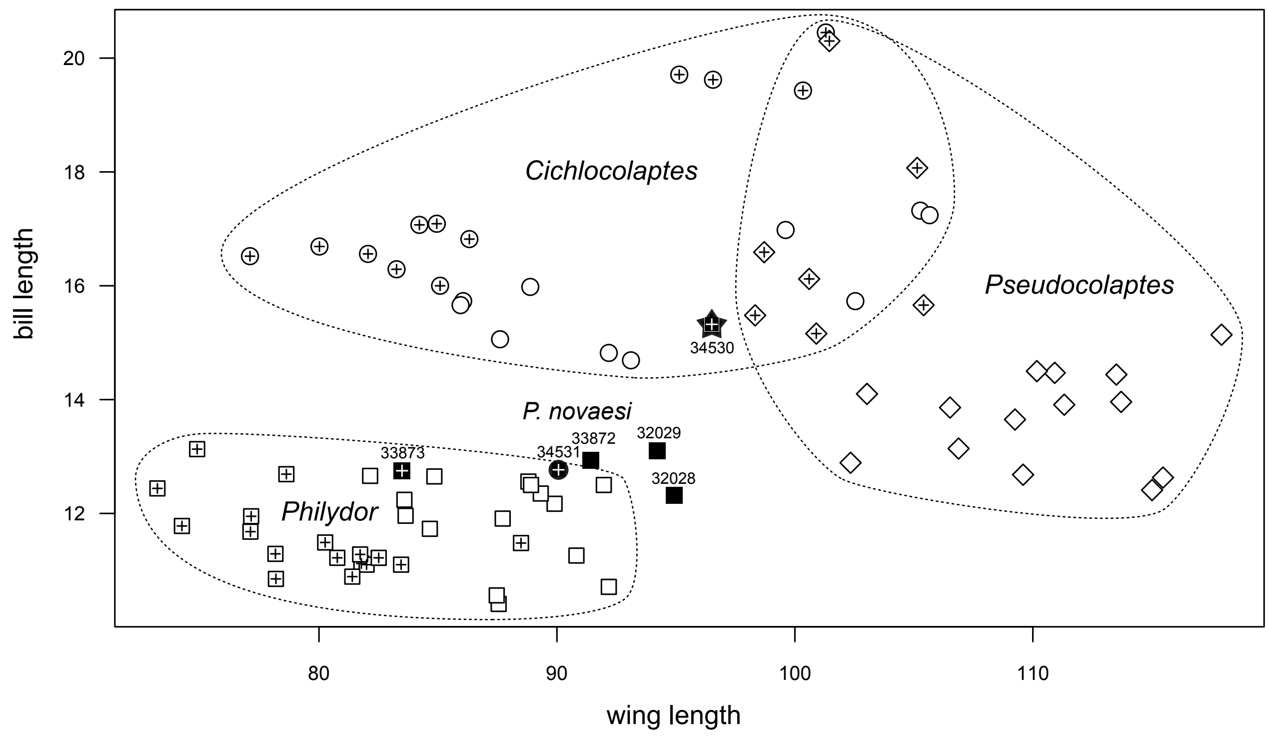

FIGURE 2. Position of male (plain) and female (cross) specimens of *Philydor*, *Cichlocolaptes*, and *Pseudocolaptes* in the morphometric space defined by wing length and bill length, includine specimens of *Philydor novaesi* (black squares),dthe holotype of *Cichlocolaptes mazarbarnetti* (black star) and a specimen of uncertain affinities (black symbol). Numbers below symbols are Museu Nacional(specimen number).

TABLE 1. Morphometric data for species of *Philydor*, *Cichlocolaptes*, and *Pseudocolaptes*, including individual data for all specimens of *Philydor novaesi* and *Cichlocolaptes mazarbarneti* (holotypes marked with *), and average and standard deviations for a combination of female specimens of *P. novaesi* and *C. mazarbarnetti*, which were originally identified as the former species only. See discussion for the placement of MN 34531 in *P. novaesi* or *C. mazarbarnetti*.

		wing		secondary 1		rectrix 1		rectrix 6		bill length		bill width		tarsus		hallux	
Taxon	*sex*	*X̄*	*SD*	*X̄*	*SD*	*X̄*	*SD*	*X̄*	*SD*	*X̄*	*SD*	*X̄*	*SD*	*X̄*	*SD*	*X̄*	*SD*
Cichlocolaptes mazarbarnetti 34530*	f	96.5		77.7		81.8		62.5		15.3		4.9		22.7		16.7	
Cichlocolaptes mazarbarnetti? 34531	fj	90.1		76.0		84.0		64.4		12.8		4.6		22.7		17.7	
Philydor novaesi																	
33873	f	83.5		68.5		76.3		58.8		12.8		4.8		20.8		16.7	
32029*	m	94.2		76.6		84.2		65.5		13.1		4.1		22.7		18.7	
32028	m	94.9		77.6		84.8		67.8		12.3		4.3		22.6		18.5	
33872	m	91.4		75.0		79.9		62.7		12.9		4.0		22.2		17.9	
	m	93.5	1.8	76.4	1.3	82.9	2.7	65.3	2.5	12.8	0.4	4.2	0.2	22.5	0.3	18.4	0.4
P. novaesi + *C. mazarbarnetti*	f	90.0	6.5	74.1	4.9	80.7	4.0	61.9	2.8	13.6	1.5	4.8	0.2	22.1	1.1	17.0	0.6
Philydor atricapillus	f	77.9	2.7	63.8	3.0	72.1	2.3	50.7	3.1	11.4	0.4	4.0	0.1	19.7	1.0	16.4	0.7
	m	84.2	0.7	69.0	1.5	76.6	2.9	55.1	1.8	12.1	0.4	3.8	0.2	20.1	0.4	16.7	0.5
Philydor pyrrhodes	f	77.5	3.9	63.9	2.6	59.1	1.5	46.3	1.2	12.3	0.8	4.4	0.3	19.5	0.6	17.7	0.5
	m	87.8	3.9	72.6	2.9	64.9	3.5	53.1	4.3	12.2	0.6	4.1	0.1	21.1	0.3	18.5	0.3
Philydor erythrocercum	f	83.3	3.5	66.2	2.6	65.1	4.6	58.3	4.4	11.2	0.2	4.2	0.3	18.9	0.5	14.0	0.4
	m	88.7	2.3	71.8	1.9	69.6	3.6	62.2	3.3	10.9	0.7	4.0	0.2	19.8	0.8	15.1	0.7
Philydor fuscipenne	f	81.3	0.9	65.3	0.5	63.9	1.6	54.6	2.7	11.2	0.2	4.3	0.2	18.3	0.6	14.5	0.7
	m	90.2	1.6	72.9	1.9	69.9	1.2	63.7	1.8	12.4	0.2	4.1	0.1	19.3	0.3	15.6	0.1
Cichlocolaptes l. leucophrus	f	98.3	3.0	77.5	2.7	87.0	3.3	64.8	3.0	19.8	0.4	5.4	0.3	23.1	0.5	18.6	0.6
	m	103.3	2.8	83.3	2.0	86.5	2.2	68.9	1.6	16.8	0.7	5.1	0.4	23.7	1.1	19.2	1.2
Cichlocolaptes l. holti	f	82.9	3.1	67.9	1.8	74.9	2.0	55.7	1.5	16.6	0.4	4.8	0.4	21.5	0.5	17.2	0.3
	m	89.0	3.1	73.6	1.8	79.5	2.1	59.1	3.0	15.3	0.5	4.5	0.3	22.5	0.9	17.9	0.6
Pseudocolaptes boissonneautii	f	100.9	2.7	83.4	2.4	90.6	4.2	65.0	3.0	17.1	2.1	4.5	0.1	24.4	0.3	18.3	0.5
	m	110.4	5.5	89.6	3.0	93.8	6.3	69.2	7.0	13.7	0.8	4.2	0.2	26.1	0.9	20.4	1.9
Pseudocolaptes lawrencii	f	103.0	3.4	83.3	3.7	92.1	3.6	66.5	4.3	15.9	0.3	4.6	0.3	25.3	0.4	20.8	0.5
	m	110.4	3.0	88.4	2.1	99.9	4.9	71.8	4.7	13.6	0.9	4.2	0.3	25.7	0.2	21.1	0.8

TABLE 2. Principal components analysis loadings and variance explained.

	PC 1	PC2
Wing length	0.37	0.23
Secondary 1	0.36	0.22
Tail length	0.48	0.15
Rectrix 6	0.36	0.27
Bill length	0.38	-0.78
Bill width	0.12	-0.44
Tarsus length	0.35	0.04
Hallux length	0.35	-0.01
% variance	67	19

is considerably smaller than males, particularly in wing and tail lengths; however, the magnitude and direction of the difference in the morphometric space is as expected given the strong sexual dimorphism in *Philydor*. In plumage coloration, this specimen is indistinguishable from males of *P. novaesi* (Mazar Barnett & Buzzetti 2014; pers. obs.). Therefore, phenotypic data suggest that 33873 is a true *P. novaesi* female.

Measurements of female 34531 do not differ much from those of males of *P. novaesi*. Although Mazar Barnett & Buzzetti (2014) concluded that this specimen is larger than males of *P. novaesi*, differences in weight (2 grams heavier than the heaviest male) and total length (2 mm longer than the longest male) are relatively minor and involved two variables with high measurement error. Female 34531 had a ca. 2 mm smooth ovary according to its label data, indicating immaturity. In addition to its size, the plumage of 34531 is closer to that of 34530, the type of *C. mazarbarnetti*, than other specimens of *P. novaesi*, which led Mazar Barnett & Buzzetti (2014) to speculate that it may represent a juvenile *C. mazarbarnetti*. Another possibility is that 34531 represents a young male *P. novaesi* and its small testicle was mistaken for a small, smooth ovary. In any case, because of its young age, it is safer to set this specimen aside for taxonomic considerations.

Female 34530, the holotype of *C. mazarbarnetti*, is different from all specimens of *P. novaesi* examined. It is similar to males of *P. novaesi* in most measurement except for its much longer bill. However, given the strong sexual dimorphism in *Philydor*, females are not expected to be similar to males. The multivariate analysis placed this specimen apart from *P. novaesi* and in a region of the morphospace occupied by *Cichlocolaptes*. Therefore, the morphometric data is at least consistent with two aspects of Mazar Barnett & Buzzetti's (2014) hypothesis: that female 34530 is not a specimen of *P. novaesi*, and that it belongs to *Cichlocolaptes*.

One alternative to this hypothesis is that *P. novaesi* itself is a *Cichlocolaptes*, or at least, a bromeliad specialist. That would explain behavioral similarities between *P. novaesi* and *Cichlocolaptes* noted in the field, and a strong reversed bill size dimorphism that would explain the longer bill of female 34530. Although *P. novaesi* has always been considered related to *P. atricapillus* based on plumage similarity (Teixeira & Gonzaga 1983b; Remsen 2003), it has never been the subject of phylogenetic analysis. *P. atricapillus* and *Cichlocolaptes leucophrus* are part of a clade that also includes *P. pyrrhodes* and *Heliobletus contaminatus* (Derryberry *et al.* 2011). *P. novaesi* may belong to this clade but, at least from a morphometric perspective, it is not clear whether it is closer to *P. atricapillus* or *C. leucophrus* since it occupies an intermediate position in the morphometric space (Figure 1). However, this hypothesis does not explain the morphometric disparity between female specimens 33873 and 34530 (both adult), neither explain the long wings of female 34530, since even among bromeliad specialists, *Cichlocolaptes* and *Pseudocolaptes*, females have considerable shorter wings than males. Although bromeliad specialists *Cichlocolaptes* and *Pseudocolaptes* tend to be morphometrically heterogeneous (see morphospace occupation in Figure 1 compared to *Philydor*), except for the sexual dimorphism in the bill, this heterogeneity most likely represents geographically structured differentiation. For example, *Cichlocolaptes leucophrus* is composed of two very distinct subspecies, *C. l. leucophrus* in northern Atlantic forests and *C. l. holti* in the south (specimens with a PC 1 score lower than 0.2; Figure 1). Within each subspecies, levels of variation among females are not greater than those of species of *Philydor* (Table 1). *Pseudocolaptes* is also composed of multiple lineages that vary geographically (Remsen 2003). In contrast, females 33873 and 34530 are from the same geographic locality.

A third possibility is that specimen 34530 is some sort of aberrant individual of *P. novaesi*, and similarities with *Cichlocolaptes* are just a coincidence. This hypothesis is difficult to test since, in principle, it does not predict a particular pattern of variation or position in the morphospace in relation to other individuals or species. However, it is not a simple case of gigantism in which an individual is isometrically larger than others in all variables. Specimen 34530 is larger than *P. novaesi* in bill and wing lengths but not in tarsus or hallux lengths. This pattern is unusual for intraspecific variation in birds since genetic changes that affect forelimb length will more likely affect hindlimb length rather than bill length (Nemeschkal 1999; Magwene 2001). Other aspects of this hypothesis can be tested with additional data. For example, comparison of levels of asymmetry can be used to evaluate whether specimen 34530 experienced an anomalous development (Palmer & Strobeck 1986).

I conclude that the existence of a new *Cichlocolaptes* species, *C. mazarbarnetti*, is a plausible explanation for the morphometric data analyzed. The reduced number of specimens available limits any definite conclusion and any taxonomic recommendation should consider also the morphological and behavioral evidence presented by Mazar Barnett & Buzzetti (2014). A source of information that may be powerful in this case is genetic material extracted from study skins (Mundy *et al.* 1997) with which the phylogenetic affinities of *P. novaesi* and specimen 34530 can be determined with more confidence. Given the high levels of genetic divergence between members of the *Cichlocolaptes-Philydor* clade (Derryberry *et al.* 2011), even a short fragment of mitochondrial DNA may prove useful in determining relationships.

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APPENDIX:

Specimens examined and measured in the collections of the American Museum of Natural History (AMNH), Louisiana State University Museum of Natural Science (LSUMZ), Museu Nacional, Rio de Janeiro (MN), and Museu de Zoologia, Universidade de São Paulo (MZUSP):

Cichlocolaptes mazarbarnetti. MN 34530 (holotype) adult female collected on 16 January 1986, 48 g, globulous 12 mm ovary with one ovum > 2 mm, ossified skull, 221 mm total length; MN 34531 (tentative assignation), young female collected on 20 January 1986, 36 g, smooth 2 mm ovary, according to a drawing in the label, 207 mm total length.

Cichlocolaptes leucophrus leucophrus. Males: AMNH 243297, 317611, MZUSP 33324, 34530. Females: AMNH 317612, 316817, MZUSP 33322, 28506.

Cichlocolaptes leucophrus holti. Males: AMNH 314749, 314748, 524356, LSUMZ 68015, 31666, MZUSP 49762. Females: AMNH 314750, 314751, 314752, 524357, LSUMZ 53001, 63359, MZUSP 32147, 54949.

Philydor novaesi. MN 32029 (holotype) adult male collected on 7 November 1979, 32 g., enlarged testis, 205 mm total length; MN 32028 (paratype) adult male, 34 g, enlarged testis, 195 mm total length; MN 33872, male, 32 g, small testis; 33873: adult female collected on 21 November 1983, 30 g, granulated 9 mm ovary, ossified skull, 195 mm total length.

Philydor atricapillus. Males: LSUMZ 63354, 70433, AMNH 314701, 243301. Females: LSUMZ 62951, AMNH 243302, 243303, 317614, 524190.

Philydor pyrrhodes. Males: LSUMZ 109768, 115010, 156423, AMNH 286828. Females:LSUMZ 137071, AMNH 430943, 824593, 142492, 274140.

Philydor erythrocercum. Males: LSUMZ 132520, 87888, 175383, 96027. Females: AMNH: 429578, 256099, 283973, 819937.

Philydor fuscipenne. Males: LSUMZ 108297, AMNH 246775, 136619. Females: AMNH 135827, 136620, 135826.

Pseudocolaptes boissonneautii. Males: AMNH 124519, 167340, 124520, 820955, 820474, LSUMZ 45349, 178990, 169854. Females: AMNH 820956, 820779, 820420, LSUMZ 81936.

Pseudocolaptes lawrencii. Males: LSUMZ 63643, 154029, AMNH 524041, 102195, 102196. Females: AMNH 811839, LSUMZ 154031.

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SHORT-COMMUNICATION

Further comments on the application of the name *Trochilus lucidus* Shaw, 1812

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ABSTRACT: A recent paper discussed the priority of the name *Trochilus lucidus* Shaw, 1812 over *Ornismya aureoventris* d'Orbigny & Lafresnaye, 1838, for the Glittering-bellied Emerald and the reasons why the senior name cannot be considered a *nomen oblitum* according to the rules of zoological nomenclature. However, all details concerning the application of the name have not been fully addressed, raising concerns among several ornithologists on the application of Shaw's name. Here we discuss in detail why the name *Trochilus lucidus* must be applied to the Glittering-bellied Emerald. All morphological characters of Azara's "El Más Bello" hummingbird (upon which the name *lucidus* was based) agree perfectly with the Glittering-bellied Emerald, reinforcing its status as the valid, senior available name to that species. This conclusion has been historically accepted by almost all ornithologists who have studied the case.

KEY-WORDS: *Chlorostilbon aureoventris*, *Chlorostilbon lucidus*, Glittering-bellied Emerald, nomenclature, priority.

INTRODUCTION

In a recent paper, Pacheco & Whitney (2006) argued that the name *Trochilus lucidus* Shaw, 1812, is a senior synonym of *Ornismya aureoventris* d'Orbigny & Lafresnaye, 1838, and should therefore be applied to the Glittering-bellied Emerald, which would become *Chlorostilbon lucidus* according to current taxonomy and systematics of the hummingbirds. However, some colleagues reasoned that, even though the priority of Shaw's name was made clear, the paper by Pacheco & Whitney has not defended why the name *T. lucidus* should apply to the Glittering-bellied Emerald. Aiming to fill this gap, here we provide a rationale for the application of Shaw's name to the Glittering-bellied Emerald.

Origin and identity of Azara's and Shaw's names

Using the name "El Más Bello" (description n. 293), Félix de Azara (1805) described one of the 11 hummingbirds dealt with in his work on the birds of Paraguay and La Plata river. Four years later, in the French edition (Azara 1809), the same species appeared with the name "le plus beau des bec-fleurs" and the naturalist Sonnini de Manoncourt, responsible for the translation, made the first attempt to associate the description of that hummingbird with the Linnean nomenclature: in a footnote, he subordinated it to *Trochilus bicolor* "Linn", which is clearly incorrect, since the latter name applies to a species from the Caribbean (presently *Cyanophaia bicolor*) and the "Más Bello" of Azara is from Paraguay.

Shaw (1812), without reference to any specimen, described *Trochilus lucidus* ["Brilliant Humming-bird"] based exclusively on the "le plus beau des bec-fleurs" of Azara. A few years later, Vieillot (1817) named *Trochilus splendidus* ["Oiseau-mouche Éclatant"] based exclusively on "El Más Bello" of Azara.

Azara's (1805:487-488) description is as follows:

(…)

Núm. CCXCIII

EL MAS BELLO

Longitud 3 1/2 pulgadas : braza 4 1/2 : cola 13 1/2 lineas : pico 7 2/3, recto y encarnado, con la punta negra. De él á la cola, cobijas y vientre, como en todos, *pero mas brillantes. Toda la garganta y la cola azules fuertes y constantes, y lo inferior y costados del cuerpo como el lomo, aunque con mas brillo ; de manera que dichos costados en oposicion brillan lo que no puede explicarse. Baxo del cuerpo es lo proprio, con ménos brillo, sucediendo lo mismo a los timoneles inferiores. Tras del ojo hay un punto blanco, que no se vé sino estando muy abierto; y la pluma del oido no es larga como en el precedente. Remos 16, sin salto, y la cola con el mismo seno que la del anterior.*

(Translation: Length 3 1/2 inches : arm [meaning wing] 4 1/2 : tail 13 1/2 lines : bill 7 2/3, straight and red, with black tip. From it [the bill] to the tail, coverts and belly, as in all [other hummingbirds], but shiner. The whole throat and the tail strong and constant blue, and the underside and the flanks as the back, though with stronger shine; in a way that makes the flanks in opposition shine like one cannot explain. Down on the body it is the same, with less gloss, the same occurring to the underwing coverts. Behind the eye there is a white spot, not seen unless it is wide open; and the auricular feathers are not long as in the previous [species]. Remiges 16, without a break, and the tail forked like the previous [species].)

He then compares his bird with Buffon's "Saphir emeraude" (from Guadalupe and Cayena), even mentioning the emerald green color with golden shine in the neck, back, breast, and belly of Buffon's bird, and ends with: "*Le parece que son variedad un de otro, ó á lo ménos especies muy próximas. Esta descripcion solo difiere de la mia en que niega el seno á la cola*" ["It seems they are varieties of each other, or at least very close species. This description differs from mine only in denying the forked tail"].

So, all the above said, one must think of a hummingbird species occurring in Paraguay that fits the description of a very brilliant bird, with a golden shining green color, red bill with black tip, deep blue forked tail, and white spot behind the eye. We see no other option than Glittering-bellied Emerald, "*C. aureoventris*". Depending on the point of view, the only inaccuracy would be the "constant blue throat". However, "*C. aureoventris*" almost always shines blue in the throat (Figure 1), and that may be the cause of this minor "inaccuracy" of a work from 1805. Not surprisingly, several field guides and books indeed illustrate that species with a blue throat (*e.g.* Schuchmann 1999; Sigrist 2006; van Perlo 2009).

FIGURE 1. Adult male Glittering-bellied Emerald (*Chlorostilbon lucidus*) photographed in Curitiba, Paraná, Brazil. All characters originally described by Azara for his "El Más Bello" can be seen in this bird: straight, red bill with a black tip; shinning golden-green overall plumage; blue throat; white spot behind the eye; and dark blue, forked tail (photo by Sergio Gregorio).

Nomenclatural history of Azara's and Shaw's names

During the 19th and beginning of 20th Centuries, most authors associated Azara's "el más belo" with the Glittering-bellied Emerald, although Shaw's name *T. lucidus* was overlooked in favor of its junior objective synonym, *T. splendidus* Vieillot. The associations were given as follows:

1) Elliot (1875) implemented the combination *Chlorostilbon splendidus*, and justified his choice:

> "In 1817 Vieillot described the *Masbello* of Azara, from Paraguay, as *Trochilus splendidus*; and his description and the locality of the specimens leave no doubt that the bird afterwards named *phaethon* by Bourcier is intended. Vieillot says << le bec incarnat, et à pointe noire >> and that all the plumage, with the exception of the throat, the front of the neck, the tail, and a white spot on the belly, is a shining golden green. I know of no other species of Humming-bird from the locality given by Vieillot which could possibly answer to his description; and I see no reason whatever that should cause ornithologists to hesitate in accepting his name as having prior claim to the bird afterwards named *phaethon* by Bourcier."

2) In an appendix made specially to correlate the identities of the birds described by Azara, Berlepsch (1887) considered the descriptions 292 (*Picaflor cola azul com seno*), 293 (*Pica flor mas bello*), and 294 (*Pica flor ceniciento-obscuro debaxo*) of the former author as referring to *Chlorostilbon splendidus*.

3) Salvin (1892; miscited as "Hartert 1892" in Pacheco & Whitney 2006) lists the humminbirds/ picaflores "*más bello*" and "*cienicento obscuro debaxo*" of Azara among the older names of *Chlorostilbon splendidus*. [Surprisingly, Salvin did not realize that *lucidus* was based on Azara as well and applied it to *Hylocharis leucotis*, a species from Central and North America, thus repeating Sonnini's mistake.]

4) Bertoni (1901) also took descriptions 292, 293, and 294 from Azara as *Chlorostilbon splendidus*.

At the same time, Hartert (1900) published a work in which he dealt with the application of Shaw's and Vieillot's names ("*Species dubiae*"; Hartert 1900:227):

> T. lucidus G. Shaw 1805 ,,*Picaflor mas bello*" + ,,*P. ceniciento–obscuro debaxo*"? + ,,*P. cola azul con seno*", Azara, Apunt. Paxaros, v. 2 p. 487, 489 | 1811 *Trochilus lucidus*, G. Shaw, Gen. Zool., v.81 p. 327 | 1817 *T. cinereus* (non Gmelin 1788) + *T. splendidus*? + *T. cyanurus* (non Gmelin 1788), Vieillot in: Nouv. Dict., ed. 2 v.7 p. 359, 361, 369 | 1822 *T. cinereicollis*, Vieillot in: Tabl. enc. méth., Orn. v.2 p. 562.
>
> Es ist möglich, dass sich alle obigen Synonyme auf ein und dieselbe Form beziehen, und dass der "*Picaflor ceniciento-obscuro debaxo*" Azara's, auf dem Vieillot's *T. cinereus* beruht, das ♀ einer *Chlorostilbon*-Art ist. Der Ausdruck Azara's "Toda la gargante y la cola azules fuertes y constantes", der sich wortgetreu bei Shaw und Vieillot übersetzt findet, verbietet, diese Beschreibung auf einen *Chlorostilbon* mit leichtem hellblauen Schimmer an der Kehle, also auch nicht auf *C. aureoventris*, anzuwenden. *T. lucidus* G. Shaw kann auch nicht als Synonym zu *Hylocharis leucotis* gezogen werden. Übrigens würde, wenn dies thunlich ware, in beiden Fällen Shaw's *T. lucidus* die Priorität haben. *T. cyanurus* Vieill. dürfte auf einem jüngeren Vogel beruhen, der immerhin zu *Chlorostilbon aureoventris* oder einer andern Art gehören könnte.

[Which we translated as: It is possible that all synonyms above refer to one and the same form, and that Azara's "*Picaflor ceniciento-obscuro debajo*", on which is based Vieillot's *T. cinereus*, is the female of a *Chlorostilbon* species. Azara's expression "Toda la gargante y la cola azules fuertes y constantes", which is found translated verbatim in Shaw and Vieillot, precludes the application of this description to a *Chlorostilbon* with a slight blue tinge to the throat, and thus do not apply to *C. aureoventris* either. *T. lucidus* Shaw cannot be also taken as a synonym of *Hylocharis leucotis*. By the way, were that possible, in both cases Shaw's *T. lucidus* would have priority. *T. cyanurus* Vieill. might be based on a younger bird that could belong, after all, to *Chlorostilbon aureoventris* or another species.]

This was a key work: after Hartert (1900), several authors opted to abandon the names *lucidus* and *splendidus* in favor of *aureoventris*. Awkwardly, in many cases the name *aureoventris* was incorrectly given priority even when the "Más Bello" and/or the name *lucidus* were positively identified as the Glittering-bellied Emerald. For instance:

1) Laubmann (1939) correlated Azara's descriptions 292, 293, and 294 to *Chlorostilbon aureoventris aureoventris* (Lafr. & d´Orb.).

2) Short (1975), Narosky & Izurieta (1987), Contreras (1987), La Peña (1988), among others, considered *lucidus* and *aureoventris* as (apparently) distinct but conspecific, however presented the combination *C. aureoventris lucidus* instead of the correct *C. lucidus aureoventris.*

Most recently, Mallet-Rodrigues (2005) argued that the name *lucidus* could not be applied to the Glittering-bellied Emerald because that species does not have a blue throat as described by Azara and Shaw, but rather a "golden-green throat with "slight blue tone" (*ligeiro tom azulado*). In his view, the name *Trochilus lucidus* should be treated as a *nomen dubium*, even though he acknowledges that its application to the Glittering-bellied Emerald cannot be disregarded.

DISCUSSION

As we stated before, we see no reason to follow Hartert's opinion on the identity of Azara's hummingbirds. Quite to the contrary, we agree with Elliot, Berlepsch, Salvin, Bertoni, Laubmann and others that Azara's "Más Bello" is perfectly identifiable so that the name *Trochilus lucidus* Shaw applies to the Glittering-Bellied Humminbird and has clear priority over *Ornismya aureoventris* D´Orbigny & Lafresnaye, 1838.

Meyer de Schauensee (1966), Sibley & Monroe (1990), and Schuchmann (1999) all recognize that the name *Trochilus lucidus* may be the valid one, but suggest it should be considered a *nomem oblitum*. Pacheco & Whitney (2006) showed that this is not possible under the rules of the ICZN (2009): a reversal of precedence (Art. 23.9) cannot be taken because the oldest available name (*lucidus*) was used as valid after 1899. Actually, a quick search showed that the name *lucidus* was used in at least 32 different works involving 33 authors (besides anonymous and institutional authorships) between 1945 and 1998, among them many publications of national scope, such as: Steullet & Deautier (1945), Cuello & Gerzenstein (1962), Olrog (1963), Olrog (1979), and Cuello (1985). Further, this widespread use of *lucidus* demonstrates that there is no "threatened stability" that would require a protective ruling by the International Commission of Zoological Nomenclature (Art. 23.9.3).

Lastly, we would like to stress that the application of the name *Trochilus lucidus* to the Glittering-bellied Emerald should not be taken merely because of the near consensus among ornithologists who have studied the case. Quite the opposite, the near consensual opinion among ornithologists is the result of a straightforward identity of Azara's hummingbird. Denying that the "Más Bello" refers to the Glittering-bellied Emerald means one believes that Azara described a [*Chlorostilbon* or *Amazilia*] species now extinct in Paraguay, while missing the most common hummingbird in that country (cf. Hayes 1995; Guyra Paraguay 2004). In our review of the evidence, this hypothesis lacks any support.

Overall, our detailed analysis provides additional evidence for Pacheco & Whitney's (2006) conclusions and we support the application of the name *Trochilus lucidus* to the Glittering-bellied Emerald.

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ARTICLE

Conducting rigorous avian inventories: Amazonian case studies and a roadmap for improvement

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ABSTRACT: Site-based avian inventories are ubiquitous in Neotropical ornithology but are prone to error if fieldworkers are not familiar with the regional species pool, particularly in species-rich regions such as the Amazon basin. Here, we review recent species lists from the Brazilian Amazon in both the primary ornithological literature and in protected area management plans to assess the level of putative errors in terms of bird species recorded in site-based inventories that are biogeographically unlikely in the sampled region. We found errors to be frequent across all inventory types. Failure to recognize recent taxonomic modifications in a cited taxonomy was a common error in many inventories. We outline a series of steps to follow to improve the utility and accuracy of avian inventories, and stress the importance of both obtaining and archiving documentary material, which should be included in the publications as digital vouchers to facilitate detailed peer review.

KEY-WORDS: Amazonia, avian surveys, checklist, documentation, taxonomy, vouchers.

INTRODUCTION

Comprehensive and accurate site-based species inventories are the backbone of macroecological studies and crucial for understanding multi-scale patterns of species richness, evolutionary processes, natural patterns of environmental heterogeneity, and species-specific responses to environmental change (Blackburn & Gaston 1998). Species lists can function as a baseline to which new ecological and evolutionary studies can be compared in the future (Moritz *et al.* 2008; Coterrill & Foissner, 2010). However, compiling species lists can be a labor-intensive and a rather unrewarding academic task, as high-impact scientific journals typically do not publish species inventories. Despite the clear importance of high-quality baseline inventories in the face of global habitat loss, fragmentation, degradation, and climate change, avian inventories are being published in lower-profile journals, which often do not demand the highest desirable scientific standards for publication. On the other hand, avian inventories are likely to be cited for centuries (e.g., Snethlage 1908), which also means that errors can potentially propagate for decades.

There is little doubt that birds represent the best-known taxonomic group in the Neotropics, yet our knowledge of the avifauna in many regions remains poorly documented, particularly in the vast Amazon basin. In fact, significant knowledge gaps regarding species identification, distribution, and taxonomy still exist in entire Amazonian regions (Aleixo 2009; Barlow *et al.* 2011). These gaps in knowledge, allied to the intrinsic difficulties of surveying birds in highly diverse tropical forests, where researchers are reliant on avian vocalizations to conduct accurate surveys (Remsen 1994; Cohn-Haft *et al.* 1997; Willis 2003) may result in false-positive detections (i.e., species that appear in regional or site-based lists that are unlikely to occur in a given region). Even well-trained ornithologists may make identification errors in these environments, which is unsurprising given the many morphologically and vocally similar species which occur in sympatry in Amazonia. These errors have been experimentally quantified before, for aural errors in controlled studies of electronically broadcast avian vocalizations (e.g., Simons *et al.* 2007) and for visual errors by releasing trapped birds (of biometrically confirmed individuals) in front of field observers (e.g., Hull *et al.* 2010), or even to test the subjectivity of abundance estimates (Cerqueira *et al.* 2013).

Identification errors that enter the primary ornithological literature (species lists in journals) may rapidly be spread into the secondary literature, leading to incorrect distribution maps in widely used field guides. This leads to further proliferation of identification errors, as ornithologists and birders alike may pay little attention to the identification of 'confusion' species (similar-looking and potentially sympatric species) widely considered to be present in a region (Robbins & Stallcup 1981; Willis 2003; Rojas-Soto & de Ita 2005; McKelvey *et al.* 2008). Given these potential problems, we believe that species inventories should be treated as rigorously as any other scientific enterprise and provide as much supporting documentary evidence as possible (e.g., Cohn-Haft *et al.* 1997; Silveira & D'Horta 2002; Silveira *et al.* 2010; Aleixo *et al.* 2011; Somenzari *et al.* 2011; Lees *et al.* 2012, 2013a) to prevent 'false presences' becoming established in the literature (McKelvey *et al.* 2008; Silveira *et al.* 2010), as well as to facilitate re-evaluations of taxonomic status in the future.

Corrections of previous mistakes have already been published in the recent Amazonian literature. For example: Cohn-Haft *et al.* (1997) removed seven species from the list of Stotz & Bierregaard (1989) of the birds north of Manaus; Naka (2006) removed, or included as hypothetical, 15 species previously reported for the Brazilian state of Roraima; Whittaker et al. (2008) re-identified or removed 30 species from the initial checklist of the birds of the upper Rio Urucú, originally published by Peres & Whittaker (1991); Lopes *et al.* (2009) re-identified and corrected 52 species from the Chapada dos Guimarães; Lees *et al.* (2013a) moved to 'hypothetical species appendix' or removed entirely 10 species from the lists of Sanaiotti & Cintra (2001) and Henriques *et al.* (2003) from around Santarém; and Lees *et al.* (2013b) removed three species from the checklist of Alta Floresta (Zimmer *et al.* 1997) and moved another nine taxa to a 'hypothetical species' appendix. However, we consider this issue likely more widespread and here evaluate the pervasiveness of problems related to bird misidentifications in both the 'primary' and 'grey' Brazilian ornithological literature. In this article, we judge the ubiquity and nature of errors in 63 Amazonian bird inventories (including all of our own) and point out likely cases of misidentification. We then suggest a roadmap for producing less error-prone avian inventories.

METHODS

Each Amazonian interfluve has its own unique avian assemblage, with species turnover particularly high across wide rivers and in families or guilds with limited dispersal capacity such as understory suboscines. These biogeographical patterns are now increasingly well understood so that unexpected presences are reasonably easy to spot. We reviewed 32 bird inventories (Appendix 1) in the Brazilian Amazon published between 2000 and 2013 to look for instances of presumed misidentification based on expert opinion of the distribution of allopatric and parapatric Amazonian bird species (see Table 1). These lists were published in international journals (*n* = 7), Brazilian journals (*n* = 21), and book chapters (*n* = 4). In addition, we also reviewed 31 reserve management plans (Appendix 2) from the Brazilian Amazon to compare error rates with those lists in the primary literature. Given the general lack of review of the grey literature, we expected to find a higher rate of errors in unpublished reports.

Our error-checking process applied only to biogeographically extremely unlikely records. When searching these inventories there were many instances of unusual boreal and austral migrants, many of which are difficult to identify, that we do not necessarily infer to be in error despite being presented without supporting information or documentation. Also, some species—such as the White-rumped Swallow *Tachycineta leucorrhoa*—are often reported from Amazonian sites, yet they lack any documentation, and we assume many reports to be in error although we do not highlight them herein. We also reviewed which supporting information was supplied with species' lists—form of documentation listed, digital vouchers included—and whether abundance and habitat type information were incorporated in the data.

RESULTS

We found evidence of presumed misidentifications in 25 inventories (78%) involving 107 records of 82 species (Table 1). The number of assumed misidentifications varied between 0 (none) and 15 (*X*, ¯ = 3.3, *SD* = 4.1, 0-3.7% of the total list). Errors could be broadly divided into two groups: a) misidentification of a species that is not known to occur in the Amazonian interfluve sampled (*n* = 74, 70.4%); and b) confusion with replacement species (taxonomic errors) for which the wrong member of a species pair or super-species complex was listed (*n* = 31, *X*, ¯ = 29.0%), often because of a failure to account for shifts in nomenclature and 'splits.'

We found that 25% of surveys informed the type of documentation obtained during the survey but only 4% provided links to digital vouchers, although some of these web-based resources have only become available recently. Nearly 20% of the surveys included qualitative abundance estimates and almost 60% included information of which habitat types species were encountered. Reserve management plans (n = 31) were more heterogeneous in their error rates with the number of assumed misidentifications varying between 0 and 35 (n =84, X, ¯= 2.71, SD = 6.64) accounting for between 0 and 7.9% of all records.

TABLE 1. A compilation of inferred errors from Amazonian avifaunal inventories between 2000 and 2013. All inferred errors represent apparently undocumented records which are not explicitly discussed in the text, some may of course be genuine, but given their biogeographic significance should be adequately documented before being presented as 'confirmed'. Species denoted with an asterix* indicate taxonomic rather than identification errors. Citations can be found in Appendix 1.

Aguiar *et al.* 2010. **Lago Piratuba, Amapá**	*Comments*
Sterna hirundinacea	Undocumented north of Bahia, would be a first for the biome.
Synallaxis propinqua	Undocumented from Amapá or anywhere in the eastern half of the Guianan Shield.
Aleixo & Poletto 2007. **BX44 Polygon, Mato Grosso/ Amazonas**	
Hylophilus hypoxanthus	Replaced by *Hylophilus muscicapinus* in this interfluve (Madeira-Tapajós).
Aleixo *et al.* 2010. **Tanguro, Mato Grosso**	
*Hypocnemis cantator**	Taxonomy followed unclear but should be *H. striata*.
Lophotriccus galeatus	Undocumented east of the rio Xingu where replaced by *Hemitriccus minor* - as reported nearby by Mestre *et al.* 2011.
Borges & Almeida 2011. **Jau National Park, Amazonas**	
*Trogon violaceus**	*Trogon ramonianus* south of the rio Amazonas and west of the rio Negro following CBRO (2009).
*Schiffornis turdina**	*Schiffornis amazonum* north of the rio Amazonas and west of the rio Madeira following CBRO (2009).
Dantas *et al.* 2011. **FLONA de Pau-Rosa, Amazonas**	
Polytmus guainumbi	Unknown in central Brazilian Amazonia, more likely to be *P. theresiae*.
Dendrocolaptes picumnus	Unknown in this interfluve (Madeira-Tapajós) where replaced by *D. hoffmannsi*.
Hylophilus hypoxanthus	Replaced by *Hylophilus muscicapinus* in this interfluve (Madeira-Tapajós).
Favaro & Flores 2009. **Terra do Meio, Pará**	
*Hylexetastes perrotii**	Does not occur south of the rio Amazonas, based on CBRO (2008) this should be *H. uniformis*.
Automolus infuscatus	Reported here as sympatric with *A. paraensis* but highly unlikely as *infuscatus* is undocumented east of the Madeira.
Pipra aureola	Not expected in the interior of the Tapajós-Xingu interfluve.
Pheugopedius genibarbis	Reported as sympatric with *P. coraya* but the two are replacement species; *genibarbis* unknown north of the Serra do Cachimbo between the Tapajós and Tocantins.

Aleixo & Guilherme 2010. Estação Ecológica do Rio Acre, Acre	
Chaetura spinicaudus	Undocumented in SW Amazonia; best treated as hypothetical.
Lees *et al.* 2008. Serra dos Caiabis, Mato Grosso	
Synallaxis cherriei	Listed in error, record pertains to *S. rutilans.*
Lees *et al.* 2012. Paragominas, Pará	
*Phaeothlypis rivularis**	Based on CBRO (2011) this should be *P. mesoleuca.*
Tangara sayaca	Archived digital voucher (a photo) appears to be a juvenile *T. episcopus,* which are very similar to *T. sayaca.* The latter would represent a significant range extension.
Euphonia chrysopasta	Archived digital voucher (a photo) is ambiguous; we consider it better to treat this record and others east of the rio Tocantins as hypothetical until better documentation available.
Lees *et al.* 2013b. Santarém, Pará	
*Phaeothlypis rivularis**	Based on CBRO (2011) this should be *P. mesoleuca.*
Mestre *et al.* 2010 . RESEX Chico Mendes, Acre	
Aulacorhynchus prasinus	This should be *Aulacorhynchus atrogularis* following CBRO (2009).
Mestre *et al.* 2011. Querencia, Mato Grosso	
Poecilotriccus fumifrons	Only *P. latirostris* expected in this region - as reported nearby by Aleixo *et al.* 2010.
Pacheco & Olmos 2005. BR163, Pará	
Hemitriccus minor	Does not occur between the Tapajós and Xingu north of the Teles Pires where replaced by *Lophotriccus galeatus*.
Pacheco *et al.* 2007. Carajas, Pará	
*Phaethornis nattereri**	The taxonomic position of this species in relation to *P. maranhaoensis* is unresolved but only the latter is expected in this region.
Myrmotherula sclateri	Undocumented east of the rio Xingu.
Hyloctistes subulatus	Undocumented east of the rio Xingu, this species was removed from the Carajás list by Aleixo *et al.* 2012.
Lophotriccus galeatus	Does not occur in this interfluve (Xingu-Tocantins) see e.g. Cohn-Haft (2000), Lees *et al.* (2013a).
Pipra aureola	Undocumented as far south as Carajás, where similarly looking *P. fasciicauda* has been documented, this species was removed from the Carajás list by Aleixo *et al.* 2012.
Turdus hauxwelli	As currently mapped this species is not expected in eastern Amazonia where *T. fumigatus* is usually reported.

Hylophilus muscicapinus	Undocumented east of the rio Tapajós, this species was removed from the Carajás list by Aleixo *et al.* 2012.
Portes *et al.* 2011. Belem Centre of Endemism, Pará	
Milvago chimango	Clerical error, should be *M. chimachima*.
Myrmeciza atrothorax	Undocumented east of rio Tocantins.
Thamnophilus schistaceus	Undocumented east of rio Tocantins.
Thamnophilus stictocephalus	Undocumented east of rio Tocantins.
Cranioleuca gutturata	Undocumented east of rio Tocantins.
Furnarius rufus	Undocumented in the Belém centre of endemism.
Hemitriccus minimus	Undocumented east of rio Tocantins, recording likely pertain to a recently discovered and as yet undescribed *Myiornis* taxon.
Hylophilus hypoxanthus	Undocumented east of rio Tocantins.
Tangara chilensis	Undocumented east of rio Tocantins.
*Phaeothlypis rivularis**	Based on CBRO (2011) this should be *P. mesoleuca,* which was recently split from *P. rivularis.*
Euphonia chrysopasta	Undocumented east of rio Tocantins.
Oliveira *et al.* 2011. Cotriguaçu, Mato Grosso	
Leucopternis lacernulatus	This species is restricted to the Atlantic Forest and is not expected in Amazonia, record likely relates to a similar species.
Circus cinereus	This would represent the first record from anywhere in central or north Brazil and would require extensive documentation.
*Pyrrhura picta**	This should be *P. amazonum* or *P. snethlageae* in this region, although the taxonomy followed in this inventory is unclear.
Pionus maximiliani	This species is undocumented from northern Mato Grosso and would represent a significant range extension.
*Notharchus macrorhynchus**	Only *N. hyperrhynchus* occurs south of the Amazon.
Colaptes campestris	Not expected in NW Mato Grosso.
Thamnomanes ardesiacus	Undocumented east of the rio Madeira.
Dysithamnus mentalis	Not expected in NW Mato Grosso, should preferably be documented.
*Schistocichla leucostigma**	This should be *Schistocichla* (formerly *Percnostola*) *rufifacies* in this region, although the taxonomy being followed in this inventory is unclear.
Xiphorhynchus spixii	*X. spixii* does not occur west of the rio Juruena (or Teles Pires), only *X. elegans* is expected.
Automolus infuscatus	*A. infuscatus* is undocumented east of the rio Madeira; this will likely pertain to *A. paraensis*.
Hemitriccus zosterops	Replaced by *H. griseipectus* south of the rio Amazonas.
*Fluvicola pica**	Undocumented and unexpected in southern Amazonia.
Turdus fumigatus	Reported as occurring sympatrically with *T. hauxwelli,* only *T. hauxwelli* expected in this interfluve (Madeira-Juruena).
Olmos *et al.* 2011. Rondônia	
Galbula albirostris	Unknown south of the rio Amazonas, *G. cyanicollis* occurs in this region.
*Notharchus macrorhynchos**	Only *N. hyperrhynchus* occurs south of the Amazon.

Capito niger	*Capito niger* only occurs north of the rio Amazonas; this record should pertain to *C. auratus* based on current taxonomy.
Pteroglossus azara	Unknown south of the rio Amazonas, *P. bitorquatus* occurs east of the Madeira.
Celeus flavescens	Within Amazonia, unknown away from the floodplain forest along the main channel of the lower Amazon River; it would represent a significant range extension requiring documentation.
Dysithamnus mentalis	Documentation would be preferable for such a significant range extension.
*Schistocichla leucostigma**	This should be *Schistocichla* (formerly *Percnostola*) *rufifacies* east of the Madeira and *S. humaythae* west of the Madeira following CBRO (2011).
Dendrocolaptes picumnus	Unknown in this interfluve where replaced by *D. hoffmannsi.*
Hemitriccus griseipectus	Undocumented in the Madeira-Tapajós interfluve.
*Schiffornis turdina**	*Schiffornis amazonum* north of the rio Amazonas and west of the rio Madeira following CBRO (2011).
Hylophilus hypoxanthus	Replaced by *Hylophilus muscicapinus* in this interfluve (Madeira-Tapajós).
Turdus fumigatus	Distribution of this species rather poorly known, but contemporary wisdom suggests that *T. hauxwelli* occurs in this interfluve.
Santos *et al.* 2011a. Juruti, Pará	
*Pyrrhura picta**	Based on CBRO (2011) this should be *P. snethlageae or P. amazonum*.
Neomorphus geoffroyi	By range more likely to be *N. squamiger.*
Capito dayi	A biogeographically extraordinary record given allopatry in *Capito* barbets, suggest should be treated as hypothetical if no photo or specimen.
Picumnus cirratus	Unexpected in sympatry with *P. varzae*, *which* becomes more heavily barred towards the western end of its distribution inviting confusion with *cirratus*.
Automolus infuscatus	*A. infuscatus* does not occur east of the rio Madeira; this will pertain to *A. paraensis*.
Pipra aureola	Sympatry with *P. fasciicauda* unknown from most of Amazonia.
Poecilotriccus fumifrons	Not expected to occur sympatrically with *P. latirostris* in this interfluve (Madeira-Tapajós).
Icterus jamacaii	Replaced by *I. croconotus* in most of Amazonia, including the Madeira-Tapajós interfluve.
Gnorimopsar chopi	An extremely significant range extension not discussed in the text, unknown from central Amazonia.
Santos *et al.* 2011b. Jí-Paraná, Rondônia	
*Megascops watsonii**	Replaced by *M. usta* south of the rio Amazonas.
Phaethornis superciliosus	Based on current taxonomy does not occur west of the Tapajós, *P. malaris* expected in this region.
Hypocnemis subflava	Absent from this interfluve (Madeira-Tapajós) where replaced by *H. ochrogyna* (in this case) and the recently described *H. rondoni*.
*Hylexetastes perrotii**	Does not occur south of the rio Amazonas, based on CBRO (2011) this should be *H. uniformis*.
Automolus infuscatus	*A. infuscatus* is undocumented east of the rio Madeira, this will likely pertain to *A. paraensis*.
*Schiffornis amazona**	*Schiffornis turdina* south of the rio Amazonas and east of the rio Madeira following CBRO (2011).
Turdus fumigatus	Distribution of this species rather poorly known, but contemporary wisdom suggests that *T. hauxwelli* occurs in this interfluve.

Santos *et al.* 2011c. Serra do Cachimbo, Pará	
Ortalis superciliaris	Endemic to north-east Brazil, the *Ortalis* occurring in this region is *O. motmot*.
*Psophia viridis**	Based on CBRO (2011) this should be *P. dextralis*.
*Pyrrhura picta**	Based on CBRO (2011) this should be *P. amazonum* or *P. snethlageae*.
Brotogeris cyanoptera	Unknown east of the Tapajós and would represent a significant range extension, better documentation is desirable.
Polytmus guainumbi	Unknown in central Brazilian Amazonia, more likely to be *P. theresiae* which is common on the Serra do Cachimbo and in other Amazonian savannah regions (*e.g.* Pacheco & Olmos 2005).
*Pteroglossus viridis**	An old record that pertains to *P. inscriptus* pre-split.
Thamnophilus murinus	Undocumented east of the rio Tapajós.
Hypocnemoides melanopogon	Unexpected in sympatry with *H. maculicauda* and is unrecorded on the Tapajós south of the mouth.
Synallaxis albigularis	Undocumented east of the rio Madeira.
Hemitriccus minor	Does not occur between the Tapajós and Xingu north of the Teles Pires where replaced by *Lophotriccus galeatus*.
Corythopis delalandi	Listed in error because of a mislabelled specimen collected by Hidasi, which was likely taken in Goias given the date (but not the locality) on the specimen label. The specimen was collected within a day of a series taken at the 'Rio Araguaia, margem direita, Aragarças (15°55'S, 52°15'W)'.
*Fluvicola pica**	An old record that pertains to *F. albiventer* pre-split.
Hylophilus brunneiceps	A clerical error only occurs in NW Amazonia.
Schunck *et al.* 2011. two localities Amapá	
Venilliornis affinis	Undocumented north of the rio Amazonas and east of the rio Branco, where replaced by *V. cassini*.
Silveira & D'Horta 2002. Vila Bela da Santíssima Trindade, Mato Grosso	
Neopelma sulphureiventer	Not expected in this interfluve, presumably a mislabelled or misidentified historical specimen.
Hylophilus thoracicus	Not expected in this interfluve, old specimen likely *H. pectoralis*, with which this species was historically lumped, see Pacheco *et al.* (2011).
Somenzari *et al.* 2011. Amazonia-Cerrado ecotone, Mato Grosso/Pará	
*Trogon violaceus**	Based on CBRO (2011) this should be *Trogon ramonianus, T. violaceus* only occurs north of the rio Amazonas and east of the rio Negro.
Serpophaga nigricans	This species was listed in error; the record pertains to *S. hypoleuca,* which is expected in this region.
Pheugopedius genibarbis	*P. genibarbis* and *P. coraya* are not expected to occur sympatrically in this region, an undocumented audio record is insufficient evidence for an important range extension.
*Phaeothlypis rivularis**	Based on CBRO (2011) this should be *P. mesoleuca.*
Caryothraustes canadensis	Undocumented south of the rio Amazonas between the rios Tapajós and Tocantins.

Vasconcelos *et al.* 2011. Monte Alegre, Pará	
Notharchus ordii	Questions over specimen provenance, likely taken on the south bank as discussed in Lees *et al.* 2013a.
Pteroglossus bitorquatus	Unknown on north bank of the Amazon.
Whittaker 2009. Rio Roosevelt, Amazonas	
Phaethornis superciliosus	Based on current taxonomy does not occur west of the Tapajós, *P. malaris* expected in this region.

DISCUSSION

Our analysis indicates that errors are near ubiquitous, albeit at a low frequency in Amazonian avian inventories in peer-reviewed papers, book chapters, and reserve management plans. Many errors may reflect a lack of prior knowledge of a recent split—in which case the parent species was listed (despite the authors referring to a contemporary taxonomic arrangement that acknowledges the split) or to assignment of the wrong member of a species complex. In some cases, errors have been propagated by authors who included historical data, but failed to adjust for subsequent changes in taxonomy split (e.g., Lopes *et al.* 2009). In many cases, inaccurate distributional maps, frequently seen in field guides and some online sites, proliferate errors. For example the tyrant flycatchers Helmeted Pygmy-Tyrant *Lophotriccus galeatus* and Snethlage's Tody-Tyrant *Hemitriccus minor* are erroneously mapped as occurring sympatrically in southern Amazonia by some authors (e.g., Ridgely & Tudor 1994; Van Perlo 2009; Sigrist 2009) when no such instances of sympatry have been confirmed (Cohn-Haft 2000).

Our review highlights apparent knowledge gaps in our collective understanding of the distribution of many difficult-to-separate Amazonian species pairs e.g., in the swifts *Chaetura chapmani/viridipennis*, the thrushes *Turdus fumigatus/hauxwelli*, and the manakins *Pipra aureola/fasciicauda* which are inadequately mapped in the literature and require more robust surveys (preferably with voucher specimens) to ascertain their actual distributional limits and zones of contact within the basin (e.g., O'Neill *et al.* 2011). In the case of the swifts we have not listed their occurrences in Table 1 as most inventories have followed the 'expected' pattern of occurrence in Amazonia based on a few specimen records, as published by Marin (1997). However we note that *Chaetura chapmani/viridipennis* are not separable in the field, nor readily diagnosable by genetic analysis (Vaseghi & Chesser 2011), so the accepted pattern of occurrence universally followed since 1997 appears to be very tenuous. In fact, reliable field identification of most species of swifts requires a highly trained observer to obtain very good, preferably prolonged, views. We must also recognize that our taxonomy of some groups such as swifts may suffer far more serious identification problems than "use of outdated taxonomy" if our working knowledge is not based on identification of topotypical material, a step rarely acknowledged as a requirement for accurate taxon identification.

The way forward—a road-map for writing species inventories.

That all inventories published in peer-reviewed journals fall within the 95% confidence interval of accuracy is an obviously satisfying statistic to report, but we believe that reducing error rates in species inventories still further is an easily achievable goal. Such reductions increase the utility of such lists for macroecologists and taxonomists studying variation in Neotropical birds, and to increase transparency, we suggest a series of guidelines that may improve the accuracy and utility of species lists.

1. Obtain good documentation

While in the field, ornithologists should make every effort to collect as much documentary evidence to prove the presence of a given species. Obviously it is not always feasible, nor strictly necessary to provide voucher material for widespread common species such as Great Kiskadee *Pitangus sulphuratus* and House Wren *Troglodytes musculus* in every inventory (although the effort to obtain documentation for these species should be negligible and is certainly welcomed). However, evidence must certainly be obtained and presented for any rarer species or poorly known species, particularly any that are not anticipated in the region. These species would typically be afforded a separate species account in the body of the text in which details of these important observations can be amplified. Evidence is ideally a combination of specimens (including tissue samples), photographs, and sound-recordings (e.g., Carlos *et al.* 2010). Detailed field notes are obviously useful (particularly in the absence of other evidence), but do not represent unquestionable proof and cannot be accepted as hard evidence. The accumulation of evidentiary information of these types can essentially eliminate pre-publication errors of identification as they become available for evaluation by outside experts. If such expert review is not obtained, then at least it will be possible for future review to correct errors. Obtaining highly accurate GPS coordinates (not coordinates taken from a map or *Google Earth*) at all inventory sites that will be listed separately in the published paper is also extremely important. These coordinates should be taken in decimal degrees, with all decimals provided by unit recorded, and include the datum and an error estimate (Chapman & Wieczorek 2006). Great care should be taken to identify which riverbanks were surveyed. If both banks of rivers are surveyed, they should have separate coordinates and indications in the list (B. M. Whitney *in litt.*).

2. Present documentation hierarchically and transparently

Once documentary evidence has been obtained, the level of documentation for each species should be listed for each species and ranked hierarchically, with permanent archived voucher material: 1) specimens, 2) video, preferably with commentary; 3) still photographs and/or sound recordings (ranked over sight records). If supporting documentation is not available, authors should indicate the identity of the observers involved in the record, and whether the record is auditory, visual, or both (Willis 2003). On some occasions video may be the most unambiguous, complete form of documentation for a rare species (B. M. Whitney *in litt.*). If a record is undocumented and of significant biogeographic interest, then authors can include morphological descriptions that lead to the species identification. If in doubt, a record should be considered as hypothetical, pending future confirmation, and excluded from the main list, or identified to the genus or species complex level. Accession numbers should be provided for important specimen records, and if possible, images of important specimens should be included as photo figures within manuscripts or as supplementary online material (SOM), which should be permanently archived at a stable URL. Museums should be encouraged to provide digital space to facilitate this archiving (F. Olmos *in litt.*). It should be noted that the highest quality evidence for different species may vary—a sound recording of an *Elaenia* may be of more value than a photograph or a prepared specimen, whereas sound recordings of many species may not be diagnosable from closely related heterospecifics.

3. If in doubt, leave it out

If doubt remains over an identification of a difficult-to-identify species pair or species complex, then a record can be either excluded or included as hypothetical, ideally with some discussion of the potential record. Future fieldwork will likely result in confirmed records. Over-confidence may lead to future identification error cascades and should be avoided.

4. Include as much supporting life history data as space allows

As highlighted above, many inventories include supporting life history information such as a) a qualitative (or better quantitative) abundance estimate or calculation, b) (micro)habitat usage, c) seasonality, d) breeding behavior (e.g., nest records, brood patches, gonadal data). These types of data add scientific value to a paper and make it more citable.

5. Archive digital vouchers

We believe it is not simply enough to indicate that documentation is archived in the author's private collections and we urge journals not to accept manuscripts that state that documentary material will be archived "at some point in the future." On many occasions we have solicited documentary evidence and it has not been forthcoming. If documentary evidence in the form of images and sound recordings is placed online in the public domain, then peer-review is immediate and the whole process becomes more transparent (*e.g.,* Lees *et al.* 2012, 2013a, 2013b). Such digital vouchers are not intended to supplant traditional specimen vouchers but instead provide an opportunity for peer review of unusual records, which is not possible if material is inaccessible. Field photographs can be archived on the Brazilian avian database *Wikiaves* (WA: www.wikiaves.com.br) where they are searchable by accession number (which can be provided in appendices), whereas both field and in-hand photographs can be archived on the *Internet Bird Collection* (IBC: ibc.lynxeds.com/). Although both of these sites are not currently institutionally hosted and therefore their existence cannot be guaranteed in perpetuity, they seem to represent long-term projects that will remain active for many years. Sound recordings can be archived in several collections, including a) *Wikiaves*; b) the global avian sound library *Xeno-canto* (XC: www.xeno-canto.org), where multiple 'background' species can be listed to reduce workload for documenting common species; c) the *Macaulay Library* (ML: http://macaulaylibrary.org/) and d) the *Avian Vocalizations Center* (AVoCet: avocet.zoology.msu.edu/) where online peer-review is also possible. Many other sound archives are available, and all of them should be able to provide accession numbers and be readily searchable on the internet. For a digital voucher to be functional, the diagnostic field marks and vocal traits need to be visible in photographs or audible in sound recordings. Presentation of undiagnosable and ambiguous material should be avoided (*e.g.,* Jackson 2006). Digitalization of specimen skins is also a highly desirable future prospect (*e.g.,* Monk & Baker 2001) that will allow for general web-based peer review and museums should ideally include their holdings on an online database.

6. Conduct rigorous searches for historical records

Incorporating old specimen records is extremely important to add historical depth and may function as reference point to quantify shifting baselines. Authors should make efforts to solicit specimen records from both domestic and foreign museums (Alberch 1993). Currently, ornithological data from 42 institutions can be searched using the digital database *Ornithology Information System* (ORNIS: www.ornisnet.org/) and more collections will be available for online search in the near future. Collecting localities can be roughly located using Paynter & Traylor (1991), which are freely available online from the *Biodiversity Heritage Library* (BHL: www.biodiversitylibrary.org/), which is itself an essential resource in searching for historic records along with the *Searchable Ornithological Research Archive* (SORA: sora.unm.edu/). However, care should be taken in the interpretation of historical data. Although it has frequently been argued that physical specimens provide the most reliable evidence for assessing species presence (*e.g.,* McKelvey *et al.* 2008), there are numerous studies indicating that specimen data are only as reliable as the associated collection details (Knox 2003; Boessenkool *et al.* 2010). We encourage compilers of inventories to check any biogeographically unusual historical record by visiting the collection to physically check specimens and their labels. If this is not possible, then curatorial staff could provide images of the specimens in question (see examples in Silveira & D'Horta 2002; Lees *et al.* 2013a). In the event that the identification is deemed secure then it may be worth double-checking collectors' itineraries and conferring against the data to make sure that no mistake was made—see the example of Southern Antpipit *Corythopis delalandi* discussed in Table 1.

7. Take care in citing digital vouchers of third parties

In addition to providing digital archives of the authors' own records, some inventories also include data and/or digital vouchers of other observers' sightings, including those of amateur ornithologists. At temperate latitudes knowledge of spatio-temporal patterns of bird distribution is collated principally by amateur ornithologists, and data is increasingly being compiled using the internet (*e.g.,* Sullivan *et al.* 2009). Similarly, the submission of digital vouchers (photographs or recordings) by amateur ornithologists using sites such as *Wikiaves* and *Xeno-canto*, or through the use of online checklist sites such as *eBird* (ebird.org/content/ebird/) promises to increase our knowledge of tropical avifaunas as long as expert ornithologists maintain a close scrutiny to filter out probable erroneous submissions. We recommend that compilers of lists use data from third parties, but we suggest that authors carry out a thorough prior error-checking, particularly if the record is unusual. This error-checking should include: 1) verifying that the image/recording is identifiable and similar species can be eliminated; and 2) checking to see if there are any grounds to doubt whether the voucher was taken in the locality to which it is attributed. This can be achieved by verifying that the other images and/or recordings taken by the same author around the same time are in complete agreement and have undoctored Exif files, *i.e.*, confirm that there is no evidence of image tampering (see *e.g.,* Harrop *et al.* 2012). Such error-checking should not be restricted to web-based resources to which members of the general public upload vouchers; errors may remain undetected or uncorrected for years in institutional-based archives, particularly those that do not carefully follow current taxonomies. Many new digital cameras come with inbuilt GPS that further reduce the possibility of fraudulent photographic evidence; one such camera was recently used in documenting the first Brazilian record of Corncrake *Crex crex* (Burgos & Olmos 2013).

8. Ensure a consistent taxonomy is followed

As our literature trawl revealed, incorrect taxonomy is a major source and propagator of errors in biodiversity inventories (see also Bortolus 2008). Some inventories do not state which taxonomy is being followed, which can make interpretation of the results difficult. We recommend that authors use the most recent version of the checklist prepared by the *Comitê Brasileiro de Registros Ornitológicos* (CBRO 2014: www.cbro.org.br/CBRO/listabr.htm) if focusing only on Brazil, or the *South American Classification Committee*'s checklist (Remsen 2013; SACC: www.museum.lsu.edu/~Remsen/SACCBaseline.html) for the wider South American region, although it should be noted that these currently diverge significantly, with SACC retaining a more conservative taxonomy. Many errors in the Amazonian inventories reflected a lack of knowledge of the most recent definitions on species limits, or a failure to cross-reference current taxonomy against older species lists. Fortunately, and as our evaluations for this paper have shown, it is usually not difficult to correctly re-identify errors of this type by simply invoking the contemporary taxonomy. When in doubt as to whether a recently split species should be included in a list for a particular area, authors should make sure that the list of the relevant committee is consulted.

9. Conduct rigorous error-checks prior to submission

Do not assume that errors will be detected during the official peer-review process. Depending on the scope of the journal, reviewers may have little experience with the biogeographic region or the taxonomic group in question, and the process is at the mercy of the rigor of the individual reviewer. Distributional error-checking should thus be conducted extensively pre-peer review, using a combination of existing field guides—such as the maps in Van Perlo (2009) or major reference works such as the *Handbook of the Birds of the World* series and online databases such as *Wikiaves, InfoNatura* (www.natureserve.org/infonatura/), and HBW Alive (www.hbw.com/). Circulate lists amongst regional experts; even if they do not have time to make a thorough review, many professional ornithologists can spot biogeographic 'outliers' in seconds. We also suggest that editors of journals allow for 'errata' within manuscripts of this type, such that mistakes can be corrected after publishing on archived PDFs.

Conclusions

Modern avian inventories are a cornerstone of ornithology for which utility, credibility, and transparency can easily be increased by some relatively simple measures highlighted herein and without a prohibitive extra investment in effort. Increasing the robustness of such surveys will reduce error rates and hence guard against error cascades into the secondary ornithological literature.

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APPENDIX 1:

Amazonian avifaunal inventories (published between 2000 and 2013) subject to the meta-analysis.

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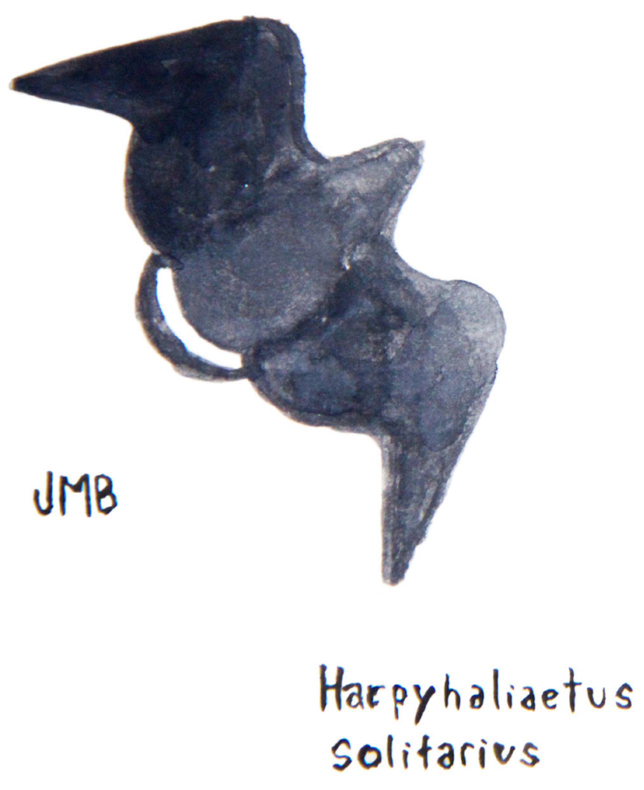
APPENDIX 2:

Reserve management plans with bird lists subject to analysis.

ESEC Rio Acre, FLONA de Carajás, FLONA de Crepori, FLONA do Amanã, FLONA do Jamanxim, FLONA do Purus, FLONA do Trairão, FLONA Macauã, FLONA Mapiá-Inauini, FLONA Tapajós, FLONA Tapirape-aquiri, PARNA Campos Amazônicos, PARNA da Serra da Cutia, PARNA da Serra do Divisor, PARNA de Anavilhanas, PARNA de Juruena, PARNA do Araguaia, PARNA do Cabo Orange, PARNA do Monte Roraima, PARNA Montanhas do Tumucumaque, PARNA Pacaás Novos, REBIO de Uatumã, REBIO do Gurupi, REBIO do Jaru, REBIO do Rio Trombetas, REBIO do Tapirapé, REBIO Guaporé, REBIO Nascentes da Serra do Cachimbo, RESEX Arapixi, RESEX Baixo Juruá, RESEX, Capanã Grande, RESEX do Cazumbá-Iracema, RESEX Rio Iriri, RESEX Riozinho do Anfrísio & RESEX Tapajós-Arapiuns.



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ARTICLE

The avifauna of Curaçá (Bahia): the last stronghold of Spix's Macaw

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ABSTRACT: The region of Curaçá was one of the first regions of the Brazilian northeast to be ornithologically explored, and is known as the type locality and last stronghold of the Spix's Macaw (*Cyanopsitta spixii*), now extinct in the wild. The region of Curaçá has been considered of high conservation importance, particularly for holding some of the last relicts of Caraíba (*Tabebuia caraiba*) gallery forest in the Caatinga, and for representing the most obvious place to start a reintroduction program for *C. spixii*. Despite international interest in the plight of the macaw and frequent visits by ornithologists in the last 30 years, no general avian survey has been undertaken in the region. In this paper, we present data from three independent field seasons in the area, conducted in 1997-98, 2000, and 2011. We include data on 204 bird species recorded in the region, including 28 taxa endemic to the Caatinga. We present an analysis of the species present in the region, in relation to their preferred habitats and include natural history and breeding data for many of them. In particular, we include our observations on the last wild individual of *C. spixii*, and describe the nest and breeding behavior of *Compsothraupis loricata*. We also present an appendix with the list of all avian species recorded in the area, including the field season when these records were obtained, their seasonal and conservation status, the main habitats and localities where each record was obtained, a quantitative assessment of abundance for part of the species, and documentation (specimen, photograph, or audio recording) available for each species. We conclude that the region of Curaçá is particularly species rich, and that a great part of this avian diversity results from its high habitat heterogeneity, which includes arboreal and shrubby Caatinga, gallery forests, riverine riparian habitats along the Rio São Francisco, and open areas and artificial ponds, which are particularly important for aquatic birds.

KEY-WORDS: Birds, Caatinga, *Cyanopsitta spixii*, gallery forest, survey.

In 1819, Johan Baptist Ritter von Spix explored the dry woodlands along the Rio São Francisco, near the village of Juazeiro, in the deep interior of the Brazilian northeast (Juniper 2003). Among the specimens he collected, was a small blue macaw. That species, first observed by Georg Marcgrave when he has working in Pernambuco during the XVII Century, is now known as Spix's Macaw (*Cyanopsitta spixii*), and was known to inhabit the gallery forests near Curaçá, a small town located some 90 km east of Juazeiro, in the state of Bahia. Curaçá not only represents the type locality of the blue macaw collected by Spix, but also remained the last stronghold of this species until the end of the XX century, when the last known individual in the wild disappeared (Silveira and Straube 2008). The presence of this global rarity near the little village of Curaçá attracted many ornithologists to the region, particularly during the 1990s, but their observations remained largely unpublished, and no general surveys of the region's avifauna have been published to date.

Curaçá is located in the heart of the Brazilian Caatinga, a habitat that represents one of the most isolated, differentiated, and botanically distinct semiarid regions on the planet (Sarmiento 1983). For many years, the Caatinga was considered a region with low endemism and lacking a biogeographical identity (Vanzolini 1976; Mares *et al.* 1981; Andrade-Lima 1982, Prance 1987), but recent studies have found a high level of avian diversity and endemism (Pacheco 2004). Climatically, the Caatinga is a region marked by its aridity, hot weather, and a short rainy season, which may fail to arrive on any given year (Ab'Saber 1977). The severe climate and geomorphological characteristics of the region may explain the existence of a highly endemic flora, with many adaptations to the dry conditions of the habitat (Mares *et al*. 1985; Sampaio 1995). Although the Caatinga has been identified as an important center of avian endemism in South America (Cracraft 1985), ecological, biogeographical, and evolutionary studies in this biome are still rare (Silva *et al*. 2003; Araujo *et al*. 2012).

Until recently, most distributional data on Caatinga birds were restricted to unpublished data or poorly known and difficult to obtain references (Pacheco 2000). The first modern compilations of the Caatinga avifauna were produced only 10 years ago, and include between 350 (Pacheco 2004) and 510 (Silva *et al*. 2003) species, depending on whether natural patches of Atlantic Forest (locally known as *brejos*) are also considered. In recent years, a clearer picture of the distribution patterns of the Caatinga avifauna have been unveiled, bringing attention to the remarkable diversity and habitat heterogeneity of this little-studied region. Such compilations were important to raise new interest in the avifauna of the Caatinga, and in 2012 the *Revista Brasileira de Ornitologia* dedicated a special issue to the region (*e.g*. Araujo *et al.* 2012; Diniz *et al.* 2012; Dornelas *et al.* 2012; Santos *et al.* 2012; Schunck *et al*. 2012; Silveira & Santos 2012; Silva *et al.* 2012; Sousa *et al*. 2012).

Lack of general distribution and diversity patterns have a direct effect on our capacity to make informed choices in terms of conservation priorities. Without a good understanding of current diversity distribution patterns, conservation priorities will hardly be effective in protecting the most representative and unique regions of the Caatinga, which is fast becoming a new agricultural frontier. Despite the fragility of this region in terms of desertification, over-exploitation, and low recovery capacity, only 7% of the native vegetation cover is included in protected areas (and only 1% in fully protected ones), and in fact, the Caatinga has the lowest number of protected areas and net protected surface of any other Brazilian major biome (Leal *et al*. 2005).

The region of Curaçá, in particular, has been indicated as being a high priority for regional conservation (Silva *et al*. 2004) and was recommended to receive full legal protection (Pacheco 2004). Among Curaçá's environmental peculiarities, it still retains a healthy and unique gallery forest dominated by Caraíba trees (*Tabebuia aurea* Bignoniaceae), which was used by Spix's Macaws as nest sites (Juniper & Yamashita 1991). The relative scarcity of this habitat, now mostly restricted to the region of Curaçá and a few areas in the neighboring state of Piauí, may have been a driver of the decline of Spix's Macaw since colonial times (Juniper & Yamashita 1991). Therefore, an assessment of the regions' avifauna may shed light into the role of this special habitat for the entire avian community.

Here, we present data from two independent surveys conducted nearly 15 years apart. During the summer of 1997, JMB, LNN, and ALR spent several months in Curaçá during activities related to the conservation of Spix's Macaw. Their observations were mostly opportunistic (composed of daily bird lists), but general notes were taken, and many of their findings remain novel today (Mazar Barnett *et al*. 2014a, this volume). In 2011, CLGS, HFPA, and AMKU revisited the region and surveyed the avifauna using mist-nets and performed quantitative surveys. In this paper, we include natural history notes on several bird species, and provide a useful characterization of the region's avifauna, calling the attention to this unique place that not too long ago represented the last stronghold of the world's rarest parrot.

METHODS

***Study Area* —** This study took place in the Municipality of Curaçá (08°59' S, 39°54'W), c. 90 km ENE of the city of Juazeiro, in the Brazilian state of Bahia (Figure 1). The climate of the region is hot (mean annual temperature of 24°C) and dry (mean annual rainfall of 66 years resulted in only 454 mm/yr; Departamento de Ciências Atmosféricas 2013). Precipitation is highly seasonal, with most rain falling between January and April (Departamento de Ciências Atmosféricas 2013). The region around Curaçá is relatively heterogeneous, including areas of dense dry forests (*Caatinga arbórea*), short shrubby vegetation (*Caatinga aberta*), and very characteristic gallery forests along seasonal watercourses, most notably Riacho da Melancia, where the last Spix's Macaws used to breed. These forests are particularly rare elsewhere and are dominated by tall Caraíba trees (*Tabebuia aurea*). Unfortunately, goats, sheep, and cattle have severely affected the regeneration of this forest (Juniper & Yamashita 1991). Other tree species that characterize the area of Curaçá include Euphorbiaceae such as *Faveleira* (*Cnidoscolus phyllacanthus*) and Pinhão (*Jatropha mollissima*), Caesalpinoidea such as the *Catingueira* (*Caesalpinia pyramidis*), and Cactacea such as Xique-xique (*Pilosocereus gounellei*) and Mandacarú (*Cereus jamaracu*). Soil is generally composed of clay, and partially covered by gravel and pebbles, with some rocky outcrops distributed throughout the landscape.

***Fieldwork* —** Our '1997' data was collected between 29 December 1996 and 8 February 1997 by JMB, LNN, and ALR. Subsequently, ALR spent six additional months between February and July 1998. Observations occurred mostly at Fazenda Concórdia (09°10'26"S, 39°46'39"W), at the former headquarters of the Spixi's Macaw Project, but other fazendas such as Gangorra (9°09'51"S, 39°45'20"W), Canabrava (9°12'28"S, 39°42'25"W), Prazeres (9°08'50"S, 39°53'37"W), and Macambira (9°01'0"S, 39°46'08"W) were also explored. Several habitats were available at those sites, including arboreal and shrubby Caatinga, as well as gallery forests along the (often dry) creeks. We also surveyed the margins of the Rio São Francisco, including the island of Curaçá (08°59'29"S, 39°55'05"W), just opposite the village. Given that the goal at the time was to provide a rapid assessment of the region's avifauna, no quantitative abundance data were collected. Between 5 and 7 January, 2000 JMB returned to Curaçá and visited the locality Poço do Baú (9º07'47"S, 39º54'37"W) and the island of Curaçá. Several years later, between 19 and 24 April 2011, CLGS, HFPA, and AMKU surveyed the avifauna of Curaçá at Fazenda Concórdia and at Serra da Gruta de Patamuté (9°19'22"S, 39°36'34"W) using several methods, including mist-nets, MacKinnon lists, and

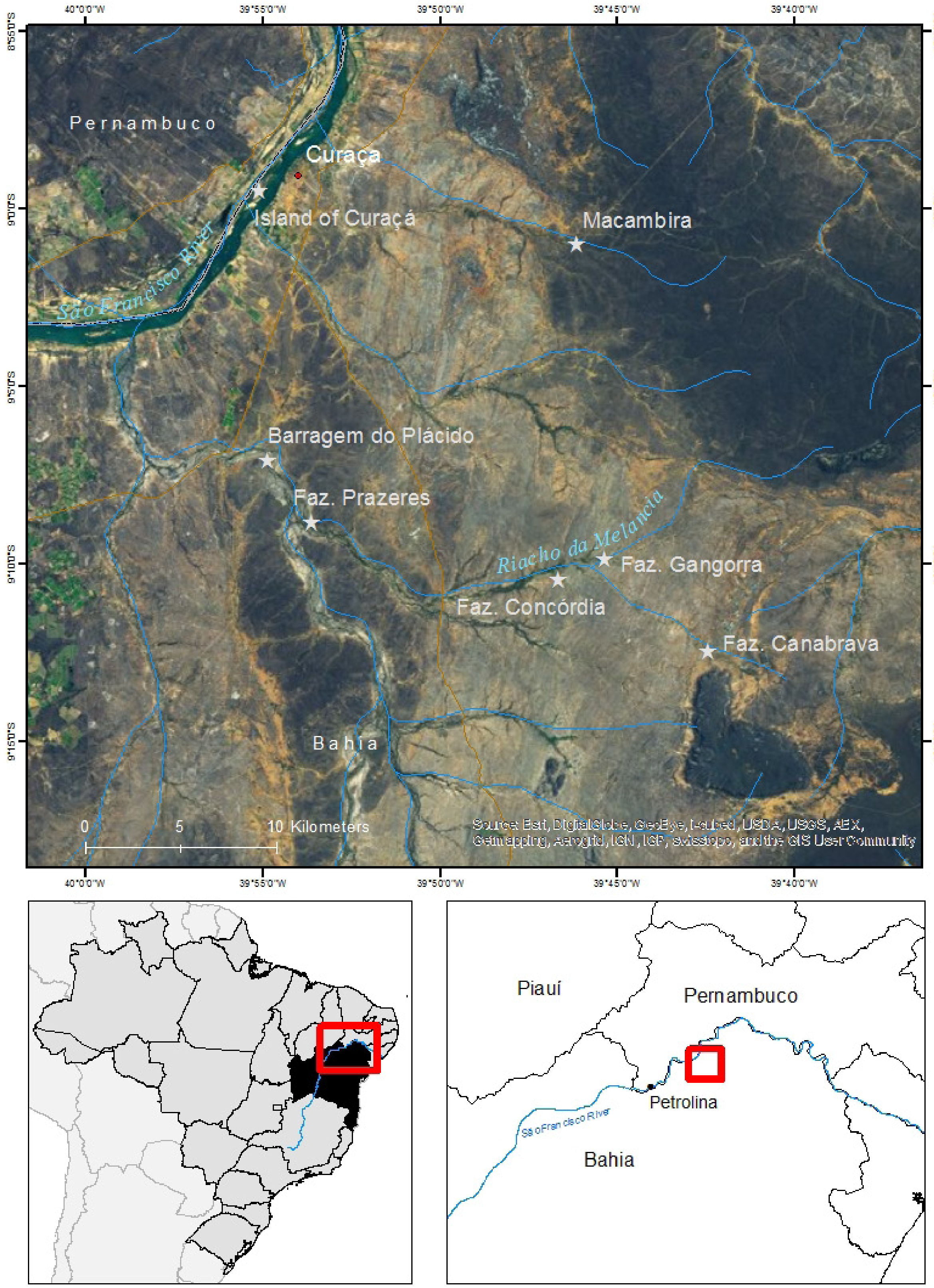

FIGURE 1. The area of Curaçá, including the main localities mentioned in the text.

opportunistic observations (Sutherland *et al*. 2004). Lines of five standard 12-m mist-nets were opened from dawn until 11 am. MacKinnon samples (10 species' lists) were produced for four different habitats, including arboreal Caatinga (31 lists), shrubby Caatinga (34 lists), open areas (7 lists), and gallery forests (29 lists). Observations were conducted along trails, from sunrise to ~11 am, and between 4 pm until sunset. Abundance data presented in the appendix were drawn from these samples.

Breeding activities were represented by observations of individuals copulating, feeding young or fledgings, carrying food, or building material for their nests, or direct observations of pairs building or using nests. We allocated the different species to different habitats, including i) dense arboreal Caatinga, ii) low shrubby Caatinga, iii) gallery forest, iv) wetlands and artificial ponds, v) riverine habitats, and vi) open areas. To explore avian similarity among habitats, we performed a cluster analysis using a similarity matrix built with Jaccard's index. This analysis was performed using Program Spade (Chao & Shen 2010). A limited number of individuals were collected to provide a reference collection of the study area. Specimens were collected under license number 54731333 (SISBIO) granted to HPFA. Specimens are held at the Coleção de Aves Heretiano Zenaide at the Universidade Federal da Paraíba (UFPB) and Coleção da Divisão de Aves do Museu de Zoologia at the Universidade Federal de Feira de Santana (DAMZFS). We present the documentation obtained for each species in Curaçá, which included specimens (see above), but also digital vouchers (or e-vouchers), which have proven to be particularly useful in avian inventories (Lees *et al*. 2014). These include recordings or photographs, which were either available through online sources such as xeno-canto (xenocanto.org) or WikiAves (wikiaves.org.br), or through the personal collection of JMB. These are currently being incorporated at the Macaulay Library Collection, and will soon be available online at macaulaylibrary.org. Taxonomy, nomenclature, and order of families and species follow the latest taxonomic treatment (Comitê Brasileiro de Registros Ornitológicos 2014).

RESULTS

A total of 204 species of 50 avian families have been recorded so far in Curaçá and surrounding areas (Appendix). We recorded most of these species (201) during our fieldwork, but documentation (photographs) of three additional species was found at WikiAves (Appendix). Most species (191) were first recorded in 1997, another six were added in 2000, and four were recorded in 2011 for the first time. Our records include 28 taxa (15 species and 13 subspecies) endemic to the Caatinga (Appendix). Most of the species recorded in Curaçá (143, or 70 % of the total) were documented by either: specimens (92 skins, 42 species), recordings (109 species), or photographs (63 species). Most of the species lacking evidence are non-passerines, which are relatively easy to identify and are known to occur in neighboring areas.

Most of the species recorded in Curaçá are assumed to be resident; we documented breeding activities in 32 of them (see Appendix), but visits at other seasons are necessary to permit a better understanding of the seasonal patterns of most species. Interestingly, there is a group of aquatic species that seem to visit the region following the local rains, when ponds and rivers fill with water. The rainy season of 1996/1997 was particularly wet, resulting in the formation of many bodies of water. In 1997, we found many aquatic bird species, including *Dendrocygna viduata* (White-faced Whistling-Duck), *Cairina moschata* (Muscovy Duck), *Sarkidiornis sylvicola* (Comb Duck), *Amazonetta brasiliensis* (Brazilian Teal), *Netta erythrophthalma* (Southern Pochard), *Nomonyx dominica* (Masked Duck), *Tachybaptus dominicus* (Least Grebe), *Podilymbus podiceps* (Pied-billed Grebe), *Nycticorax nycticorax* (Black-crowned Night-Heron), *Aramides ypecaha* (Giant Wood-Rail), *Gallinula galeata* (Common Gallinule), *Gallinula melanops* (Spot-flanked Gallinule), *Vanellus cayanus* (Pied Lapwing), *Himantopus mexicanus* (Black-necked Stilt), and *Actitis macularius* (Spotted Sandpiper), all of which were not found in 2011.

Among all habitats explored, we recorded the most species in low shrubby Caatinga (96 species), followed by gallery forests (72 species), dense arboreal Caatinga (70), open areas (60), riverine environments (46), and wetlands and ponds (36) (Appendix). We observed a higher similarity (among habitats) between the avifaunas of arboreal Caatinga and gallery forests, and of both with shrubby Caatinga. The avifauna found on riverine enviroments and wetlands and ponds were most dissimilar (Figure 2).

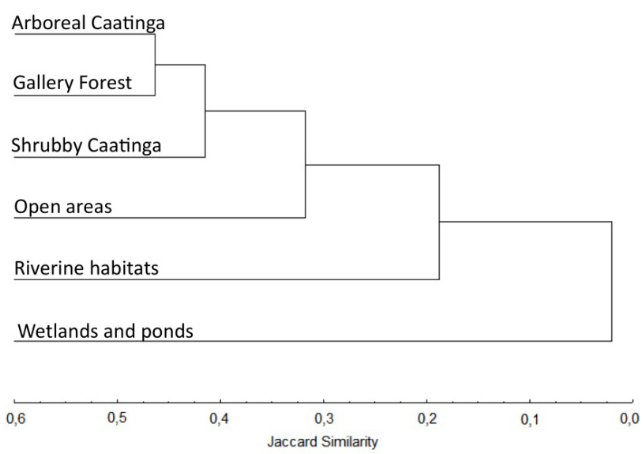

FIGURE 2. Cluster analysis (obtained from a similarity matrix using Jaccard's index) of the bird species composition in each major habitat described in the text.

Below, we include some natural history notes on poorly known or rare species, including some unreported observations of Spix's Macaw, as well as previously undescribed breeding behaviors of several species.

Species accounts

Netta erythrophthalma Southern Pochard

We observed two females and a male at an artificial pond at Fazenda Concórdia on 29 December 1996; two males and a female were present at the site on 2 January 1997. Numbers of individuals continued to fluctuate on the following weeks, ranging from 11 birds on 6 January to 30 birds on 17 January, which was the last time we observed the species at the pond. Seasonal movements of this species are poorly known, particularly in South America (Carboneras 1992), but lack of records in other seasons suggests that this species is undertaking seasonal movements to locate ephemeral wetlands throughout the Caatinga.

Penelope jacucaca White-browed Guan

This Vulnerable species (BirdLife International 2012a) was frequently observed in gallery forests along dry creeks during our 1997 fieldwork. Between March and June 1998, ALR observed small groups (ranging from 2 to 7 individuals) drinking water in small ponds along a particular temporary creek (Riacho da Melancia). These observations occurred after the rainy season, suggesting that temporary ponds remain important for this species. A detailed compilation of these records have been published previously (Roos & Antas 2006).

Nyctidromus hirundinaceus Pygmy Nightjar

We found four active 'nests' around the headquarters of Fazenda Concórdia in January 1997, which possibly belonged to three different pairs. As is the case for other species in the family, no actual nest is built by this species; eggs were found on the ground, at the side of a dirt road used only occasionally by vehicles and people, whereas another egg was found close to a rocky outcrop. All 'nests' contained a single egg, laid directly on the sandy or stony ground. Detailed observations of these nests, eggs, and chicks, including details of their breeding behavior are available elsewhere in this volume (Mazar Barnett *et al.* 2014).

Cyanopsitta spixii Spix's Macaw

The last known wild individual of this species was observed several times during our 1997 field season and in January 2000. In 1997, the male was often seen flying along the dry creeks together with a female *Primolius maracana* (Blue-winged Macaw), with which it had attempted to breed in previous years and with which it had produced infertile eggs (BirdLife International 2013). On 3 January 1997, the hybrid pair was observed at a particular Caraíba tree, known locally as the *caraíba dos três ocos* (caraíba with the three holes). We observed the hybrid pair perched on this tree at 5:55 am, sharing the tree with another pair of *Primolius maracana*. In a couple of occasions, the male Spix's made short flights in order to chase away the pair of *Primolius*, as if defending the potential nesting site. At 7:15, the hybrid pair started to explore the largest of the three holes, which the male Spix's eventually entered. A few minutes later both individuals departed, and, a few hours later, were heard in another location. On 7 January, the hybrid pair was seen exploring the area around a nesting box, to which they returned a couple of hours later. The last time we saw the male Spix's during our 1997 field season was on 22 January at Fazenda Prazeres, when the male accompanied the female *Primolius* to her roosting site at dusk, before departing, probably to his own roost site. In 2000, JMB made detailed observations of the same pair which this time had laid eggs. On 6 January, the male Spix's was observed to leave the nest in the early morning. Its flight when leaving the nesting tree was rather erratic, including slow, arrhythmic, and shallow flaps and many glides making use of the wind. During that day it was seen again a couple of times, including flights with the female *maracana*, which was flying below the male. The male only returned to the nest during the afternoon, when it perched near the nesting hole. During that time, it emitted some nasal soft calls "au," probably contacting the female *maracana* that was likely inside the nest. About 1 hr before sunset, the male left the nesting area, and was heard vocalizing a few hundred meters from the nest, where it probably spent the night. On the following day, the hybrid couple left the nesting hole agitated as they heard human activities near the nest, and performed a couple of flights in circles above the 'intruders.' A few minutes later, the pair returned to the nest, but given the presence of people nearby were reluctant to enter the nest, and flew in a few circles until they perched on the top of nearby trees. Eventually, the female *maracana* entered the nest and the male Spix perched close to the nesting hole in the *caraibeira* tree, somewhat hidden in the foliage, vocalizing its typical "prrr prrr" call. The male Spix finally flew to the top of a nearby tree. Those were our last observations of the last individual in the wild of Spix's Macaw, which finally disappeared a few months later and was never to be seen again in the wild.

Eupsitulla cactorum Cactus Parakeet

We found four active nests at Fazenda Concórdia in January, February, and March 1997. All nests were located within active arboreal termite (*Nasutitermes*) mounds. Clutch sizes varied from 4 to 6 eggs, and all eggs were laid within an internal chamber excavated by the pairs.

Detailed observations of these nests and eggs have been published previously (Naka 1997).

Synallaxis hellmayri Red-shouldered Spinetail
This Caatinga endemic was seen only by JMB at Serra do Icó, Fazenda Macambira on 8 February 1997, in an area of dense Caatinga. Despite being a vocally conspicuous species, *S. hellmayri* was not found in other areas around Curaçá (such as Fazenda Concórdia). Its absence around Curaçá is surprising, and together with other Caatinga endemics not found around Curaçá (e.g., *Megaxenops parnaguae* Great Xenops or *Sakesphorus cristatus* Silvery-cheeked Antshrike), quite intriguing.

Compsothraupis loricata Scarlet-throated Tanager
JMB made detailed observations of a nesting site of this species on 31 January 1997 at the Fazenda Gangorra (9°09'51"S, 39°45'20"W). Until now, very little information regarding the breeding biology of this Caatinga endemic is available, and no detailed description of its nest is available (Hilty 2011). The nest was found on top of a large leafless Caraíba tree (*Tabebuia caraiba*). It was relatively small made of sticks, resembling somewhat that of an old *Pseudoseisura cristata* (Caatinga Cacholote). It differed from a chachalote's nest in having a wider entrance, and a much thinner 'see-though' outer structure, suggesting that it was not an old abandoned nest and might have been built by the tanagers themselves, although this remains unclear. The nest was located on a tree where three other nest-like structures were apparent; the largest structure possibly represented an old abandoned cachalote nest; the second appeared to be either an old tanager nest (from a previous season) or a false nest, to trick possible predators; the third structure represented a shapeless accumulation of sticks, and could have been an even older nest, or even a second false nest. The hypothesis of a false nest seems quite plausible, given that the nesting individuals often passed by this structure before and after carrying food to the active nest, from which begging calls could be heard. Birds were observed on several occasions approaching what it seemed as the entrance of this inactive nest, and lowering their heads as if looking inside or as if feeding a chick. After spending some time at this structure, birds would move slowly to the active nest. The nest was attended by four individuals, including an adult male, two female-looking individuals, and an immature male. This group clearly represented an adult pair, and two young (a male and a female) that likely acted as helpers. There were no clear differences among the two females, but the young male was completely black (as the females) except a few red feathers (sometimes difficult to see) on the throat. On two occasions, a female was seen inside the nest, while the adult male vocalized from a nearby tree and the two immature birds were elsewhere. Very often, all four individuals would arrive together carrying food, although it was the adult male that first visited the begging chick(s). This male seemed to perform a sort of ritual before entering the nest, fluffing the feathers of the throat, chest, head, and flanks, while lowering its head and performing short jumps. Sometimes, none of the birds would visit the chicks immediately, and remain with the food in their bills for some time, either hiding in the vegetation or doing their typical vocalizations. After some time, all individuals would approach the nest. The immature male seemed to be the most cautious (possibly due to the presence of the observer) and on some occasions it would approach the nest, only to leave again, and start the approaching process all over again. Once a *Falco femoralis* (Aplomado Falcon) passed by the nest, while chasing a *Falco sparverius* (American Kestrel). When the four tanagers detected the falcons, they left the tree immediately and went to the ground, from where they uttered some alarm calls. On two occasions the four tanagers were seen chasing a *Sporophila albogularis* (White-throated Seedeater), while allowing two adult male *Coereba flaveola* (Bananaquits) to stay atop of the tree. A second group was later found near the Riacho da Melancia, which consisted of a female and two young birds, which begged for food, although not too insistently. A male within that group was seen carrying a small stick, but nest building was not detected.

***Charitospiza eucosma* Coal-crested Finch**
This Near Threatened species (BirdLife International 2012b) was relatively rare in Curaça in 1997, and was not recorded in 2011. JMB found a pair feeding a young bird on the ground in an area of shrubby Caatinga on 18 January 1997. The young bird was similar to the female in plumage, although slightly smaller in size, with a shorter tail, and vestiges of a yellow gape were apparent. There are very few records of the species breeding in the Caatinga, and its nest was only recently described in the Cerrado of central Brazil (Borges & Marini 2008). A more detailed study suggested that the species breeds on the rainy season in central Brazil (Diniz *et al.* 2013), as seems to be the case in the Caatinga, given our observations.

***Icterus jamacaii* Campo Troupial**
We found a pair using an old *Pseudoseisura cristata* (Caatinga Cacholote) nest to breed around the houses at the headquarters of the Fazenda Concórdia on 31 December 1996. On 10 January 1997, three young birds left the nest and were seen on the ground. That same used nest was then occupied by a pair of *Agelaiodes fringillarius* (Pale Baywing) in the following weeks (see below).

***Agelaiodes fringillarius* Pale Baywing**
Several breeding behaviors were observed during our 1997 field season. On 3 January, JMB observed a pair of this Brazilian endemic occupying a nest. The nest consisted of a base of sticks and a large cup on top (similar to a thrush nest) on which one individual sat for a while. Once, a pair *Pseudoseisura cristata* (Caatinga Cacholote)

arrived and chased the blackbirds away. On 24 January, JMB observed another pair using an old cachalote nest, which had been used by *Icterus jamacaii* (Campo Troupial) two weeks before. The pair was observed carrying nesting material (grasses) to the nest, likely to line the main incubation chamber. Up to four individuals of the species were observed around the nest, suggesting the presence of helpers. Occasionally, birds performed agonistic behaviors, although those were not too violent. Another abandoned cachalote nest was visited by another pair of baywings, which slept below the construction. The nesting behavior of *A. fringilloides* remained poorly known until recently (Fraga 2011, and Fraga & D'Angelo, this volume), although the use of abandoned nests of furnariids was well established in the group (Friedmann 1929, Jaramillo & Burke 1999). The observations of four individuals at the nesting site probably represent one of the first evidences of cooperative breeding in this species, which is described in further detailed by Fraga & D'Angelo Neto (this volume).

DISCUSSION

The avifauna of Curaçá is rather typical for the Caatinga, both in terms of species richness and species composition. We believe that we have detected the most representative species in the region, having recorded over 200 species. It is quite clear, however, that other species are likely to be found with further sampling, particularly if different seasons are sampled. Surprisingly, only four species not detected in 1997 were detected in 2011. Three of these were small tyrant flycatchers (*Elaenia chilensis* Chilean Elaenia, *Casiornis fusca* Ash-throated Casiornis, and *Cnemotriccus fuscatus* Fuscous Flycatcher) caught in mist-nets. *Casiornis fusca* seems to have a rather secretive behavior and is more often found in mist-nets than in acoustic surveys, possibly passing undetected during our first field season. Both *Elaenia chilensis* and *Cnemotriccus fuscatus* have migratory populations, and individuals recorded in April 2011 may represent early migrants.

On the other hand, 91 species were recorded in 1997 but not in 2011. Although a large part of this difference can be attributed to a longer field season in 1997 (more than 40 days in the field), some aquatic species were clearly absent in 2011. In fact, a group of 16 species tight to aquatic environments were present on temporary ponds around the Spix's Macaw's Project headwaters in 1997, but were not recorded in 2011. The rainy season of 2011 was not as intense as that of 1997, and few bodies of water formed during that year, explaining the absence of water-related species, and suggesting the existence of local movements where these species must be tracking available bodies of water or exploring other regions (Olmos *et al.* 2005; Araujo *et al.* 2012).

Given a variety of methodologies and sampling used, comprehensive comparisons between our observations and other sites are unwarranted; yet a figure of ~200 bird species recorded in Curaçá is expected for a relatively well-preserved locality in the Caatinga. Olmos (1993) recorded 208 species at Serra da Capivara, Piauí; Nascimento *et al.*, (2000) recorded 193 at Chapada do Araripe, Ceará; and Lima *et al.* (2003) recorded 191 at the Raso da Catarina, Bahia. On the other hand, surveys in areas with more human activities often report fewer species, such as the studies conducted by Olmos *et al.* (2005) in western Pernambuco and Ceará (where they recorded between 93 and 125 species in eight different localities), or Farias *et al.* (2006) with only 94 species at Curimataú, Paraíba, or even Araújo & Rodrigues (2011) with 120 species at the interior of Alagoas. Although sampling effort is not comparable throughout the different studies, it seems quite clear that more pristine areas harbor higher number of species (Araujo & Rodrigues 2011), and Curaçá is one of the most speciose sites in the biome, possibly due to its relatively high habitat heterogeneity.

Among the species absent in 2011 we can sadly include Spix's Macaw, extinct in the wild since 2000 (Silveira & Straube 2008). Until 1985, Curaçá, and more particularly the Riacho da Melancia (one of the areas we sampled), represented the last stronghold for this species, as the last five individuals were found in the area (Rowley & Collar 1997). Unfortunately most of those birds were likely taken by the illegal trade and only a single bird remained to be seen during our 1997 field season. Several management strategies were planned, from exchanging the infertile cross-species eggs with real captive-produced Spix's eggs, to releasing a captive female to mate with the lone male. A female was eventually released, but never paired with the male, and ultimately both birds disappeared (Juniper 2003). Despite the absence of the macaw, Curaçá has been considered as a priority area for conservation (Tabarelli & Silva 2004), and remains the best candidate area for a reintroduction program, particularly given the abundance of remnant Caraíba woodlands (*Tabebuia aurea*) that seem to represent a vital resource for the reproductive success of Spix's Macaw (Collar *et al.* 1997).

From our surveys, it is quite evident that several Caatinga specialists are absent from Curaçá. Species such as *Megaxenops parnaguae* (Great Xenops), *Herpsilochmus sellowi* (Caatinga Antwren), *Sakesphorus cristatus* (Silvery-cheeked Antshrike), *Hylopezus ochroleucus* (White-browed Antpitta), or *Synallaxis scutata* (Ochre-cheeked Spinetail) seem to be completely absent in the region. And in fact, the only area where *Synallaxis hellmayri* (Red-shouldered Spinetail) was present was in Fazenda Macambira, some 20 km from Fazenda Concórdia, where most of our fieldwork took place. All these species are quite widespread in the Caatinga, and have been recorded nearby. Understanding the drivers of these local distribution patterns is a biogeographic and conservation priority. These species may require denser Dry Forests (or Caatinga *arbórea*), a physiognomy that may not be that common around Curaçá.

In terms of compositional similarity, we found that the avifauna of the dense arboreal Caatinga was most similar to that of the gallery forests. This similarity is possibly explained by the presence of forest-dependent species in both habitats. On the other hand, we also found an equally high level of similarity between low shrubby Caatinga and gallery forests, possibly due to the presence of streams and their accompanying matrix of lower vegetation. The high species richness found in Curaçá seems to be the result of greater habitat heterogeneity. Some habitats, like the riparian vegetation found at the island of Curaçá, provided the only records of some species (e.g., *Laterallus melanophaius* Rufous-sided Crake, *Phacellodomus ruber* Greater Thornbird, *Cranioleuca vulpina* Rusty-backed Spinetail, *Saltator coerulescens* Grayish Saltator, and *Thlypopsis sordida* Orange-headed Tanager), which were only recorded along the Rio São Francisco. These observations suggest that this habitat is unique in the region and stands out as an important habitat for many species. This heterogeneity enforces the need of conservation efforts in areas with habitat diversity (Araujo & Rodrigues 2011, Araujo *et al.* 2012), such as Curaçá. Our results suggest that the region of Curaçá remains a hotspot for biodiversity in the Brazilian Caatinga, and requires immediate legal protection, particularly given its potential for the reintroduction of Spix's Macaw.

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APPENDIX:

List of bird species recorded in Curaçá, Bahia, including field season of records, breeding, migratory, or endangered status, habitats used in the area, abundance (observation frequency), and documentation. Taxonomy, nomenclature, and species order follows the Comitê Brasileiro de Registros Ornitológicos (2014), except for the Nightjars where we follow Sigurdsson and Cracraft (2014) and for some Thraupidae where we follow Burns et al. (2014).

Families and species[1]	**Field season**[2]		**Status**[3]	**Localities**[4]	**Habitats**[5]	**Ab.**[6]	**Documentation**[7]
	1997-98	**2011**					
RHEIDAE							
Rhea americana	x		NT	Co	O		
TINAMIDAE							
Crypturellus parvirostris	x	x		Cn, Co, Ma, PB	B F O	1,98	R (JMB:T5)
Crypturellus tataupa	x	x		Ca, Gp, Ma	A B F	15,84	
Rhynchotus rufescens[ssp]	x			Co	B		R (JMB:T8)
Nothura boraquira	x			Cn, Co, PB	B O		R (JMB:T4)
Nothura maculosa	x			Co	B O		R (JMB:T8)
ANATIDAE							
Dendrocygna viduata	x		Sea/W	Co, IC	W		R (XC15376)
Cairina moschata	x		Sea/W	Co, Ga, Pr	W		
Sarkidiornis sylvicola	x		Sea/W	Co	W		R (XC33195)
Amazonetta brasiliensis	x		Sea/W	Co, IC	W		
Netta erythrophthalma	x		Sea/W	Co	W		R (XC33194)
Nomonyx dominica	x		Sea/W; br	Co	W		R (JMB:T4)
CRACIDAE							
Penelope jacucaca[sp]	x		Vul	Co, Rm, Bp	F		P (WA665458)
PODICIPEDIDAE							
Tachybaptus dominicus	x		Sea/W	Co	W		R (XC15443)
Podilymbus podiceps	x		Sea/W	Co	W		R (XC15464)
CICONIIDAE							
Ciconia maguari	x		Sea/W	Pr	W		
Mycteria americana		x	Sea/W	Co	W O	1,98	
PHALACROCORACIDAE							
Phalacrocorax brasilianus	JMB 00			IC	W		
ARDEIDAE							
Tigrisoma lineatum	x		Sea/W	Co, Rm	W		
Nycticorax nycticorax	x		Sea/W	Bp	W		P (WA717303)
Butorides striata	x		Sea/W	Cn, Co, Bp	W		
Bubulcus ibis	x	x		Co	W O	1,98	P (WA839919)
Ardea alba	x	x		Bp, Co	W B O F	6,93	
Egretta thula	x		Sea/W	Bp, Co	W		
CATHARTIDAE							
Cathartes aura	x	x		Bp, Cn, Co, PB	B F	2,97	
Cathartes burrovianus	x	x		Cn, Co	O	0,99	
Coragyps atratus	x	x		Bp, Cn, Co, Gp, Rm	A B O	3,96	
Sarcorhamphus papa	x			Cn	B		
ACCIPITRIDAE							
Gampsonyx swainsonii	Wikiaves		**br**				P (WA691106)

Families and species[1]	Field season[2] 1997-98	2011	Status[3]	Localities[4]	Habitats[5]	Ab.[6]	Documentation[7]
Accipiter bicolor	x			Co	F		P (WA856148)
Rostrhamus sociabilis	x			Co	W		
Geranospiza caerulescens	x			Cn, Co, PB, Rm	B F		R (XC15402)
Heterospizias meridionalis	x			Cn			
Rupornis magnirostris	x	x		Bp, Cn, Co, IC,Gp, Rm	A B F R	12,87	P (WA811814); R (JMB:T8)
Geranoaetus melanoleucus	x			Cn, Co	A		R (XC15326)
ARAMIDAE							
Aramus guarauna	JMB 00			IC	W		
RALLIDAE							
Aramides ypecaha	x			Pr, Rm	W		
Aramides cajaneus	x	x		Co, PB, Pr, Rm	F	0,99	
Laterallus melanophaius	x			IC			R (JMB:T9)
Gallinula galeata	x		Sea/W	Co	W		
Gallinula melanops	x		Sea/W	Co	W		
CHARADRIIDAE							
Vanellus cayanus	x		Sea/W	Co, IC			
Vanellus chilensis	x	x		Bp, Co	O W	4,95	P (WA282375); R (JMB:T8)
Charadrius collaris	x		Sea/W	IC			P (WA612146); R (JMB:T9)
RECURVIROSTRIDAE							
Himantopus mexicanus	x		Sea/W	Co	W		P (WA612145); R (JMB:T6)
SCOLOPACIDAE							
Actitis macularius	x		Sea/W; VN	Co	W		
Tringa solitaria	x	x	Sea/W; VN	Co	W	0,99	R (XC15346, JMB:T4)
JACANIDAE							
Jacana jacana	x		Sea/W	Co	W		
COLUMBIDAE							
Columbina minuta	x	x		Cn, Co, IC, Pr	B O F	19,8	S (CAHZ00194); R (JMB:T8)
Columbina talpacoti	x			IC	O R		
Columbina squammata	x	x		Cn, Co, Gp, IC, Rm	A B O F R	29,7	S (CAHZ00203) R (JMB:T4)
Columbina picui	x	x		Cn, Co, Gp, IC, Pr, Rm	A B O F R	29,7	S (CAHZ 00205); P (WA283113); R (JMB:T6)
Patagioenas picazuro	x	x		Co, Gp, PB, Rm	A B O F	6,93	R (XC15463; JMB:T6)
Zenaida auriculata	x			Cn, Co, PB	B O		S (CAHZ 207)
Leptotila verreauxi	x	x		Co, Gp, IC, Rm	A B O F R	28,71	R (JMB:T8)
Leptotila rufaxilla	x			Cn, Co, IC	F		R (JMB:T4)
CUCULIDAE							
Piaya cayana	x	x		Co, Gp	A F	6,93	
Coccyzus melacoryphus	x			Cn, Co	B		P (WA816425)

Families and species[1]	Field season[2] 1997-98	2011	Status[3]	Localities[4]	Habitats[5]	Ab.[6]	Documentation[7]
Coccyzus americanus	JMB 00		VN	PB	A		
Crotophaga major	x			Bp, Co, PB	W		
Crotophaga ani	x	x		Co	B O F	1,98	
Guira guira	x			Cn, Co, IC	B R		R (JMB:T4)
Tapera naevia	x			Cn, Co, IC	B R		
TYTONIDAE							
Tyto furcata	JMB 00			Cur	V		
STRIGIDAE							
Megascops choliba	x	x	br	Co, Gp, Ma, Pr	A F	2,97	S (CAHZ 215)
Bubo virginianus	x			Rm	F		
Glaucidium brasilianum	x	x		Co, Gp	A F	2,97	P (WA705505)
Athene cunicularia	x			Co	O		
NYCTIBIIDAE							
Nyctibius griseus	x			Co, Pr	F		
CAPRIMULGIDAE							
Antrostomus rufus	Wikiaves						P (WA856139)
Hydropsalis parvulus	x	x		Co, PB, Pr	B V	0,99	
Nyctidromus hirundinaceus[ssp]	x	x	br	Cn, Co, PB	B O		P (WA628847); R (JMB:T8)
Hydropsalis torquata	x			Co			R (JMB:T8)
Chordeiles pusillus[ssp]	x	x	br	Co, Cur	B O		R (JMB:T4)
Chordeiles acutipennis	x			Cur, Pr	B O V		
Podager nacunda	x			Cur	V		
APODIDAE							
Tachornis squamata	x			Cur	V		
TROCHILIDAE							
Eupetomena macroura	x	x		Bp, Cn, Co, Gp, Rm	A B F	2,97	S (CAHZ198); P (WA710911)
Chrysolampis mosquitus	x	x	br	Co, PB, Rm	B F	0,99	R (WA143290; JMB:T8)
Chlorostilbon lucidus	x	x	br	Bp, Cn, Co, Gp, PB, Pr	A B F	10,89	S (CAHZ 236)
Amazilia fimbriata	x			IC			
Heliomaster squamosus	x	x		Co, Gp	A B	1,98	S(CAHZ 246)
ALCEDINIDAE							
Megaceryle torquata	x			IC	W R		R (JMB:T9)
Chloroceryle americana	x			Bp, Co	W		
GALBULIDAE							
Galbula ruficauda	x			IC			R (JMB:T9)
BUCCONIDAE							
Nystalus maculatus	x	x	br	Cn, Co, Gp, PB	A B	5,94	P (WA747548)
PICIDAE							
Picumnus pygmaeus[sp]	x	x	br	Co, IC	O F R	1,98	P (WA954833); R (JMB:T6)
Melanerpes candidus	x			Cn	B		
Veniliornis passerinus	x	x		Bp, Co, Gp, IC	A B O F	10,89	P (WA705491)

Families and species[1]	**Field season**[2] **1997-98**	**2011**	**Status**[3]	**Localities**[4]	**Habitats**[5]	**Ab.**[6]	**Documentation**[7]
Colaptes melanochloros	x	x		Cn, Co	F	2,97	S (CAHZ 221); P (WA945563); R (JMB:T8)
Colaptes campestris	x			Cn, Co	B O		R (JMB:T5)
Campephilus melanoleucos	x	x		Co, Ga, Gp, Rm	A B F	5,94	P (WA665479); R (JMB:T8)
CARIAMIDAE							
Cariama cristata	x	x	br	Bp, Cn, Co, Gp, PB	A B O W	10,89	R (JMB:T4)
FALCONIDAE							
Caracara plancus	x	x		Bp, Cn, Co	B F	0,99	P (WA710916); R (JMB:T4)
Milvago chimachima	x	x		Co	F O	0,99	
Herpetotheres cachinnans	x	x	br	Cn, Co, Ga, Gp, PB	A F	2,97	P (WA992909); R (JMB:T4)
Falco sparverius	x	x		Cn, Co, Gp	A B	0,99	S (CAHZ 230)
Falco femoralis	x			Bp, Co, IC	B R		P (WA1055939)
Falco peregrinus	x		VN	Co, Cur, IC	V		
PSITTACIDAE							
Cyanopsitta spixii[sp]	x		CE / Ext W	Bp, Co, PB, Pr	A B F		P (WA41251); R (JMB:T9)
Primolius maracana	x	x	Br / NT	Bp, Cn, Co, Gp, PB, Pr, Rm	B O F	6,93	P (WA791457); R (JMB:T4)
Thectocercus acuticaudatus[ssp]	x		br	Bp, Cn, Co, Pr	B F		P (WA958781); R (JMB:T4)
Eupsittula cactorum[sp]	x	x	br	Bp, Cn, Co, , PB, Pr, Rm	A B O F	42,57	S (CAHZ 231); P (WA960813)
Forpus xanthopterygius	x	x		Cn, Co, IC, PB	B O F R	8,91	P (WA961430); R (JMB:T7)
Amazona aestiva	x	x		Co, Pr, Rm, Bp	A B O F	14,85	
THAMNOPHILIDAE							
Myrmorchilus strigilatus[sp]	x	x		Cn, Co, Gp, IC, Ma	A B O	13,86	S (CAHZ 199); R (JMB:T5)
Formicivora melanogaster[ssp]	x	x		Co, Gp, IC, Ma	A B R	5,94	R (JMB:T9)
Thamnophilus capistratus[sp]	x	x	br	Cn, Co, Gp, Pr	A B	2,97	R (JMB:T5)
Taraba major	x	x		Gp,IC	A R	2,97	S (CAHZ 245); R (JMB:T9)
DENDROCOLAPTIDAE							
Sittasomus griseicapillus	x	x		Co, Gp, Rm	A O F	16,83	S (CAHZ 228); P (WA964806); R (JMB:T8)
Lepidocolaptes angustirostris[ssp]	x	x		Cn, Co, Gp, Rm	A B O F	42,57	S (CAHZ 224); P (WA960808); R (JMB:T4)
FURNARIIDAE							
Furnarius figulus	x	x		Cn, Co, Cur, IC	A F R	1,98	R (JMB:T9)
Furnarius leucopus	x	x		Bp, IC, PB, Rm	A F	16,83	S (CAHZ 217); R (WA143316; JMB:T4)
Pseudoseisura cristata[sp]	x	x	br	Bp, Cn, Co	B F	1,98	P (WA959729); R (JMB:T8)
Phacellodomus rufifrons[ssp]	x			IC	B O R		

Families and species[1]	Field season[2] 1997-98	2011	Status[3]	Localities[4]	Habitats[5]	Ab.[6]	Documentation[7]
Phacellodomus ruber	x			IC			R (JMB:T9)
Certhiaxis cinnamomeus	x			Cur, IC			R (JMB:T9)
Synallaxis hellmayri[sp]	x		NT	Ma, PB	A		R (JMB:T9)
Synallaxis frontalis	x	x	br	Co, Gp, IC, PB, Rm	F R	4,95	S (CAHZ 222); R (WA143325)
Synallaxis albescens	x			Co, Cn	B O		R (JMB:T4)
Cranioleuca vulpina[ssp]	x			IC	W		P (WA791433); R (WA727033; JMB:T9)
TITYRIDAE							
Pachyramphus viridis	x		br	Co, IC	F		
Pachyramphus polychopterus	x	x		Cn, Co, Gp, PB, Rm	A B F	11,88	S (CAHZ 227); R (JMB:T8)
Pachyramphus validus	x		br	Co, PB	F		R (JMB:T9)
Xenopsaris albinucha	x		br	Cn, Co	B		P (WA856146); R (JMB:T8)
RHYNCHOCYCLIDAE							
Tolmomyias flaviventris	x	x	br	Cn, Co, Gp, IC, PB, Rm	A B O F R	29,7	S (CAHZ 218); P (WA964815), R (JMB:T4)
Todirostrum cinereum	x	x	br	Cn, Co, Gp, IC, PB, Rm	A B F R	15,84	S (CAHZ 211); P (WA959689)
Hemitriccus margaritaceiventer	JMB 00	x		Co, Gp, PB	A B	12,87	S (CAHZ 234); P (WA961437)
TYRANNIDAE							
Hirundinea ferruginea	x	x		Cn, Gp	A	0,99	P (WA764856)
Stigmatura napensis[ssp]	x	x		Cn, Co, IC, PB	B O R	6,93	S (CAHZ 192); P (WA705472); R (JMB:T6)
Stigmatura budytoides[ssp]	x			Co	B		P (WA782431)
Euscarthmus meloryphus	x	x		Cn, Co, IC	B	3,96	R (JMB:T5)
Camptostoma obsoletum	x	x		Cn, Co, Gp	B O F	3,96	S(CAHZ 187); R (JMB:T5)
Elaenia spectabilis	x	x		IC	A	0,99	S (CAHZ 241); P (WA856150)
Elaenia chilensis		x	VS	Gp	A	0,99	S(CAHZ 237)
Suiriri suiriri[ssp]	x	x	br	Co	B O	2,97	S (CAHZ 210); P (WA964822)
Myiopagis viridicata	x	x		Cn, Co, Gp, PB, Rm	A F	10,89	S (CAHZ 247); R (JMB:T4)
Phaeomyias murina	x	x		Cn, Co, Gp, IC, PB, Rm	A B R	6,93	R (JMB:T6)
Myiarchus swainsoni	JMB 00			PB			P (WA816423)
Myiarchus tyrannulus	x	x		Cn, Co, Rm, PB	A B O F	49,5	S (CAHZ 238); P (WA1121635); R (JMB:T8)
Casiornis fuscus[sp]		x		Gp	A	1,98	P (WA857041)
Pitangus sulphuratus	x	x		Cn, Co, PB, Pr, Rm	B F	1,98	R (JMB:T4)
Machetornis rixosa	x			Bp, Co, Pr	O		R (JMB:T6)
Myiodynastes maculatus	x	x	br	Cn, Co,Gp, Rm	A B O F	15,84	S (CAHZ 212)
Myiozetetes similis	x	x		Cn, Co, IC	A O F	9,9	P (WA302938); R (JMB:T4)
Megarynchus pitangua	x			Cn, Co, Gp, PB, Rm	A F R		S (CAHZ 243); R (JMB:T8)

Families and species[1]	Field season[2] 1997-98	2011	Status[3]	Localities[4]	Habitats[5]	Ab.[6]	Documentation[7]
Tyrannus melancholicus	x	x		Cn, Co, Gp, IC, PB, Rm	A B O F R	50,49	R (WA876462)
Tyrannus savana	x			IC	R V		
Empidonomus varius	x	x		Cn, Co, Gp, IC, Rm	A B F R	9,9	S (CAHZ 196); P (WA282376); R (JMB:T8)
Myiophobus fasciatus	x						
Sublegatus modestus	x			Cn, Co	B		R (JMB:T5)
Fluvicola albiventer	x		br	Co	W		P (WA606629; JMB:T4)
Fluvicola nengeta	x			Bp, Co, IC			P (WA839912)
Arundinicola leucocephala	x		br	Cur, IC	R W		P (WA769720)
Cnemotriccus fuscatus		x		Gp	B		
Satrapa icterophrys	x			Co	F		
Xolmis irupero[ssp]	x	x		Co	B	1,98	P (WA960812)
VIREONIDAE							
Cyclarhis gujanensis	x	x		Cn, Co, Gp, IC, Rm, PB	A B O F	21,78	R (JMB:T6)
Vireo olivaceus	x	x	VN	Co, IC, PB, Rm	A F R	8,91	S (CAHZ 233); R (WA138581; JMB:T4)
CORVIDAE							
Cyanocorax cyanopogon[sp]	x	x		Bp, Cn, Co, Rm	A B O F	36,63	S (CAHZ 220); P (WA835028); R (JMB:T8)
HIRUNDINIDAE							
Progne tapera	x			Co, IC	B W		R (JMB:T4)
Progne chalybea	x			Cur	W		
Tachycineta albiventer	x			Co	W		R (XC15335)
Riparia riparia	x		VN	Cur, IC			
Hirundo rustica	x		VN	Cur, IC	V		R (JMB:T9)
TROGLODYTIDAE							
Troglodytes musculus	x	x		Bp, Cn, Co, Gp, IC, PB, Rm	A B O F	45,54	S (CAHZ 226); R (WA1143402; JMB:T8)
Cantorchilus longirostris[ssp]	x	x		Cn, Co,Gp, IC, Ma	A B	19,8	R (JMB:T8)
POLIOPTILIDAE							
Polioptila plumbea	x	x		Bp, Cn, Co, Gp, IC, PB, Rm	A B O F R	27,72	S (CAHZ 208); P (WA1121632); R (JMB:T8)
TURDIDAE							
Turdus rufiventris	x	x		Cn, Co, Gp, IC, Rm	A B F R	3,96	P (WA705501); R (JMB:T7)
Turdus amaurochalinus	x	x		Cn, Co	B F	3,96	S (CAHZ 216); R (JMB:T8)
MIMIDAE							
Mimus saturninus[ssp]	x	x		Bp, Cn, Co	B O	7,92	
PASSERELLIDAE							
Zonotrichia capensis	x	x		Cn, Co, IC	B O		

Families and species[1]	Field season[2] 1997-98	2011	Status[3]	Localities[4]	Habitats[5]	Ab.[6]	Documentation[7]
Ammodramus humeralis	x	x		Cn, Co, PB	B O	3,96	S (CAHZ 204); P (WA960804); R (JMB:T6)
ICTERIDAE							
Procacicus solitarius	x			IC			P (WA879413); R (JMB:T9)
Icterus pyrrhopterus	x	x		Bp, Co, Gp, IC, Pr	A F R	1,98	P (WA710908); R (JMB:T8)
Icterus jamacaii[sp]	x	x	br	Bp, Cn, Co, Gp,IC, Rm	A B O F	3,96	P (WA973957; R (JMB:T4)
Chrysomus ruficapillus	x			Co, Pr	O		R (XC15396)
Agelaioides fringillarius[sp]	x		br	Bp, Cn, IC	B R		P (WA710906); R (JMB:T9)
Molothrus rufoaxillaris	x			Cn	A		
Molothrus bonariensis	x			Cn, Pr	B O		
Sturnella superciliaris	Wikiaves						R (WA141160; JMB:T8)
THRAUPIDAE							
Coereba flaveola	x	x		Bp, Co, PB, Rm	A B F	6,93	S (CAHZ 213); R (JMB:T4)
Saltator coerulescens	x			IC			R (JMB:T9)
Saltator similis	x			Cn, IC	A B		R (JMB:T8)
Compsothraupis loricata[sp]	x	x	br	Bp, Cn, Co, Ga, Gp, PB	A B	3,96	P (WA961425); R (JMB:T4)
Nemosia pileata	x			Bp, Co, Gp,Rm	A		R (XC15437)
Thlypopsis sordida	x			IC			R (JMB:T9)
Coryphospingus pileatus	x	x		Cn, Co, Gp, IC, PB, Rm	A B O R	42,57	S (CAHZ 235); R (WA143333; JMB:T8)
Tangara sayaca	x	x		Cn, Co,Gp, IC	A B F R	5,94	
Paroaria dominicana	x	x	br	Bp, Cn, Co,Gp, IC, PB	A B O F R	24,75	S (CAHZ 188); P (WA765294); R (JMB:T5)
Conirostrum speciosum	x	x		Bp, Co, PB	A B F	2,97	
Sicalis columbiana	x			Cur	V		P (WA606652); R (JMB:T9)
Sicalis flaveola	x		br	Co	B		P (WA961434); R (JMB:T6)
Sicalis luteola	x			Co	B		R (JMB:T6)
Volatinia jacarina	x	x		Bp, Co, IC, Rm	A B O	8,91	S (CAHZ 206); R (JMB:T9)
Sporophila lineola	x	x		Co, Cur, IC, Rm	A O R	0,99	R (XC33350)
Sporophila nigricollis	x			Co	W		R (WA141097; JMB:T8)
Sporophila caerulescens	x			Co	W		
Sporophila albogularis[sp]	x	x		Bp, Co	B O F	12,87	S (CAHZ 229)
Sporophila bouvreuil	x			Co, IC	W		R (JMB:T6)
Charitospiza eucosma	x		Br / NT	Cn, Co	B		P (WA791455); R (JMB:T7)
CARDINALIDAE							
Cyanoloxia brissonii	x	x		Co, IC, Gp	A B	1,98	R (JMB:T9)
FRINGILLIDAE							
Euphonia chlorotica	x	x		Cn, Co, Gp, IC, Rm	A B F R	6,93	R (JMB:T9)

Families and species[1]	Field season[2] 1997-98	2011	Status[3]	Localities[4]	Habitats[5]	Ab.[6]	Documentation[7]
PASSERIDAE							
Passer domesticus	x		Introduced	Co, Cur	V		

[1] Families and Species. Caatinga endemic taxa are denoted by a superscript note referring to whether a given taxon represents an endemic species [SP] , or subspecies [SSP].
[2] Field Season. Refers to the date when our observations were obtained. Because two independent groups provided records, this information may be important for follow-up inquiries or to assess temporal changes in the avifauna. Rather than including a third column for JMB's observations during a short period in 2000, we included his novel observations under the 1997-98 column followed by "JMB 00". When records were not obtained by any of the authors, we included a note indicating the source of the data.
[3] Status. We include here data on breeding, migratory, or conservation status. Breeding species (br) represent those species for which we personally made observations suggestive of breeding activity. Observations included i) pairs copulating, ii) birds attending or building a nest or carrying nesting material, iii) presence of chicks, nestlings or fledgings, or iv) birds carrying food. Migratory species represent taxa that are unlikely to spend the entire year in Curaçá, and include Northern Visitors (NV), represented by birds that breed in the Northern Hemisphere and spend the austral summer (November – April) in the area; Southern Visitors (SV), which breed in Southern South America spend apparently spend the austral winter (May - September) in the area; and Seasonal Visitors (Sea), which are likely to performed seasonal movements that are not well understood. We also noted those seasonal visitors that appear following the availability of water resources (Sea/W), such as natural ponds or artificial lakes. We believe that all other species are likely residents and breed in the area, but we do not have data to support this assessment. We also included whether a species is endangered according to the IUCN (BirdLife International 2013), denoting which species is Extinct (Ext), Critically Endangered (CE), Vulnerable (Vul), or Near-threatened (NT).
[4] Localities. Refers to the general locations where each species was recorded. Fazendas Concórdia (Co), Gangorra (Ga), Canabrava (Cn), Prazeres (Pr), and Macambira (Ma), Gruta Patamuté (Gp), Island of Curaçá (IC), Poço do Baú (PB), Town of Curaçá (Cur), Riacho da Melancia (Rm), and Barragem do Plácido (Bp). For coordinates and a brief description of these localities see Study Area.
[5] Habitat. Represents the major habitats where we recorded each species in Curaçá. A: Arboreal of dense Caatinga; B: Shrubby or low Caatinga; F: Gallery Forest; O: Open areas; R: Riparian Forest; V: villages and towns; W: wetlands and ponds.
[6] Abundance. Refer to frequency of observations derived from quantitative data obtained through MacKinnon lists. Abundance data was only included for the 2011 field season.
[7] Documentation. Refers to the hard evidence supporting the presence of each species in the study area. S: specimens (held at the Bird Collections of the Federal Universites of Paraíba (UFPB) and Feira de Santana (UEFS); R: recordings, are available at Xeno-canto (xenocanto.org), wikiaves (wikiaves.org.br), or the personal collection of JMB, which is currently being included in the Macaulay Library database (macaulaylibrary.org).

Cyanopsitta spixii – Propyrrhura maracana

"Gangorra", Rcho Melancia, Curaçá – 03/I/97

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ARTICLE

The avifauna of Viruá National Park, Roraima, reveals megadiversity in northern Amazonia

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ABSTRACT: While many published maps of avian species richness indicate northern Amazonia to be somewhat species-poor, recent surveys reveal that this area actually possesses one of the most species-rich avifaunas in the Neotropical lowlands. Our surveys indicate that at least 520 bird species occur in Viruá National Park (VNP) and adjacent areas, which is located in the Brazilian state of Roraima (northern Amazonia). Here, we present the results of our ornithological efforts since 2001, based on audio-visual and mist-netting surveys, vouchered by tape and digital recordings, photographs, and collected specimens. VNP is dominated by Amazonian white-sand forest (locally known as *campina* and *campinarana*) on an extensive floodplain influenced by muddy-, clear-, and black-water rivers, forming a complex mosaic of habitats that includes *várzea*, *igapó*, and hilltop "islands" with *terra-firme* forest. The high avian diversity found at VNP is likely due to both biogeographic- and local-scale processes. Each habitat contains a particular avian assemblage. Patches of *terra-firme* forest have a typical Guianan avifauna. *Campina* and *campinarana* contain unique species, including some poorly known and range-restricted (e.g., *Aprositornis disjuncta*), as well as species typical of the northern Roraiman savannas (e.g., *Icterus nigrogularis*). The *várzea* of the Rio Branco (with its associated river islands) is particularly species-rich, including the endemic *Cercomacra carbonaria* and isolated populations of white-river-island specialists (e.g., *Mazaria propinqua*). VNP protects important ecological ecotones and biogeographical contact zones, as well as 27 threatened and 45 migratory bird species. On the other hand, 71 species reported for our study area have been found outside the current boundaries of the park. Ongoing proposals of expanding the limits of the park would absorb most of these species. With its outstanding bird species richness and wide variety of habitats, VNP emerges as an important site for Amazonian avian research, tourism, and conservation. Despite the park's protected status, the Brazilian government plans to build a hydroelectric dam in the region, representing the main threat to its avifauna and overall biodiversity.

KEY-WORDS: ornithological inventory; species richness; threatened species; white sand forest; Rio Branco

INTRODUCTION

Viruá National Park (VNP), located in the center of the Brazilian state of Roraima, represents an environmentally complex, relatively intact, and until recently, poorly known region of the Amazon basin. White-sand forests (*campinas* and *campinaranas*) dominate the landscape. Perched just above these waterlogged habitats, scattered hills support lowland *terra firme* forest. The entire region is drained by muddy-, clear-, and black-water rivers, forming a complex mosaic of riparian habitats (including *várzeas* and *igapós*). Despite being located in what is supposed to be one of the poorest regions of the Amazon (Rahbek & Graves 2001; Bass *et al.* 2010; Jetz *et al.* 2012), the environmental heterogeneity found at the park fosters high avian species richness.

The sandy, waterlogged soils of the park sustain low-stature forests, of low logging worth, and are generally considered too poor for agriculture. This has resulted in a very low human impact in the park, which is virtually uninhabited and almost entirely pristine (Schaeffer *et al.* 2009). On the other hand, a large hydroelectric dam imminently planned for the Rio Branco 30 km north of the park (MME 2011), represents a serious threat to the park's natural hydrological cycle and, consequently, to the biodiversity of the entire region (Campos 2011).

Biodiversity inventories are vital to understanding ecological and biogeographical processes, and are especially urgent when an entire ecosystem is under threat. Avifaunal surveys, in particular, are useful to establish conservation priorities. Many species are habitat specialists and can be good indicators of habitat integrity (Stotz *et al.* 1996). Birds are also better known than most other animal groups and a list of the birds recorded in a given area provides baseline data that can be monitored and followed in the future (Lees *et al.* 2014). Recent avian inventories conducted throughout Amazonia have resulted in a better understanding of the association between birds and vegetation types, regional variation in species abundance, and significant range extensions for many species (e.g., Cohn-Haft *et al.* 1997, 2007a; Naka 2004; Robbins *et al.* 2007; Whittaker 2009; Aleixo *et al.* 2011; Borges & Almeida 2011; Lees *et al.* 2012). Furthermore, extensive bird inventories have helped recognize and delimitate areas of endemism (Naka 2011; Borges & Silva 2012). Finally, avian inventories offer distribution data to support better delimitations of protected areas and Important Bird Areas (De Luca *et al.* 2009), both of which are important to protect more habitat and encourage ecotourism (Laranjeiras & Naka 2014), which supports economic development.

Here, we present the results of several years of ornithological surveys at VNP and adjacent areas. Our results include a comprehensive list of the park's avifauna, its distribution across habitats, and notes and commentaries on some highlighted species of biogeographic and conservation concern. This study will improve our understanding of avian distribution patterns in Roraima and northern Amazonia, and will be useful for the management of one of the most diverse avian communities in the world.

METHODS

Study Area

Viruá National Park, 230,000 ha, is located in the center of the state of Roraima in northern Brazil (1°20'N; 61°10'W), nearly 150 km south of Boa Vista (Figure 1). The park is bounded by the Rio Branco to the west, the BR-174 highway to the northeast, the *Estrada Perdida* (lost road) to the east, and the Rio Anauá to the south. We have also included in our surveys some areas that are outside the current boundaries of the park, including the village of Vista Alegre, the islands of the Rio Branco, the right margin of Rio Anauá near the confluence with the Rio Branco, and the left margin of the Rio Barauana. The two latter have been officially included in a request to expand the boundaries of the park, which is currently under consideration by the Brazilian government (see proposed VNP limits in Figure 1; MMA 2010). Four additional protected areas have been created in the region, including two Ecological Stations (Niquiá and Caracaraí), a National Forest (Anauá), and a National Park (Serra da Mocidade), forming a 1,200,000-ha network of protected land.

The climate at VNP is warm and wet, with a mean annual temperature of 26°C, with mean annual precipitation ranging from 2,000-2,300 mm in the south and 1,700-2,000 mm in the north (Barbosa 1997; Schaefer *et al.* 2009). Rainfall concentrates from May to July and the dry period occurs from December to March-April.

Habitats

VNP is located in an ecotone area, which is mostly covered by Amazonian white-sand forests (*campinas* and *campinaranas*; Figure 1). Other habitats present in the park are seasonally flooded riverine forests, such as *várzeas* and *igapós*; *terra-firme* forests on more elevated areas, forming forested hilltop "islands"; aquatic environments; and a small extent of open savanna on the park's northern limit. Small human-altered areas are also present. Elevation ranges from 50-60 m at the margin of the Rio Branco to 360 m at the Serra do Viruá. Bird habitat characterization and terminology follow Naka *et al.* (2006). More details on the vegetation and soil types present at VNP are available elsewhere (Schaefer *et al.* 2009; Adeney 2009; Gribel *et al.* 2009; Mendonça 2011; Rossetti *et al.* 2012; Damasco *et al.* 2013).

***Campina* and *campinarana*.** These habitats represent the dominant vegetation type in the park, covering ~45% of the area (Schaeffer 2009). We have included here more open (*campina*) and more forested (*campinarana*) areas, which share similar poorly drained sandy soils. Plant species richness is very variable between these vegetation types. Typical elements in the *campina* are the endemic small palm *Barcella odora*, species of Cyperaceae (*Lagenocarpus* spp.), and several species in the family Poaceae. In the *campinarana*, the canopy is taller and generally more uniform, reaching up to 15 m. It is formed predominantly by trees of the Vochysiaceae family, especially *Ruizterania retusa* and *Vochysia ferruginea* (Gribel *et al.* 2009)

***Terra-firme*.** Although this represents the dominant forest type in Amazonia, it covers only ~6% of the park (Schaeffer 2009). *Terra-firme* forests are more species rich than *campina* or *campinarana*, but are restricted in the park to the slopes of two hilly areas (Serra do Viruá and Serra do Preto) and to areas that do not flood along the Rio Branco and Rio Baruana. The plant species composition is considerably variable between localities, and plant richness is higher along the Rio Baruana. The canopy is tall, with emergent trees that can reach 40-45 m in height. The understory is generally open and rich in palms, such as *inajá* (*Maximiliana maripa*) and *bacaba* (*Oenocarpus bacaba*; Gribel *et al.* 2009).

Várzea. This represents the main habitat found along the Rio Branco and river islands, but is only present within the boundaries of the park along a thin stretch on the western side of VNP, covering only ~5% of the park's area (Schaeffer 2009). The *várzea* is composed of a series of successional vegetation types that are seasonally flooded by white-water rivers in Amazonia. It includes grassy sandbars, sandbar scrubs, river-edge forest (dominated by C*ecropia* spp.), and tall forests with well-developed canopy (transitional forest). There are no studies on the floristic composition of these habitats at VNP, but *jauari* palms (*Astrocaryum jauari*) and *jacareúva* trees (*Calophyllum brasiliense*) are common in these areas.

Igapó. This forested habitat occurs in areas that are seasonally flooded by black-water and nutrient-poor rivers, and covers ~40% of the park's area (Schaeffer 2009). The stature, plant species richness, and composition are very variable at different sites and rivers. Along the Rio Iruá, *igapós* are floristically diverse but lower in stature, resembling *campinarana*, with palms virtually absent; the *igapós* of the Anauá and Baruana rivers seem to be more structured, with a common presence of trees in the family Fabacae (Gribel *et al.* 2009).

Savanna. This open vegetation type in VNP is restricted to the surroundings of Vista Alegre at the northern edge of the park, covering only 170 ha (less than 0.1% of the study area). This region is currently outside the boundaries of the park, but has been included in a proposed expansion of the park's area (MMA 2010). The savannas are characterized by the sparse presence of small trees, with predominance of *caimbé* (*Curatella americana*) and *murici* (*Byrsonima* spp.), over continuous grassland.

Aquatic environments. Water-related habitats, including rivers, lakes with floating vegetation, and sandbanks, cover ~4% of the park (Schaeffer 2009). At VNP, natural lakes appear a few kilometers inland from the margin of the Branco, Anauá, and Baruana rivers and in low-lying areas in some *campinas*. Along the Estrada Perdida and the main highway (BR-174), the removal of soil for road construction has formed extensive artificial ponds.

Human-altered areas. These areas include pastures and other human land uses that have caused deforestation or degradation of natural habitats. In our study area, human-altered areas are limited to the park's administrative buildings on the Serra do Viruá, the village of Vista Alegre, the Rio Baruana access, the margins of the BR-174 highway, and along the *Estrada Perdida*.

Survey localities

We concentrated our ornithological surveys at nine major localities (Table 1).

1. Serra do Viruá. A small hill (maximum elevation 360 m above sea level) with slopes covered mainly by *terra-firme* forest. Administrative buildings and a 60-km trail system across a 25-km^2 area (5 x 5 km) are located in this section of the park. The trail system also crosses *igapós*, *campinas*, and *campinaranas*. We concentrated our surveys on this trail system, and also along a 5-km road that gives access to the administrative buildings (*Estrada do Portão*), covered by secondary forests, and another 2-km road that borders the hill (*Estrada do Neri*).

2. Estrada Perdida. An abandoned stretch of the BR-174 highway that crosses ~40 km of *campinas* and *campinaranas*, but also a few human-altered areas, *igapós*, and Moriche palm swamps (*buritizais*). There are some trails, including the *Estrada do Preto* (that gives access to the *Serra do Preto*), that cross a mosaic of all these vegetation types.

3. Igarapé do Aliança. This site includes mainly seasonally flooded forests, including *igapós* along the Aliança stream and *várzeas* in the confluence with the Rio Branco, but also patches of adjacent *terra-firme* forest and aquatic habitats. Two 5-km trails run next to the stream. We also surveyed early-successional vegetation and *várzea* forest in the Aliança, Pascoal, Inajatuba, Muriru, and Ajarani islands on the Rio Branco.

4. Ilha do Palhal. An island on the Rio Branco covered with early-successional vegetation and tall *várzea* forest. Our surveys also included other aquatic environments nearby and along the margins of the Rio Branco.

5. Boca do Anauá. A group of riverine islands with early-successional vegetation and tall *várzea* forests in the confluence of the Branco and Anauá rivers. We also surveyed other aquatic environments near these islands, and the lower course of the Rio Anauá.

6. Rio Iruá. The main watercourse inside VNP, which drains most of its territory. This river crosses several different vegetation types, mainly *campinaranas*, forming low *igapós*. We concentrated our surveys along the lower course of the river, near the confluence with the Rio Anauá.

7. Campinho do Rio Anauá. An open area with *campinas* along the margins of the Rio Anauá, surrounded by *campinaranas*, *igapós*, and other aquatic environments. A 5-km trail from the river crosses and borders these vegetation types.

8. Trilha do Baruana. This is a highly heterogeneous 5-km trail, which encounters *igapós*, *terra-firme* forests, and *campinaranas*, ending at an open *campina*. In this site, we also surveyed the aquatic environments and *igapó* surrounding the entrance of the trail in the river, as well as human altered areas around the campsite.

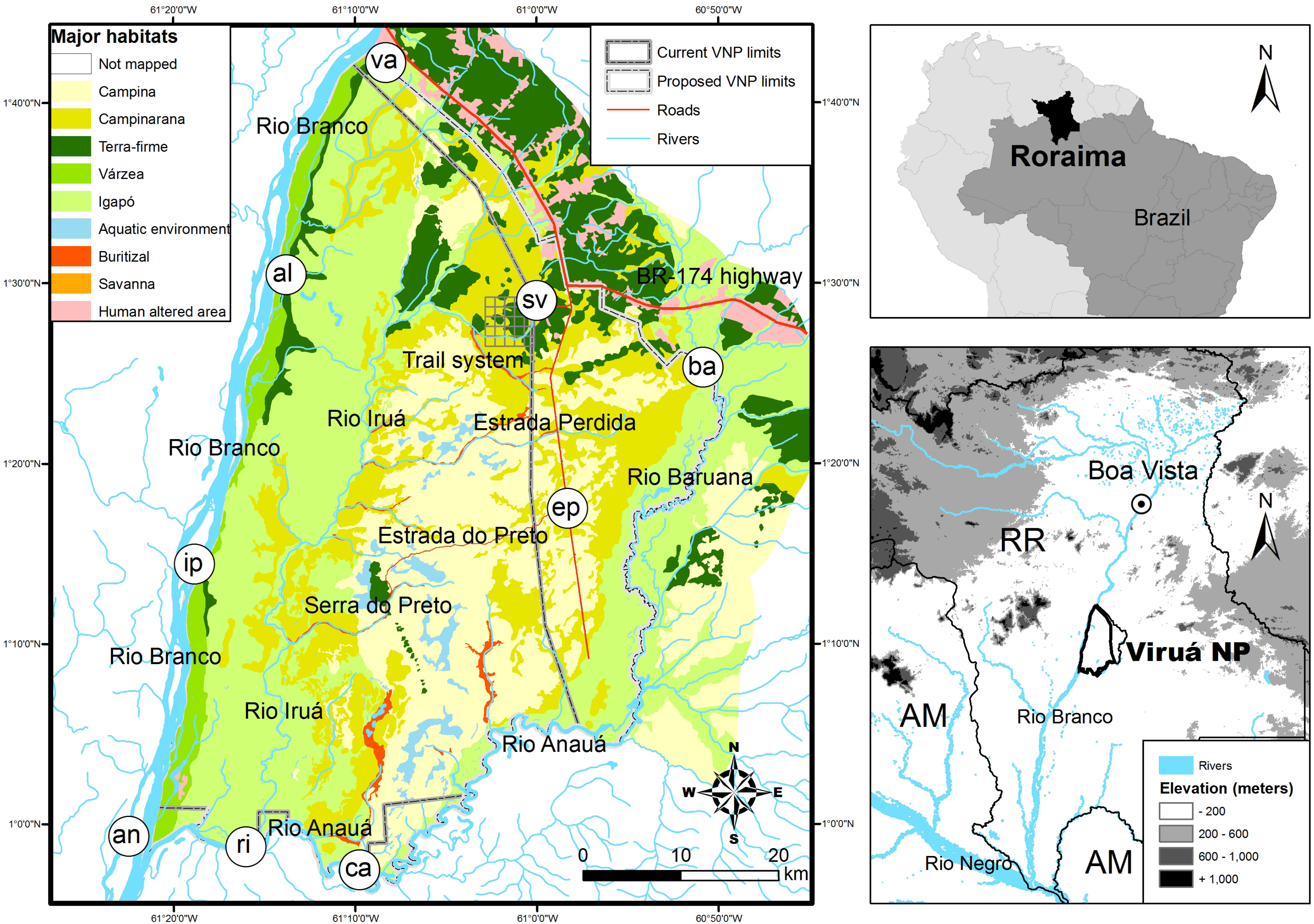

FIGURE 1. Location of Viruá National Park in northern South America (upper right) and in Roraima (lower right) and the distribution of major habitats and survey localities along rivers and main roads (left). va – Vila de Vista Alegre; sv – Serra do Viruá; ep – Estrada Perdida; ba – Trilha do Baruana; al – Igarapé do Aliança; ip – Ilha do Palhal; an – Boca do Anauá; ri – Rio Iruá; ca – Campinho do Rio Anauá.

9. Vila de Vista Alegre. A small village located along the Rio Branco, where the BR-174 bridge crosses the river. We surveyed mainly the savanna, but also the *várzeas* along the Rio Branco, small patches of *terra-firme* forest, artificial ponds, and open areas near the bridge.

Fieldwork

Fieldwork involved a series of complementary bird surveying techniques in order to detect a maximum number of species in different habitat types. We conducted auditory and sight observations, playback trials, and mist-net surveys. Birds were documented with vocalization recordings, photographs, and specimens. Surveys took place usually in the early morning (05:00 – 12:00 h) and late afternoon (15:00 – 18:00 h) and sporadically at night (18:00 – 21:00 h).

MCH, LNN, and MFT first visited VNP in May 2001. Subsequently, we conducted major expeditions in 2002, 2006, and 2008, sampling most habitats and localities, and using all bird sampling techniques described above. Some of us also visited the park for short periods (< 2 days) during these years, for a total of ~30 days of opportunistic observations, mainly around the park's headquarters and the Estrada Perdida. In August 2009, TOL started identifying areas for birdwatching purposes, and since then he has visited the park periodically. Also, since 2012, LNN and TOL began conducting systematic surveys along the Rio Branco. Survey effort totals > 134 days (see Table 2 for all surveying periods and efforts).

Species list

We present a list of all bird species recorded at VNP and adjacent areas, which includes data obtained predominantly during our fieldwork (see above), but also data gathered from unpublished sources (visitor reports). We tentatively assign species to their main habitats, and provide their local status (qualitative abundance categories), based on our own observations in the park. Qualitative abundance was determined subjectively, combining number of detections during our main expeditions in 2006 and 2008 and our impressions in the field. Species believed to be widespread in the appropriate habitat were assigned as common; species believed to occur in most, but not all seemingly appropriate habitat, were assigned as uncommon; and species observed in less than four occasions (including records obtained through visitor reports) were assigned as rare. Our abundance assignments are clearly dependent on survey effort and methods in each habitat, and our ratings should be interpreted as hypotheses of abundance that can be tested by quantitative census techniques (Cerqueira *et al.* 2013). Information on regional occurrence, seasonality, and conservation status is based on published sources (Stattersfield *et al.* 1998; Naka *et al.* 2006; ICMBio 2014; CBRO 2014; BirdLife International 2014). We also present the physical evidence used for the inclusion of each species in the list (specimen, audio recordings, and photographs), including the catalog number of at least one voucher, when available. Species lacking evidence refer to lack of visual or auditory records during our surveys. Taxonomy and species nomenclature follow the Brazilian Ornithological Records Committee (CBRO 2014), except for the Caprimulgidae, the genus *Cercomacra*, the species *Mazaria* (*Synallaxis*) *propinqua*, and the genus *Tachyphonus* and *Eucometis*, where we follow, respectively, Sigurdsson & Cracraft (2014), Tello *et al*. (2014), Claramunt (2014), and Burns *et al*. (2014).

TABLE 1. Ornithological survey effort and sampled habitats in each main study locality at Viruá National Park and adjacent areas.

Locality	General geographic coordinates	Effort	Habitats[1]
Serra do Viruá	1°29'30.46"N; 61°00'21.33"W	47	tf, ig, cp, cm, at
Estrada Perdida	1°24'34.72"N; 60°59'15.97"W	29	cp, cm, at, ig
Igarapé do Aliança	1°27'46.20"N; 61°14'51.04"W	26	vz, ig, tf, wa
Ilha do Palhal	1°14'19.91"N; 61°19'16.10"W	10	vz, aq
Boca do Anauá	0°57'59.06"N; 61°21'56.40"W	5	vz, aq
Rio Iruá	0°59'37.39"N; 61°15'23.93"W	5	ig, cm, aq
Campinho do Rio Anauá	0°57'32.19"N; 61°09'33.25"W	5	ig, cp, cm, aq
Rio Baruana	1°25'02.40"N; 60°50'46.30"W	5	ig), tf, cp, cm, at, aq
Vila de Vista Alegre	1°42'42.37"N; 61°08'46.27"W	2	sa, vz, tf, at

[1]Habitats: cp – *campina*; cm – *campinarana*; tf – *terra-firme* forest; vz – *várzea*; ig – *igapó*; sv – savanna; aq – aquatic environment; at – human-altered areas

TABLE 2. Dates of ornithological surveys at Viruá National Park and adjacent areas, including effort (in days) and localities.

Period	Team	Effort	Localities[1]
May 2001	MCH, LNN, MFT	2	sv, ep
Oct 2001	LNN, JMB	7	an
Aug 2002	MPDS	15	sv, ep, al, ip
May 2006	TOL	8	sv, ep
Oct 2006[2]	LNN, MCH, CB	20	All except ba, va
Mar-Apr 2008[2]	AMFP, CBA, CFV, CHS, GLR, MCC, MCH, MFT, TOL, TVVC	23	All
Aug 2009	TOL	6	sv
Jan 2010	TOL, MFT	4	ep
Apr 2010	TOL, MFT, LNN	4	sv
Jul 2010	TOL	5	sv, ep, al
Jan 2011	TOL, LNN	4	sv, ep, ba
Jul 2011	TOL	3	ri, ca
Jan 2012	TOL, MFT	3	sv, ep
Apr 2012	TOL	3	sv, ep
Mar 2012	LNN	5	al[3]
Sep 2012	LNN, TOL	4	al, ip[3]
Nov-Dec 2012	TOL	9	sv, ep, al
Ago-Sep 2013	TOL	5	sv, ep
Oct 2013	LNN, TOL	4	ip[3]
	Total effort	**134 days**	

[1]Localities: sv – Serra do Viruá; ep – Estrada Perdida; al – Igarapé do Aliança; ip – Ilha do Palhal; an – Boca do Anauá; rb – Rio Branco; ri – Rio Iruá; ca – Campinho do Rio Anauá; ba – Trilha do Baruana; va – Vila de Vista Alegre. [2]Main expeditions. [3]includes other sites along Rio Branco near the locality.

RESULTS

We recorded 520 bird species for VNP and adjacent areas, which are distributed over 70 bird families (Appendix A). A total of 71 species (~13%) were found exclusively in areas outside the park boundaries (including 16 that were found exclusively on islands on the Rio Branco). The most representative families were Tyrannidae, Thamnophilidae, and Thraupidae, with 48, 44, and 41 species, respectively. For the non-passerines, the most represented families were Accipitridae, Trochilidae, and Psittacidae, with 23, 22, and 21 species, respectively.

We documented the presence of ~83% (431 species) of the bird species included on the list. The presence of 339 species (~65%) was documented with photographs; 303 species (~58%) with audio recordings, and 245 species (~47%) with specimens (Appendix A). The remaining ~17% (89 species) were listed for VNP based on sight and/or auditory records. Most of the species recorded without physical evidence are widespread and common taxa, which are expected to occur in the region and do not represent any identification challenges.

Six bird species (*Gallinula galeata, Aratinga solstitialis, Pyrrhura picta, Tyranneutes stolzmanni, Leptopogon amaurocephalus*, and *Tachyphonus rufus*) have been mentioned to occur in the park, but their presence has not been documented. Because these species are not expected to occur in the park, or at least lack records in nearby localities, we have opted to wait for additional records before including them on the list, so these species are noted as hypothetical.

Most species (~78%) occur in more than one locality (Appendix A), but nearly half of the species recorded in the park (259) were detected exclusively in a single habitat type (Table 3). The *várzeas* of the Rio Branco and the *terra-firme* forests represent the habitats where we detected the highest numbers of species, with 276 and 240 species, respectively (157 of these were detected exclusively in one of the two). As expected, sandy-soiled *campina* and *campinarana* harbour fewer species (about 185), but 37 of them were found nowhere else in the park.

A total of 27 bird species are currently considered threatened at global (BirdLife International 2014) or national (ICMBio 2014) levels, including one Critically Endangered species (*Cercomacra carbonaria*; Appendix A). One species (*Neochen jubata*) is listed as Data Deficient, and five species are considered to have restricted geographic distributions (*Aprositornis disjuncta, Myrmotherula klagesi, C. carbonaria, Hemitriccus inornatus*, and *Dolospingus fringilloides*). Most of the species recorded seem to be permanent residents in the park, but nearly

10% (45 species) possibly visit the park on a seasonal basis (Appendix A). From these, nearly half (24 species) represent North American or neartic migrants; 14 species represent southern South American or austral migrants; and seven species seem to arrive from other regions within northern South America or Amazonia.

TABLE 3. Total avian species richness and number of exclusive species for each major habitat in Viruá National Park and adjacent areas.

Habitat	Total	Exclusive
Campina	88	19
Campinarana	130	10
Sand soil forest total[1]	185	37
Terra-firme	240	95
Várzea	276	62
Igapó	144	7
Flooded forest total[2]	297	93
Savanna	34	2
Aquatic environment	75	29
Human altered area	89	3
Total single habitat species		259

[1]Includes *campina* and *campinarana.*
[2]Includes *várzea* and *igapó.*

Species accounts

In this section we present data on some poorly known species, records that represent range extensions and records that we consider important in biogeographical or conservation terms.

Orinoco Goose (*Neochen jubata*)

The Orinoco Goose (Figure 2) is a widespread but poorly known species regularly seen on sandy beaches along the Rio Branco. Although this species is known to perform seasonal movements, at least in part of its distribution in southern Amazonia (Davenport *et al.* 2012), very little is known about this species at VNP, or along the entire Rio Branco, where it regularly occurs. Fortunately, this species seems not to be seen as a good source of food by local human communities (TOL and LNN pers. obs.). Given its reliance on sandy beaches, the construction of a dam on the Rio Branco, with its potential impacts on flooding and sedimentation regimes represents a serious threat to the survival of this species in the region.

FIGURE 2. Orinoco Goose (*Neochen jubata*) at Ilha do Palhal in the Rio Branco (T.O.L.)

Crested Bobwhite (*Colinus cristatus*)

The Crested Bobwhite (Figure 3) occurs in northern South America in arid lowlands and locally into the subtropical zone, using thickets, woodland edges, savannas, roadsides, and embankments (Carroll & Boesman 2013). It is generally considered more common in open savannas, and its presence on sandy-soiled *campinas* is poorly documented. We frequently recorded this species in the *campinas* along the Estrada Perdida and Rio Anauá. VNP seems to represent its southernmost area of occurrence in Roraima.

FIGURE 3. Crested Bobwhite (*Colinus cristatus*) at a human-altered area near the Estrada Perdida (T.O.L.)

Least Nighthawk (*Podager pusillus*)

The Least Nighthawk represents a geographically widespread species with an apparently disjunct population in northern Amazonia (Cleere & Kirwan 2013). It seems that two different forms occur within the state of Roraima (*septentrionalis* and *esmeladae*), which segregate geographically and possibly by habitat (Naka *et al.* 2006). All specimens from the park seem to be *esmeraldae*. We found this species to be fairly common along the Estrada Perdida, in *campinas* adjacent to Iruá and Anauá rivers, as well as in the open savannas of Vista Alegre.

Spot-tailed Nightjar (*Hydropsalis maculicaudus*)

This species is patchily distributed in South America and its seasonal movements are poorly understood; some populations are sedentary, while others are likely migratory (Cleere & Bonan 2013). In March 2008, we recorded this nightjar daily in the *campinas* along the Estrada Perdida. These represent the only known records for the park, suggesting possible seasonal movements in the region. The same pattern has been observed in central Amazonia (MCH pers. obs.), although populations known to be resident are found along the lower Rio Amazonas (Arizmendi *et al.* 2013). While it inhabits open habitats, its presence in sandy-soil *campina* is poorly documented.

Barbets (*Capito* spp.)

Two species of *Capito* barbets occur in Roraima and they are thought to replace parapatrically along the Rio Branco (Naka *et al.* 2006, 2012). Similar to the pattern followed by *Pyrilia* parrots (see below), we only recorded *C. niger* (a Guaianan endemic) in *terra-firme* forest around Serra do Viruá, while *C. auratus* was regularly present on islands covered with *várzea* forest along the Rio Branco, just opposite the park boundaries.

White-bellied Piculet (*Picumnus spilogaster*)

The White-bellied Piculet (Figure 4) has a relatively narrow range in northern South America. It only occurs in Brazil in Roraima and at the mouth of Rio Amazonas, near Belém (Winkler & Christie 2002), where the population may represent another taxon (Lees *et al.* 2014). This species was previously considered a gallery forest specialist, restricted to riparian vegetation along rivers, and patches of deciduous forests in the savannas of northern Roraima (Naka *et al.* 2007). On 23 March 2008, we collected one individual of this species at Ilha do Palhal on the Rio Branco. Another specimen was collected at Ilha do Ajarani in September 2012. These specimens represent the southernmost records of the nominate form along the Rio Branco, and the first evidence that it also occurs in *várzea* forests.

FIGURE 4. White-bellied Piculet (*Picumnus spilogaster*) at Ilha do Ajarani in the Rio Branco (T.O.L.)

Parrots (*Pyrilia* spp.)

Two species of *Pyrilia* parrots occur in Roraima, and although they are thought to replace parapatrically along the Rio Branco (Naka *et al.* 2006, 2012), we observed and tape-recorded both Caica *P. caica* and Orange-checked *P. barrabandi* Parrots in VNP. Nevertheless, the Caica Parrot (a Guianan endemic) was recorded exclusively in the *terra-firme* forest around Serra do Viruá, whereas the Orange-cheeked Parrot (a widespread western Amazonian species) occurred in the *várzea* forest along the Rio Branco and the lower Rio Anauá. The presence of *P. barrabandi* east of the Rio Branco represents an exception to the observed pattern of western elements being restricted to the west bank of the Rio Branco (Naka *et al.*, 2006). Although both species co-occur in the park, they seem to segregate ecologically.

Black-throated Antshrike (*Frederickena viridis*)

The Black-throated Antshrike (Figure 5) is a relatively uncommon understory Guianan endemic, that until recently was only known from a single record for the entire state of Roraima (Naka *et al.* 2006). In 2007, we recorded a male in a *terra-firme* forest at ~7 km from the park's boundaries (1°39'20"N, 61°2'14"W), but in December 2012 and August 2013, we voice-recorded and photographed a female in the *terra-firme* forest along the Buritizal Trail, near the park headquarters, and in February 2014 we found another individual at the Estrada do Neri. These are the only records of this species in VNP, and the third known locality for Roraima.

FIGURE 5. Black-thorated Antshrike (*Frederickena viridis*) around the Serra do Viruá (T.O.L.)

Klages's Antwren (*Myrmotherula klagesi*)

This species (Figure 6) is a range-restricted, Near Threatened (BirdLife International 2014), seasonally flooded forest specialist (Zimmer & Isler 2003). Although it was only recently added to the state of Roraima list (Naka *et al.* 2006), it is a common inhabitant of the *várzea* forests along the entire lower Rio Branco (LNN and TOL, unpublished data), where it occurs on river islands and forested margins (Naka *et al.* 2007). We documented its presence in the park along the eastern bank of the river, from Vista Alegre (possibly the northernmost locality of its entire distribution) to the mouth of the Rio Anauá (at the southern edge of the park). Despite its threatened status, there is no evidence of habitat loss or population decline in the region, although modification of the habitat by the proposed dam will reduce the *várzea* habitat upon which it relies, and will likely have negative consequences for the Rio Branco populations of this species.

FIGURE 6. Klages's Antwren (*Myrmotherula klagesi*) at an unnamed island in the Rio Branco (T.O.L.)

Leaden Antwren (*Myrmotherula assimilis*)

This is a *várzea* forest specialist is restricted to the understory and mid-story of both river islands and forested river edges along some of the largest rivers in the Amazon basin (Zimmer and Isler 2003). It was only recently found to occur along the Rio Branco (Naka *et al.* 2007). We voice-recorded and collected this species on several river islands along the Rio Branco. On 6 October 2006 and 1 April 2008 we found this species in VNP, near the confluence of this river and the Rio Anauá, representing the northernmost records of this species.

Rio Branco Antbird (*Cercomacra carbonaria*)

The Rio Branco Antbird (Figure 7) is a range-restricted Rio Branco near-endemic, which is currently considered Critically Endangered (Vale *et al.* 2007; BirdLife International 2014). We commonly recorded this antbird on river islands and more rarely along the margins of the Rio Branco, from Vista Alegre to the Rio Anauá. Previous records extended its known distribution more than 300 km southward (Naka *et al.* 2007). Although it is relatively common in suitable habitat, habitat modifications

FIGURE 7. Rio Branco Antbird (*Cercomacra carbonaria*) at Ilha do Palhal in the Rio Branco (T.O.L.)

due to the construction of the proposed dam will have consequences on the global population of this species, which occurs along the Rio Branco and a few of its tributaries.

Yapacana Antbird (*Aprositornis disjuncta*)

This range-restricted, monotypic antbird (Figure 8) is known from a handful of localities in northern Amazonia (Zimmer & Isler 2003). We first recorded this *campina* specialist in VNP in May 2001, and it has been recorded regularly in different localities along the Estrada Perdida and near the Rio Anauá ever since. VNP remains the only known locality of this taxon in Roraima, and only the second Brazilian site.

FIGURE 8. Yapacana Antbird (*Aprositornis disjuncta*) in the campinaranas around the Estrada Perdida (T.O.L.)

Fuscous Flycatcher (*Cnemotriccus fuscatus*)

This widespread understory tyrant likely represents several biological species, which taxonomic status is currently under investigation (MCH and collaborators, unpublished data). Two forms of this polytypic species are present at VNP: the form *fumosus* is commonly found along the Rio Branco, particularly (although not exclusively) in *várzea* forest, whereas the form *duidae* has been found in the *campinas* along the Estrada Perdida.

Pale-bellied Mourner (*Rhytipterna immunda*)

This poorly known, sandy-soil specialist was found to be uncommon in the *campinaranas* associated with the Anauá, Iruá, and Barauana rivers, as well as along the Estrada Perdida. The species was only recently reported to occur in Roraima (Naka *et al.* 2006) and are still only a handful of records. We found this species on only five occasions, despite many days of fieldwork in apparently suitable habitat, suggesting that it is indeed uncommon (or very local) as suggested for other regions, such as neighboring Venezuela (Hilty 2003).

White Bellbird (*Procnias albus*)

This remarkable species is known to occur in northern Amazonia, but its distribution and seasonal patterns remain poorly understood (Snow 2004). We observed and heard this species in *terra-firme* forest around the Serra do Viruá and at Igarapé do Aliança in October 2006 and October 2012, respectively. The species had not been reported for the Rio Branco region before, and few records for Roraima are available (Naka *et al.* 2006). It seems quite possible that this species is only seasonally present in the park, but we cannot refute the hypothesis that birds are residents but go silent during the rest of the year. Year-round surveys may contribute to the understanding of this species' seasonal patterns in the region.

Large-billed Seed-Finch (*Sporophila crassirostris*)
A relatively widespread species in northern South America, yet very uncommon in Brazil (Jaramillo 2011). In the state of Roraima, it is only known from a couple of localities (Naka *et al.* 2006). On March and April 2008, we recorded and collected this species in an open sandy soil *campina* along the Estrada Perdida. In Brazil, there are very few recent records and the species has been up-listed to Vulnerable on the national Red List (ICMBio 2014). The species is common in captivity in Boa Vista (TOL pers. obs.).

Black-stripped Sparrow (*Arremonops conirostris*)
Although this species (Figure 9) is widespread in northern South America and southern Central America, the state of Roraima represents the only known area of occurrence in Brazil. We recorded this species in VNP during our surveys in early successional vegetation on islands along the Rio Branco. The population in Roraima seems to represent the nominate form, which is isolated from the main distribution of the species in northern South America (Hilty 2003).

FIGURE 9. Black-stripped Sparrow (*Arremonops conirostris*) at Ilha do Aliança in the Rio Branco (T.O.L.)

Yellow Oriole (*Icterus nigrogularis*)
The Yellow Oriole is known from northern South America (Hilty 2003), reaching Brazil in a few localities north of the Rio Amazonas. In Roraima, this species is quite common on the Roraima-Rupunnuni savannas, but becomes rarer further south. On 22 March 2008, we voice-recorded and collected this bird in the *campinaranas* along the Estrada do Preto. This is the only record for VNP. Although it occurs in a variety of open habitats, including urban areas around Boa Vista and other towns, its presence in sandy soils remain poorly documented.

DISCUSSION

Avian diversity

With over 500 bird species recorded, Viruá National Park and its adjacent areas harbors an unexpectedly species-rich avifauna, which includes more than 70% of all bird species recorded in the Brazilian state of Roraima (Naka *et al.* 2006). This is particularly impressive, given the almost negligible altitudinal range within the park, which ranges from 50 m to 360 m, and that most of the park is located on top of sandy soils. The high avian diversity found in VNP is likely due to both biogeographic- and local-scale processes.

At a biogeographical scale, VNP is located at the confluence of different biogeographical regions (see ***Biogeographical affinities*** below). It includes a described contact zone for *terra-firme* forest birds (Naka 2011), an ecotone region of flooded forests (*várzea* and gallery forest; Naka *et al.* 2007) and a transition zone between open areas (savanna and *campina*). The Rio Branco, which dissects the state in an eastern and western half, represents one of the most important biogeographical barriers in the Amazonia for birds (Naka *et al.* 2012). In addition, because of its latitude, VNP receives migratory birds from both northern and southern South America, although these are responsible for only 7% (45 species) of the total.

Locally, there are extremely high levels of environmental complexity within and between habitats. *Terra-firme* forests are known to have the greatest species richness anywhere in Amazonia (Cohn-Haft *et al.* 1997) and *várzea* and *igapó* are also very rich (Rosenberg 1990; Cohn-Haft *et al.* 2007b; Borges & Almeida 2011). Seasonally flooded forests (where, in fact, we found more species; see Table 3), in particular, have a variety of successional stages that result in the occurrence of many specialized birds, which inhabit different microhabitats (Remsen & Parker 1983; Rosenberg 1990; Borges & Carvalhes 2000). Also, species from adjacent *terra-firme* forest (e.g., *Dendrocincla fuligionsa*, *Formicarius colma*) may explore tall *várzea* and *igapó* during dry periods (Beja *et al.* 2010). Sandy soil habitats (*campina* and *campinarana*) have a lower number of species, but add many unique ones to the park (Borges 2004). A similar pattern is observed for the savannas and aquatic environments. As the bird communities among habitats are, in general, distinct, the total avian diversity is very high.

Our results also show that the avian richness of VNP is higher than expected (almost 100 species more) given known large-scale patterns of species richness (see Rahbek & Graves 2001; Bass *et al.* 2010; Jetz *et al*. 2012). Although avian species richness in Amazonia seems to increase westwards to the Andes (Cohn-Haft *et al.* 1997; Rahbek & Graves 2001), previous studies may have neglected the contribution of sandy soil and flooded forests to avian diversity in the Guianan Shield. In fact, areas with > 500 bird species are starting to appear throughout the Brazilian Amazon (Pacheco *et al.* 2007; Somenzari *et al.* 2011; Lees *et al.* 2013a,b), also contradicting the overall species richness pattern. More attention to microhabitats and a better knowledge of avian vocalizations may be responsible for these increasing numbers.

Despite our efforts, it is likely that the bird list of VNP will continue to grow. After 13 years since we first visited the park, we continue to find new species in the area (see Figure 10), even in heavily surveyed sites (e.g., Serra do Viruá). We believe that at least 20 more bird species are very likely to be found in the park with further sampling, and another 50-60 species could potentially be found within the park boundaries (Appendix B). Therefore, we believe that VNP and its adjacent areas will likely reach 550 bird species in the next few years.

On the other hand, some species that were expected to occur within the park seem to be absent. More than 20 species that are common and easily detectable in the *terra-firme* forests north of Manaus (e.g., *Thamnomanes ardesiacus*, *Formicarius analis*, *Corapipo gutturalis*, *Vireolanius leucotis*, *Tangara chilensis*, *Dacnis lineata*) (Cohn-Haft *et al.* 1997), 500 km south of VNP, have not yet been recorded in the park. One possible explanation for their apparent absence is the small proportion of *terra-firme* forest and its naturally fragmented distribution within VNP. Additionally, most of our surveys in *terra-firme* forests were limited to a few sites within the park (Serra do Viruá). It is possible that exploring new areas within the park's forests, some of those absent species may finally appear. The apparent rarity of some species in VNP (e.g., *Piaya melanogaster*, *Saltator grossus*), suggests that many *terra-firme* forest birds may be indeed rare and very local, and therefore including new sampling areas may significantly enhance the chances of finding more bird species.

Biogeographical affinities

VNP is located entirely on the eastern bank of the Rio Branco, and therefore has a typical Guianan avifauna in the *terra-firme* forest, including 71 Guianan endemic taxa (26 species and 45 subspecies). In fact, 12 endemic species and 20 endemic subspecies are restricted to the eastern side of the Rio Branco (Table 4). On the other hand, another three species not considered Guianan endemics seem to be absent west of the Rio Branco in Roraima (*Microrhopias quixensis*, *Cercomacra laeta,* and *Cercomacra nigrescens*). Whether these absences are real or a function

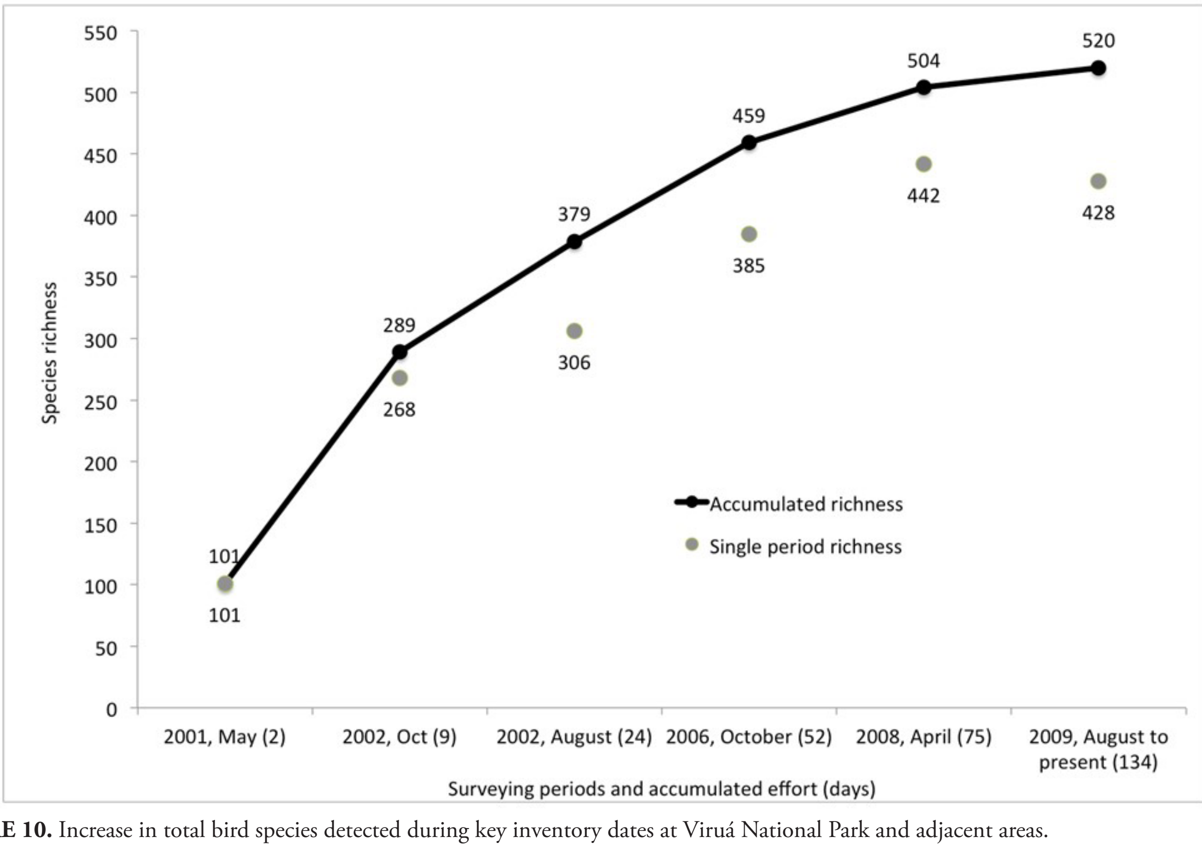

FIGURE 10. Increase in total bird species detected during key inventory dates at Viruá National Park and adjacent areas.

of lack of sampling remains to be evaluated. Despite being entirely within the Guianan Area of Endemism, we have mapped some contact zones in the study area, such as for a pair of parrots in the genus *Pyrilia* (*caica* and *barrabandi*) and a pair of barbets in the genus *Capito* (*auratus* and *niger*).

The *várzeas* along the Rio Branco are particularly interesting. Typical *várzea* species (known from most of the Amazon basin) are present, such as *Thamnophilus nigrocinereus*, *Myrmotherula assimilis*, *Myrmoborus lugubris*, and *Dendroplex kienerii* (Table 4). The avian communities found along these *várzeas* seem to be quite similar to those found on the Anavilhanas archipelago on the lower Rio Negro (Cintra *et al.* 2007). On the other hand, a handful of white-water (muddy) river specialists that are apparently absent from the Rio Negro are present in isolated populations along the Rio Branco (see Naka *et al.* 2007), as well as on the river islands just opposite the park boundaries (Table 4). For flooded-forest birds, the Rio Branco also represents an ecological ecotone, which influences bird species composition. The Rio Branco runs along a latitudinal gradient, which goes from the savannas (around Boa Vista) into the forest realm (south of Caracaraí). Along its margins, gallery forests on the upper Rio Branco are replaced by *várzeas* further south, and this replacement seems to occur near VNP (Naka *et al.* 2007). Therefore, although the vegetation of the Rio Branco is composed of *várzea* forests along VNP, some gallery forest specialists are still found near the park's boundaries, such as *Picumnus spilogaster*, *Hylophilus pectoralis*, and *Turdus nudigenis* (Table 4).

The *campinas* and *campinaranas* host a typical sandy-soil avifauna, similar to that present in other localities in northwestern Amazonia, such as Jaú NP in Brazil (Borges 2004), or Campamento Junglaven in Venezuela (Zimmer & Hilty 1997). Typical white-sand forest birds include *Myrmotherula cherriei*, *Aprositornis disjuncta*, *Elaenia ruficeps*, and *Dolospingus fringilloides*, among others (Table 4). Although savannas are virtually absent in the park, present only near the village of Vista Alegre, we found a group of species that are generally restricted to the savannas of northern Roraima inhabiting the *campinas* in the park (Naka *et al.* 2006; Santos & Silva 2007). The presence of savanna species such as *Colinus cristatus*, *Sporophila intermedia*, *Sporophila crassirostris,* and *Icterus nigrogularis* may simply be due to a 'leakage' from the nearby savannas. In fact, VNP may represent the southern limit of the distribution of some of these species. Other avian elements in the *campinas* include species that are widely distributed in open areas in South America and predominantly absent in Amazonia, such as *Chordeiles pusillus*, *Hemitriccus margaritaceiventer*, *Tangara cayana*, and *Geothlypis aequinoctialis*. Most of these species are polytypic and their populations in VNP deserve genetic and taxonomic studies.

Conservation, implications for management, and future research

Although VNP is part of a large mosaic of protected areas, current agricultural and forestry developments around the park are of concern. Currently, southern Roraima is under severe threat from deforestation (Soares-Filho *et al.* 2006; Campos 2011). With more than 200,000 ha, VNP offers significant protection for the biodiversity found in the state, including several threatened bird species. Within the park, very few areas have been modified and the park seems to be large enough to hold stable populations of threatened and non-threatened species. However, the connectivity of the park with other healthy natural vegetation communities is necessary for maintaining large-scale ecological and evolutionary processes. The proposal to expand the park boundaries (MMA 2010) moves toward this goal and also, importantly, reinforces the protection of 55 bird species that we found exclusively in the requested expansion areas (Appendix A).

The construction of a hydroelectric dam on the Rio Branco, only 30 km north of the park's boundaries represents a serious threat to riverine bird species, some of which are range-restricted and threatened (e.g., *C. carbonaria* and *Myrmotherula klagesi*; Appendix A; Vale *et al.* 2008; Bird *et al.* 2012). Studies to assess the population status and vulnerability of these riverine bird species are urgently needed. Besides the direct loss of habitat due to flooding above the dam (which would likely not affect VNP directly), hydroelectric dams affect the flood pulse of the river, which will affect the existence and formation of river-created habitats (Junk & Mello 1990), especially river islands (Remsen and Parker 1983). River islands, which shelter a unique avifauna (Rosenberg 1990), including 16 exclusive species in the study area, are outside the boundaries of VNP, and lack any legal protection. Because of their ephemeral nature, there is an urgent need to categorically protect river islands in Amazonia, independent of their geographic location (Cohn-Haft *et al.* 2007b).

Maintaining habitats in VNP for threatened and range-restricted birds is also important because these species attract bird watchers and ecotourists. VNP offers easy access to sandy-soil habitats (*campinas* and *campinaranas*) and to flooded forests, where most of these rare species can be readily found (Laranjeiras & Naka 2014). Moreover, a network of trails within the Park offers access to all of the diverse habitats found within the region, allowing the observation of a great variety of birds in a single day. If promoted properly, ecotourism could become a major force helping conservation and economic development in the region.

Finally, our results show that VNP and adjacent areas represent an important site to learn more about ecological and biogeographical processes in Amazonia. The presence of species from distinct biogeographical regions demonstrates that VNP lies in a significant contact zone for avian species (Naka *et al.* 2012). Distributions of other taxa should be explored, to determine whether the park's region plays a similar role for groups other than birds. The park also hosts multiple large-scale ecotones, as well as a variety of habitats that influence local diversity. The absence of several *terra-firme* forest species deserves further attention. Isolated populations of *várzea*

TABLE 4. Species from distinct biogeographical regions found at Viruá National Park and adjacent areas, listed by their habitat association.

***Terra-firme* (26 species): Guianan endemic species. *species that are restrict to the east side of rio Branco**		
Crax alector	*Veniliornis cassini*	*Xiphorhynchus pardalotus*
Penelope marail	*Epinecrophylla gutturalis**	*Campylorhamphus procurvoides**
Psophia crepitans	*Myrmotherula surinamensis**	*Lepidocolaptes albolineatus**
*Pyrilia caica**	*Myrmotherula guttata*	*Schiffornis olivacea**
*Notharchus macrorhynchos**	*Frederickena viridis*	*Perissocephalus tricolor*
Monasa atra	*Myrmelastes leucostigma**	*Todirostrum pictum*
*Capito niger**	*Percnostola subcristata**	*Zimmerius acer*
*Selenidera piperivora**	*Hypocnemis cantator**	*Cyanocorax cayanus*
Pteroglossus viridis	*Gymnopithys rufigula*	
***Campina* (7 species): Northwestern Amazonia typical species. *also found in scattered sites southeastward in Amazonia.**		
*Elaenia ruficeps**	*Myrmotherula cherriei*	*Hemitriccus inornatus**
Euphonia plumbea	*Heterocercus flavivertex*	*Dolospingus fringilloides**
Aprositornis disjuncta		
***Campina* (8 species): Species from northern South America, absent in most of Amazonia but present in northern Roraima open savannas**		
Colinus cristatus	*Mimus gilvus*	*Sporophila crassirostris*
Hydropsalis cayennensis	*Sporophila intermedia*	*Icterus nigrogularis*
Fluvicola pica	*Sporophila minuta*	
***Campina* (10 species): Species that are widely or disjunctly distibuted in South America (and absent in most of Amazonia)**		
Diopsittaca nobilis	*Tangara cayana*	*Sporophila plumbea*
Chordeiles pusillus	*Schistochlamys melanopis*	*Sporophila nigricolis*
Todirostrum cinereum	*Emberizoides herbicola*	*Geothlypis aequinoctialis*
Hemitriccus margaritaceiventer		
***Várzea* (7 species): Typical species of Amazonian seasonally flooded forest (*várzea* and *igapó*) and generally absent in northern Amazonia. * Species exclusively present in *igapó*.**		
Myrmotherula klagesi	*Myrmoborus lugubris*	*Inezia subflava**
Myrmotherula assimilis	*Dendroplex kienerii*	
Thamnophilus nigrocinereus	*Hemitriccus minor*	
***Várzea* (5 species): White-water river *várzea* specialists (absent in lower Rio Negro)**		
Mazaria propinqua	*Stigmatura napensis*	*Conirostrum bicolor*
Synallaxis gujanensis	*Serpophaga hypoleuca*	
***Várzea* (7 species): Species absent in most part of Amazonia but present in northern Roraima gallery forests**		
Picumnus spilogaster	*Turdus leucomelas*	*Arremonops conirostris*
Poecilotriccus sylvia	*Turdus nudigenis*	*Conirostrum speciosum*
Hylophilus pectoralis		
***Várzea* (9 species): Species predominantly restricted to western Amazonia, and absent east of Rio Branco. *Also found in southeastern Amazonia**		
Phaethornis hispidus	*Celeus grammicus**	*Cyanocorax violaceus*
Capito auratus	*Pyrilia barrabandi*	*Dacnis flaviventer**
Pteroglossus pluricinctus	*Pipra filicauda*	*Psarocolius bifasciatus**

specialists along the Rio Branco also deserve further study, as they may indicate the presence of either old relictual populations or recent long-distance dispersal (Naka *et al.* 2007). Future ornithological research that will help elucidate these questions include investigating patterns of bird occupancy and movement within habitats and between seasons, surveys in isolated and yet unexplored patches of *terra firme* forest, such as Serra do Preto, and systematic surveys along the *várzeas* of the Rio Branco. VNP has great scientific and conservation potential and we hope this detailed study of its avifauna will serve as a starting point to help develop that potential.

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APPENDIX A:

List of all bird species recorded in the Viruá National Park and adjacent areas, including habitats used, localities of records, migratory and endangered status, and documentation. Taxonomy and species nomenclature follow the Brazilian Ornithological Records Committee (CBRO 2014), except for the Caprimulgidae, the genus *Cercomacra*, the species *Mazaria* (*Synallaxis*) *propinqua*, and the genus *Tachyphonus* and *Eucometis*, where we follow, respectively, Sigurdsson & Cracraft (2014), Tello *et al.* (2014), Claramunt (2014), and Burns *et al.* (2014).

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Tinamidae							
Tinamus major	Tf, Vz, Ig	sv, al, ip, an, ri, ca, ba, va	C	NT		T.O.L.	WA 51601
Crypturellus cinereus	Tf, Vz	sv, ep, al, ip, ca, ba	C			T.O.L.	
Crypturellus soui	Cm, Vz, Ig	sv, ep, al, an, ri, ca, va	C			T.O.L.	
Crypturellus undulatus	Vz, Ig	al, ip, an, ca, va	C			WA 417150	
Crypturellus erythropus	Tf	sv	U				
Anatidae							
Dendrocygna viduata	Aq	al	R				
Dendrocygna autumnalis	Aq	al	R				
Neochen jubata	Aq	ip, an, out	U	NT, (DD)		XC 138968	WA 261937
Cairina moschata	Aq, At	ep, al, ip, an, ri, ca, ba	C				WA 618182
Anas discors	Aq, At	ep, out	R	NEA			WA 570953
Cracidae							
Penelope marail	Tf	sv, al, ba	U		MPEG 56256	XC 138892	WA 827866
Aburria cumanensis	Vz, Ig	ip, an, ba	U	VU			WA 8875
Ortalis motmot	Cm, Tf, Vz, Ig, Sv	all localities	C		MPEG 56257	ML (C.B.A.)	
Crax alector	Tf	sv	C	VU			WA 281360
Pauxi tomentosa	Cp, Cm, Tf, Vz, Ig	ep, al, ip, an, ri, ca, ba	C	NT		ML (C.B.A.)	WA 181578
Odontophoridae							
Colinus cristatus	Cp, At	ep, ca	C		INPA 1453		WA 181253
Odontophorus gujanensis	Tf	sv, ba	R	NT			
Podicipedidae							
Tachybaptus dominicus	Aq	va, out	R				
Ciconiidae							
Ciconia maguari	Cp, Aq, At	ep, al, ip, ri, ca	U	INT?			WA 252860
Jabiru mycteria	Cp, Aq, At	ep, ri, ca, ba	C	INT?			WA 72044
Mycteria americana	Cp, Aq, At	ep, al, ip	C	INT?			WA 825390
Phalacrocoracidae							
Phalacrocorax brasilianus	Aq	al	U				

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Anhingidae							
Anhinga anhinga	Aq	al, ip, an, ri, ca	C				WA 17675
Ardeidae							
Tigrisoma lineatum	Aq, At	sv, ep, an, ca, ba	C			T.O.L.	WA 252499
Agamia agami	Vz, Aq	ip, ba, out	R	VU	INPA A2254		WA 8845
Cochlearius cochlearius	Vz, Aq	al, an, ba	U		INPA A2223		
Zebrilus undulatus	Aq, Vz-is	al, out	R	NT	INPA 1536		
Nycticorax nycticorax	Aq	ep, sv	R			JPC	
Butorides striata	Vz, Ig, Aq, At	sv, ep, al, ip, an, ri, ca, ba	C		MPEG A8310		WA 197826
Bubulcus ibis	Sv, At	sv, al, va	U				
Ardea cocoi	Sv, Aq, At	ep, al, ip, an, ri, ca, ba, va	C				WA 252850
Ardea alba	Sv, Aq, At	ep, al, ip, an, ca, ba, va	C				
Pilherodius pileatus	Vz, Ig, Aq	sv, ep, al, ip, an, ri, ca, ba	C				WA 818983
Egretta thula	Aq	ep, al, ip, an, ri, ca, ba	C				
Egretta caerulea	Aq	al, an, ca	U				WA 19190
Threskiornithidae							
Mesembrinibis cayennensis	Cm, Vz, Ig, Aq, At	ep, al, an, ri, ca, ba	C				WA 219890
Platalea ajaja	Aq	al, ca	C				WA 8876
Cathartidae							
Cathartes aura	Cp, Cm, Sv, At	all localities	C				WA 815007
Cathartes burrovianus	Cp, At	ep, ca, ba	C				WA 1306894
Cathartes melambrotus	Tf	sv, al, ba, va	C				WA 813219
Coragyps atratus	Cp, Cm, Vz, Ig, Sv, At	all localities	C				WA 181365
Sarcoramphus papa	Tf	sv, ba	U				WA 34400
Pandionidae							
Pandion haliaetus	Vz, Ig, Aq	sv, al, ip, an, ri, ca, ba	C	NEA			WA 825371
Accipitridae							
Leptodon cayanensis	Cm	ep, out	R				WA 618194
Elanoides forficatus	Tf, Vz	sv, al, ba	U	INT?			WA 781925
Gampsonyx swainsonii	Cp, At	ep, ba, out	U			WA 62869	WA 866635
Harpagus bidentatus	Tf	sv	U			T.O.L.	WA 51625
Ictinia plumbea	Cm, Vz, Ig, Sv	ep, al, ip, an, ba, va	C	NEA			WA 181591
Busarellus nigricollis	Vz, Ig, Aq, At	ep, al, an, ba	C			ML (C.B.A.)	WA 252507
Rostrhamus sociabilis	Vz	al	R				
Geranospiza caerulescens	Vz, Ig	ep, al, ri, ca, ba	C				

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Buteogallus schistaceus	Vz	al, ip	U		INPA 1538		WA 6070
Heterospizias meridionalis	Cp, Cm, Aq, At	sv, ep, ca, ba	C				WA 21336
Urubitinga urubitinga	Cm, Tf, Vz, Ig	sv, ep, al, ip, an, ri, ca, ba	C				WA 178577
Rupornis magnirostris	All habitats	all localities	C		MPEG 56253	T.O.L.	WA 284083
Geranoaetus albicaudatus	Cp	ep, out	R		MPEG 56252		
Pseudastur albicollis	Tf	sv	R				PNV
Leucopternis melanops	Tf	sv, ba	U			WA 48648	
Buteo nitidus	Vz	al, ip, an, ba	C				WA 12421
Buteo platypterus	Tf	sv	R	NEA			WA 820557
Buteo brachyurus	Cp	ca	R				WA 410906
Morphnus guianensis	Tf	sv, al	R	NT, (VU)			WA 35751
Harpia harpyja	Tf	sv	R	NT, (VU)		ML (C.B.A.)	
Spizaetus tyrannus	Tf, Vz	sv, ep, al, ip, ba	U				
Spizaetus melanoleucus	Vz	ip	R				WA 261943
Spizaetus ornatus	Tf	sv	R	NT			
Eurypygidae							
Eurypyga helias	Cm, Vz, Ig, Aq	ep, al, ip, an, ri, ca, ba	C			T.O.L.	WA 872563
Aramidae							
Aramus guarauna	Aq, At	ep, al, an	C				WA 19191
Psophidae							
Psophia crepitans	Tf	sv, ba	C		MPEG 56259	ML (C.B.A.)	WA 202090
Rallidae							
Aramides cajaneus	Tf, Sv, Aq, At	sv, va	U			ML (C.B.A.)	WA 219856
Laterallus viridis	Aq, At	sv, ep	U			ML (C.B.A.)	
Laterallus exilis	Aq, At	ep, out	R				
Porzana albicollis	Aq, At	ep, al, ba	U			ML (L.N.N.)	
Porphyrio martinicus	Aq, Vz-is	al, out	R				
Porphyrio flavirostris	Aq	ep, out	R			M.C.H.	
Heliornithidae							
Heliornis fulica	Aq	al, ba	R		MPEG 56267		
Charadriidae							
Vanellus cayanus	Cp, Aq, At	ep, al, ip, an, ri, ca, ba	C				WA 816641
Vanellus chilensis	Cp, Aq, At	sv, ep, al, ca, va	C			WA 63056	
Charadrius collaris	Aq	al, ip, an, ca	C		INPA A2176	ML (C.B.A.)	WA 287883

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Scolopacidae							
Gallinago paraguaiae	Cp, Aq	ep, ri	R			ML (L.N.N.)	WA 828969
Gallinago undulata	Cp, Aq	ep, out	R			JPC	
Bartramia longicauda	Cp	ba, out	R	NEA			
Actitis macularius	Aq, At	ep, al, ip, ri, ca, ba	U	NEA	MPEG 56268		WA 15157
Tringa solitaria	Aq, At	ep, ri, ca, ba	C	NEA			WA 812251
Tringa melanoleuca	Aq, At	ep, al, ip, ri	U	NEA		ML (C.B.A.)	
Tringa flavipes	Aq, At	ip, ri	R	NEA			WA 281359
Calidris minutilla	Aq	al, ip, ri	R	NEA	INPA A2202		WA 15675
Calidris fuscicollis	Aq	al	R	NEA			
Calidris melanotos	Aq	al, ip	R	NEA	INPA A8312		WA 866340
Jacanidae							
Jacana jacana	Sv, Aq, At	sv, ep, al, ba,va	C				WA 195585
Sternidae							
Sternula superciliaris	Aq	ep, al, ip, an, ri, ca	C				WA 272934
Phaetusa simplex	Aq	ep, al, ip, an, ri, ca	C				WA 252542
Rynchopidae							
Rynchops niger	Aq	al, ip, an, ri, ca	C				WA 862787
Columbidae							
Columbina passerina	Cp, Cm, Vz, At	sv, ep, ca, ba	C		INPA A1022		WA 281416
Columbina minuta	Cp, Cm	ep, ba, out	R				
Columbina talpacoti	At	ba, out	C				
Claravis pretiosa	Vz	ba, out	R			ML (C.B.A.)	
Patagioenas speciosa	Cm, Vz, Ig, Sv	all localities	C			ML (C.B.A.)	WA 181582
Patagioenas cayennensis	All habitats	all localities	C			T.O.L.	WA 219857
Patagioenas plumbea	Tf, Vz	sv, ca, ba, va	C			ML (C.B.A.)	WA 410882
Patagioenas subvinacea	Cm, Tf, Vz, Ig	sv, al, an, ri, ca, ba, va	C	VU	MPEG A8295		WA 1255218
Leptotila verreauxi	Vz	al, ip, an, ba	C		MPEG 56266		
Leptotila rufaxilla	Cm, Tf, Vz, Ig, At	sv, al, ip, an, ri, ca, ba	C		INPA 1527	ML (C.B.A.)	
Geotrygon montana	Tf, Vz	sv, al, ip	C		INPA A2110		WA 45327
Opisthocomidae							
Opisthocomus hoazin	Vz	al, ca, ba	C		INPA A2080	WA 62971	WA 15158
Cuculidae							
Coccycua minuta	Tf, Vz	sv, al, an, ca, ba	U		MPEG 56285		

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Piaya cayana	Cp, Cm, Tf, Vz, Ig	all localities	C			ML (C.B.A.)	WA 195582
Piaya melanogaster	Tf	va, out	R				
Coccyzus melacoryphus	Ig	ri	R	AUS			WA 410881
Coccyzus americanus	Cm	ca	R	NEA			
Coccyzus euleri	Tf	sv	R	AUS?			WA 639970
Crotophaga major	Vz, Ig	sv, al, ip, ri, ca, ba	C				WA 326669
Crotophaga ani	Cp, Vz, Ig, Sv, At	sv, ep, al, ip, ca, ba, va	C			T.O.L.	
Tapera naevia	Cp, Vz	ep, al, ba	C			ML (C.B.A.)	WA 188425
Strigidae							
Megascops choliba	Cm, Vz, Ig	ep, al, ip, ri, ca	C		MPEG 56815		
Megascops watsonii	Tf	sv, ba, va	C			ML (C.B.A.)	WA 854716
Lophostrix cristata	Tf	sv	C				WA 351967
Pulsatrix perspicillata	Tf	sv, ba	U		MPEG 56282		
Bubo virginianus	Cm	ep, out	R		MZUSP 77931	WA 62750	WA 1024047
Strix sp. (*virgata*)	Tf, Vz	sv, ep, ip	U			T.O.L.	
Glaucidium hardyi	Tf	sv, ba	U				WA 1295126
Glaucidium brasilianum	Cm	ir	R				
Nyctibiidae							
Nyctibius grandis	Tf	sv, ba	U			T.O.L.	WA 1256913
Nyctibius griseus	Cm, Tf, Ig	sv, ep, ri, ca, ba	C			XC 139202	WA 281361
Carpimulgidae							
Antrostomus rufus	Cm, Tf, Vz	sv, ep, ca	U			T.O.L.	
Lurocalis semitorquata	Cm, Vz	ep, al, ip, ba	C				
Nyctiprogne leucopyga	Vz, Ig	al, ip, an, ri, ca, ba	C		INPA 1535	ML (C.B.A.)	WA 815037
Nyctidromus nigrescens	Tf	sv, ba	U			XC 138999	WA 180933
Nyctidromus albicollis	Tf, Aq, At	sv, ep, al, ip, an, ri, ca, ba	C		INPA 1455	ML (C.B.A.)	WA 181087
Hydropsalis maculicauda	Cp	ep, out	R	AUS?	INPA A1800	ML (C.B.A.)	
Hydropsalis cayennensis	Cp	ep, out	C		INPA 1454	WA 47137	WA 640068
Hydropsalis climacocerca	Vz	al, ip, an, ca, ba	C		INPA 1456	ML (C.B.A.)	WA 9745
Podager nacunda	Aq	ri	R	AUS?			PNV
Podager pusillus	Cp, Sv, At	sv, ep, ri, ca, va	C		INPA 1533	ML (C.B.A.)	WA 18050
Chordeiles acutipennis	Vz	al	R	NEA?	INPA 1531		
Apodidae							
Streptoprocne zonaris	Vz	al	R				
Chaetura spinicaudus	Tf, Ig	sv, ca, ba	C				WA 1295119
Chaetura cinereiventris	Ig	al, ri, ba	U				

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Chaetura brachyura	Tf, Vz, Ig, Sv	sv, ep, an, ri, ca, ba, va	C			ML (C.B.A.)	
Tachornis squamata	Ig	sv, ep, ri, ca, ba	C			T.O.L.	WA 862587
Panyptila cayennensis	Tf	sv	R				WA 1066541
Trochilidae							
Glaucis hirsutus	Vz	al, an, ba	U		INPA 1461		
Threnetes leucurus	Tf	sv	R			ML (C.B.A.)	
Phaethornis rupurumii	Cm, Tf, Vz	sv, al, ca, ba, va	C		INPA 1131	ML (C.B.A.)	WA 806659
Phaethornis ruber	Cm, Tf, Vz	sv, al, ip, ca, ba, va	C			ML (C.B.A.)	WA 282800
Phaethornis hispidus	Vz	al, ip	U				
Phaethornis bourcieri	Tf	sv, va	U				
Phaethornis superciliosus	Tf, Vz	sv, ba, va	U		INPA 1133	XC 138943	WA 849680
Campylopterus largipennis	Tf, Ig	ep, al, ri	R				
Florisuga mellivora	Cp, Ig, At	ep, ri, ca	U				WA 205169
Anthracothorax nigricollis	Vz, At	al, ba	R				WA 18139
Chrysolampis mosquitus	Cp, Vz, Ig	ep, al, ri, ca	C	INT?	INPA A2077		WA 814605
Chlorostilbon notatus	Cm, Vz, Ig	ep, al, ip, ri, ca	C		INPA A2083		M.F.T.
Chlorostilbon mellisugus	Cp, At	ep, ba, out	U				WA 813210
Thalurania furcata	Tf	sv, ba	U				WA 287337
Hylocharis sapphirina	Cm, Tf	sv, ri	U			ML (L.N.N.)	WA 862680
Hylocharis cyanus	Cm, Tf, Vz	sv, ep, ip, ba	C		INPA 1457	XC 138917	WA 15676
Polytmus theresiae	Cp, Ig	ep, ri, ca	C		INPA 1460	T.V.V.C.	WA 181096
Amazilia versicolor	Vz	al, ca	U		INPA A2134		WA 18140
Amazilia fimbriata	Cp, Cm, Tf, Vz, Ig	sv, ep, al, ri, ca, ba	C		INPA 1462	T.O.L.	WA 326725
Heliothryx auritus	Tf	sv, ba	U				WA 351968
Heliomaster longirostris	Tf	sv, ep, al	R				WA 856773
Calliphlox amethystina	Ig, At	ep, ba, out	R				WA 281362
Trogonidae							
Trogon melanurus	Tf, Vz	sv, va	U		INPA 1137	T.O.L.	WA 827852
Trogon viridis	Cm, Tf, Vz, Ig	all localities	C		INPA 1140	T.O.L.	WA 813899
Trogon violaceus	Cm, Tf	sv, an, ba	C			WA 50045	WA 51626
Trogon rufus	Tf	sv, al	R				
Alcedinidae							
Megaceryle torquata	Vz, Ig, Aq, At	sv, ep, al, ip, an, ri, ca, ba	C		MPEG A8307	T.O.L.	WA 872562
Chloroceryle amazona	Vz, Ig, Aq, At	sv, ep, al, ip, an, ri, ca, ba	C			ML (L.N.N.)	WA 177934
Chloroceryle aenea	Vz, Ig, Aq	ep, al, ip, ri, ca	C		INPA A1002	XC 138856	WA 262713
Chloroceryle americana	Vz, Ig, Aq, At	ep, al, an, ri, ca, ba	C		INPA 1466		WA 221242
Chloroceryle inda	Vz, Ig, Aq	ep, al, ip, ri, ba	U		INPA 1467		WA 219853

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Momotidae							
Momotus momota	Tf, Vz	sv, al, ip, ba, va	C			T.O.L.	WA 866361
Galbulidae							
Brachygalba lugubris	Vz	al, ca, ba	U		INPA A2244	ML (C.B.A.)	WA 8879
Galbula albirostris	Tf	sv	U		INPA 1145	T.O.L.	WA 818444
Galbula galbula	Cp, Cm, Vz, Ig, Sv	all localities	C		INPA 1471	ML (C.B.A.)	WA 6440
Galbula leucogastra	Cm, Tf, Ig	sv, ri, ca	C		INPA 1473	XC 138860	WA 410878
Galbula dea	Tf, Ig	sv, ri, ba, va	C				WA 505401
Jacamerops aureus	Tf	sv, ba	C		INPA 1142	XC 139195	WA 180495
Bucconidae							
Notharchus macrorhynchos	Tf, Vz, Ig	sv, al, ip	C			T.O.L.	WA 326670
Notharchus tectus	Tf, Vz	sv, al, ba	U			T.O.L.	WA 181581
Bucco tamatia	Cm, Tf, Vz, Ig	all localities	C		MPEG 56300	WA 63519	WA 44266
Bucco capensis	Tf, Vz	sv, al	U				WA 866551
Monasa atra	Cm, Tf, Vz, Ig	sv, al, ip, an, ca, ba, va	C		INPA A2108	XC 138895	WA 813265
Monasa nigrifrons	Vz	al	U				
Chelidoptera tenebrosa	Cp, Cm, Tf, Vz, Ig, At	sv, ep, al, ip, an, ri, ca, ba	C		MPEG 56303		WA 180999
Capitonidae							
Capito niger	Tf	sv	U		INPA 1477	T.O.L.	WA 862590
Capito auratus	Vz-is	an, out	U		INPA 1479	T.V.V.C.	
Ramphastidae							
Ramphastos toco	At	ep, out	R				
Ramphastos tucanus	Cm, Tf, Vz, Ig	sv, al, ip, an, ca, ba, va	C		MPEG 56306	WA 360170	WA 181366
Ramphastos vitellinus	Cm, Tf, Vz, Ig	sv, al, ip, an, ri, ca, ba, va	C			XC 138846	WA 262722
Selenidera piperivora	Tf	sv	C			WA 649302	WA 195584
Pteroglossus viridis	Tf, Vz, Ig	sv, al, ca, ba	C				WA 8966
Pteroglossus aracari	Cm, Tf, Vz, Ig	sv, al, ip, an, ca, ba, va	C		MPEG 56814		WA 50866
Pteroglossus pluricinctus	Vz-is	ip, out	R				
Picidae							
Picumnus exilis	Cp, Cm, Ig	sv, ep, al, ri, ca, ba	C		INPA 1482	ML (C.B.A.)	WA 854677
Picumnus spilogaster	Vz-is	al, out	R	VU	INPA 1481		WA 1295127
Melanerpes cruentatus	Tf, Vz	sv, al, ip, ba, va	C		MPEG 56312	T.O.L.	WA 866626
Veniliornis cassini	Tf, Vz	sv, al, ip, an, ba	C		INPA 1151	XC 139809	WA 505417
Veniliornis passerinus	Vz	al	R				
Piculus flavigula	Tf, Vz	sv, al, an, ba	C		MPEG 56310	T.O.L.	WA 273449

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Piculus capistratus	Tf	sv, va	U			ML (L.N.N.)	
Colaptes punctigula	Tf, Vz	sv, al, ba	U		MPEG 56827	ML (L.N.N.)	
Celeus grammicus	Tf, Vz	sv, al	U		MPEG 56309		
Celeus elegans	Cm, Tf, Vz	sv, ep, al, ip, ca, ba	C		INPA 1362	WA 62763	WA 180493
Celeus flavus	Cp, Cm, Tf, Vz, Ig	sv, ep, al, ip, ca, ba, va	C			XC 138839	WA 807515
Celeus torquatus	Tf, Vz	sv, al, ba, va	U		INPA 1147	T.O.L.	WA 814078
Dryocopus lineatus	Cp, Cm, Tf, Vz, Ig	sv, ep, al, an, ca, ba, va	C		MPEG 56315	ML (C.B.A.)	WA 866638
Campephilus rubricollis	Tf, Vz	sv, ip, ba	U		MPEG 56313	T.O.L.	WA 827193
Campephilus melanoleucos	Tf, Vz, Ig	sv, al, ip, an, ri, ca, ba	C			ML (C.B.A.)	WA 8874
Falconidae							
Daptrius ater	Vz	al, ca, ba	C			T.O.L.	WA 866606
Ibycter americanus	Cm, Vz	ep, al, ba	C				WA 858617
Caracara cheriway	At	ep, out	R				
Milvago chimachima	Cp, Cm, Vz, Ig, Sv, At	sv, ep, ri, ca, va	C		MPEG 56832	ML (C.B.A.)	WA 181925
Herpetotheres cachinnans	Cm, Vz, Sv	sv, ep, al, an, va	C			ML (C.B.A.)	WA 252858
Micrastur ruficollis	Tf	sv	R				
Micrastur gilvicollis	Tf	sv, ba	U				
Micrastur mirandollei	Tf, Vz	sv, ca, ba	U				
Micrastur semitorquatus	Tf, Vz, Ig	sv, al, ca, ba	C				
Falco sparverius	Sv, At	ep, va, out	R				
Falco rufigularis	Cm, Tf, Vz, Ig	sv, ep, al, ri, ca	C		MPEG 56254		
Psittacidae							
Ara ararauna	Cm, Tf, Vz, Ig, Sv	all localities	C			T.O.L.	WA 181593
Ara macao	Cm, Tf, Vz	sv, ep, an, ba	U				WA 177386
Ara chloropterus	Tf, Vz	sv, an, ba	C			ML (L.N.N.)	WA 252839
Ara severus	Vz	al, an	C			ML (C.B.A.)	WA 8846
Orthopsittaca manilatus	Cm, Tf	sv, ep	C			XC 139203	WA 816636
Diopsittaca nobilis	Cm, Ig	ep, ri, ca	C			ML (C.B.A.)	WA 1334808
Psittacara leucophthalmus	Cm, Vz, At	ep, ca	U			ML (L.N.N.)	
Eupsittula pertinax	Cp, Cm, Vz, Ig, Sv, At	sv, ep, al, an, ri, ca, ba, va	C		MPEG 56277	ML (C.B.A.)	WA 181278
Brotogeris chrysoptera	Cm, Tf, Vz	sv, an, ca, ba, va	C		INPA 1135	WA 48647	WA 287075
Touit huetii	Cm, Vz	sv, ba	C	VU		ML (C.B.A.)	WA 78853
Touit purpuratus	Cm, Tf	sv, ep	U		MPEG 56276		
Pionites melanocephalus	Tf, Vz	sv, ba, va	C		MPEG 56274	XC 139204	WA 8965
Pyrilia barrabandi	Vz	an, out	R	NT			
Pyrilia caica	Tf	sv, al	U	NT		XC 139205	
Pionus menstruus	Cm, Tf, Vz	sv, ep, al, an, ba, va	C		MPEG 56280	T.V.V.C.	WA 866581
Pionus fuscus	Cm, Tf, Vz	sv, al, ip, va	C				WA 862753

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Amazona festiva	Vz	al, ip, an, ca, ba	C	VU		XC 138940	WA 181590
Amazona farinosa	Tf	sv, ba	C			XC 139187	WA 181094
Amazona amazonica	Cm, Tf, Vz, Ig, Sv	all localities	C			ML (C.B.A.)	WA 181598
Amazona ochrocephala	Cm, Tf, Vz	sv, ep, al, ip, an, ca, ba, va	C		MPEG A8296	XC 138900	WA 283369
Deroptyus accipitrinus	Cm, Tf, Vz	sv, ca, ba, va	C		MPEG 56279	WA 50046	WA 325113
Thamnophilidae							
Pygiptila stellaris	Tf, Vz	sv, al, ip, an, ba	C		INPA 1376	XC 139264	WA 202576
Microrhopias quixensis	Tf, Vz	sv, al, ba	C		INPA A2104	XC 139197	WA 807882
Epinecrophylla gutturalis	Tf	ba, out	R				
Aprositornis disjuncta	Cp, Cm	ep, ca	C		INPA 780	WA 47135	WA 130462
Myrmophylax atrothorax	Tf	sv, ip, ba	C		INPA 1193	XC 139199	WA 180497
Myrmotherula brachyura	Cm, Tf, Vz	sv, al, ip, ca, ba	C		INPA 1405	XC 139806	WA 649879
Myrmotherula surinamensis	Vz, Ig	al, ca, ba	U	VU	INPA A2181	ML (C.B.A.)	WA 181283
Myrmotherula cherriei	Cp, Cm	sv, ep, ri, ba	C		INPA 1489	XC 138852	WA 351964
Myrmotherula klagesi	Vz	al, ip, an	C	NT, (VU)	INPA A2189	T.V.V.C.	WA 802504
Myrmotherula axillaris	Cm, Tf, Vz, Ig	sv, al, ip, ri, ca, ba, va	C		INPA 1191	WA 50042	WA 854693
Myrmotherula longipennis	Tf	sv	R				
Myrmotherula assimilis	Vz-is	ip, an, ba, out	U			ML (C.B.A.)	
Formicivora grisea	Cp, Ig	ep, ri, ca, ba	C		INPA 1491	WA 62864	WA 814481
Isleria guttata	Tf	ba, out	R		INPA A2240		
Thamnomanes caesius	Tf, Vz	sv, al, ba	C			WA 48660	WA 51649
Herpsilochmus dorsimaculatus	Cm, Tf, Vz, Ig	sv, al, ip, an, ri, ca, ba, va	C		INPA 1199	XC 138988	WA 51602
Herpsilochmus rufimarginatus	Cm, Tf, Vz, Ig	sv, ep, al, ip, an, ri, ca, ba	C		INPA A2149	ML (C.B.A.)	WA 7305
Sakesphorus canadensis	Cm, Vz, Ig	sv, ep, al, ip, an, ri, ca, ba	C		INPA 1484	XC 139207	WA 181002
Thamnophilus doliatus	Cm, Vz, Ig	sv, ep, al, ip, an, ri, ca, ba	C		INPA 1485	T.O.L.	WA 272920
Thamnophilus murinus	Tf, Vz	sv, ip, ba, va	C		INPA 1180	ML (C.B.A.)	WA 827245
Thamnophilus nigrocinereus	Vz-is	al, ip, an, out	U	NT	INPA 1487	ML (C.B.A.)	
Thamnophilus punctatus	Cm, Tf, Vz	sv, al, ip, ca, ba, va	C		INPA 1185	ML (C.B.A.)	WA 51664
Thamnophilus amazonicus	Tf, Vz, Ig	sv, al, ip, ri, ca, ba	C		INPA 1184	ML (C.B.A.)	WA 807541
Cymbilaimus lineatus	Tf, Vz	sv, an, ba	U				
Taraba major	Tf, Vz	sv, al, ba, va	C			ML (C.B.A.)	WA 18048
Frederickena viridis	Tf	sv	R			WA 829047	WA 829032
Myrmoderus ferrugineus	Tf	sv, ba	C		INPA A1054	WA 50041	WA 51648
Hypocnemoides melanopogon	Cm, Vz, Ig	ep, al, ip, an, ri, ca, ba	C		INPA 1495	WA 417140	WA 262712
Hylophylax naevius	Tf	sv	R				
Hylophylax punctulatus	Vz	al, ip, an, ba	U		INPA 1497	WA 62901	WA 8862
Sclateria naevia	Vz, Ig	ip, ca, ba	U		INPA A2235	XC 138941	WA 261944
Myrmelastes leucostigma	Tf	sv	U			ML (C.B.A.)	WA 45344
Myrmoborus leucophrys	Cm, Tf, Vz	sv, al, ip, an, ca, ba	C		INPA A2174	WA 48644	WA 50869

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Myrmoborus lugubris	Vz-is	ip, an, out	U	VU	INPA 1494	ML (C.B.A.)	WA 1248476
PercnosT.O.L.a subcristata	Cm, Tf, Vz, Ig	sv, al, ip, ri, ca, ba, va	C		INPA 1416	WA 48654	WA 813117
Cercomacra cinerascens	Tf	sv, al, ba	C		INPA A1731	XC 138894	
Cercomacra carbonaria	Vz-is	al, ip, an, out	C	CR	INPA 1505	XC 139258	WA 8861
Cercomacroides tyrannina	Tf	sv	C		INPA 1176	XC 139189	WA 854720
Cercomacroides laeta	Cm, Tf, Vz	sv, al, ip, ca, ba	C		INPA A1048	WA 48646	WA 51663
Cercomacroides nigrescens	Vz	al, ba	C		INPA A2076	WA 62805	WA 411490
Hypocnemis cantator	Cm, Tf, Vz	sv, al, ip, ba	C	NT	INPA 1197	XC 139803	WA 807533
Pithys albifrons	Tf	sv, al	U				
Willisornis poecilinotus	Tf	sv, ba	U		INPA 1189	WA 48656	WA 854805
Gymnopithys rufigula	Tf	sv, al, ip, ba	C		INPA 1434	XC 138904	WA 854012
Grallariidae							
Myrmothera campanisona	Tf	sv, al, ba, va	C		INPA 1194	WA 50428	WA 1258745
Formicariidae							
Formicarius colma	Tf, Vz	sv, al, ba	U		MPEG 56414	XC 139261	
Dendrocolaptidae							
Dendrocincla fuliginosa	Tf, Vz	sv, al, ip, ba	U		INPA 1425	ML (C.B.A.)	WA 854695
Dendrocincla merula	Tf	sv	U				
Deconychura longicauda	Tf	sv	R	NT			
Sittasomus griseicapillus	Tf, Vz	sv, al	R		INPA 1170		
Glyphorynchus spirurus	Tf, Vz, Ig	sv, al, ip, an, ba	C		INPA 1421	XC 139009	WA 813260
Xiphorhynchus pardalotus	Tf	sv, ba, va	C		INPA 1165	T.O.L.	WA 51604
Xiphorhynchus obsoletus	Cm, Tf, Vz, Ig	all localities	C		INPA 1545	XC 138982	WA 1261649
Xiphorhynchus guttatus	Cm, Tf, Vz, Ig	sv, al, ip, an, ca, ba, va	C		INPA 1367	XC 139213	WA 813258
Campylorhamphus trochilirostris	Vz	an, out	R				
Campylorhamphus procurvoides	Ig	ca	R				
Dendroplex picus	Cm, Vz, Ig	sv, ep, al, ip, an, ri, ba	C		INPA 1543	ML (C.B.A.)	WA 814936
Dendroplex kienerii	Vz, Ig	al, ip, an, ri, ca	C	NT	INPA 1544	T.V.V.C.	WA 7302
Lepidocolaptes albolineatus	Tf	sv, ip	R		INPA 1167	ML (L.N.N.)	
Nasica longirostris	Vz, Ig	al, ip, an, ri, ca, ba	C		INPA A2140	XC 139201	WA 281363
Dendrexetastes rufigula	Tf	sv, ba	R		INPA 1166	XC 139214	WA 282812
Dendrocolaptes certhia	Tf, Vz	sv, an, ba, va	C		INPA 1427	ML (C.B.A.)	WA 51624
Dendrocolaptes picumnus	Tf, Vz	sv, al, ip, an, ba	C		INPA A1751	ML (C.B.A.)	WA 351965
Xenopidae							
Xenops minutus	Tf	sv, ba	U		MPEG 56347	T.O.L.	WA 188427

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Furnariidae							
Furnarius leucopus	Vz	al, ip, an, ba	C		INPA 1508	ML (C.B.A.)	
Automolus rufipileatus	Vz	al	U		MPEG 56345	WA 417154	WA 411492
Automolus cervicalis	Tf	sv, al	R		MPEG ?		
Automolus ochrolaemus	Tf	sv, al	C		INPA 1370	XC 138891	WA 45338
Philydor pyrrhodes	Tf, Vz	sv, al, ip, an	U		UFPE 5081	T.O.L.	WA 781991
Certhiaxis cinnamomeus	Cp, At	ep, out	U				WA 205165
Mazaria propinqua	Vz-is	al, ip, out	C		INPA 1521	XC 138961	WA 866320
Synallaxis albescens	Cp	ep, ca	C		INPA 1522	WA 47145	WA 273450
Synallaxis rutilans	Tf, Vz	sv, ip, ba	U		INPA 1436	WA 48963	WA 50874
Synallaxis gujanensis	Vz-is	al, an, ba, out	C		INPA 1517	XC 139211	WA 181279
Cranioleuca vulpina	Vz, Ig	al, ip, an, ca, ba	C		INPA 1524	ML (C.B.A.)	WA 802131
Cranioleuca gutturata	Vz	al, ip, ca, ba	U		INPA A989	ML (C.B.A.)	
Pipridae							
Pipra filicauda	Vz	al, ip, ca, ba	C		INPA 1565	XC 138911	WA 990976
Ceratopipra erythrocephala	Cm, Tf, Vz	sv, al, ip, ca	C		MPEG 56459	ML (C.B.A.)	WA 205164
Manacus manacus	Tf	sv	U		MPEG 56451	T.O.L.	
Heterocercus flavivertex	Cm, Ig	ep, al, ri, ca, ba	U		INPA A1005	WA 417144	WA 410877
Dixiphia pipra	Tf, Vz	sv, al, ip, ca, ba, va	C		INPA 1206	WA 48658	WA 50873
Xenopipo atronitens	Cm	sv, ep, ri, ca	C		INPA 1566	WA 63408	WA 261946
Chiroxiphia pareola	Vz	ip, va, out	R				
Onychorhynchidae							
Onychorhynchus coronatus	Tf, Vz	al, ip, ba	U		INPA 1560		T.O.L.
Terenotriccus erythrurus	Tf, Vz	sv, al, ip, ba	U		INPA A2097	XC 138898	WA 631432
Myiobius barbatus	Cm, Vz, Ig	al, ca, ba	U		MPEG 56445		
Tityridae							
Schiffornis major	Vz, Ig	sv, al, ca, ba	C		MPEG 56467	XC 138914	WA 781926
Schiffornis olivacea	Tf	sv	U			T.O.L.	
Laniocera hypopyrra	Tf	sv	U			WA 649330	WA 862785
Tityra inquisitor	Tf, Vz, Ig	sv, an, ba	U				WA 1295152
Tityra cayana	Tf, Vz	sv, al, ba	C			T.O.L.	WA 826954
Pachyramphus rufus	Cp, Cm, Vz, At	sv, ep, al, ip, an, ba, va	C		INPA 1569	T.O.L.	WA 181000
Pachyramphus polychopterus	Vz, At	sv, al, an, ba	C			T.O.L.	
Pachyramphus marginatus	Tf, Vz	sv, ip	U		INPA 1203	T.O.L.	
Pachyramphus surinamus	Tf, Vz	sv, ip, an, ba, va	U			T.O.L.	
Pachyramphus minor	Tf	sv, va	U			XC 138896	WA 827661

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Cotingidae							
Lipaugus vociferans	Tf, Vz, Ig	sv, al, ip, ri, ba, va	C		MPEG 56468	T.O.L.	WA 195583
Gymnoderus foetidus	Vz	al, ip, ca	U				WA 351966
Xipholena punicea	Cm, Tf	sv, ri	U				
Procnias albus	Tf	sv, al, ba	U			ML (L.N.N.)	
Cotinga cayana	Tf, Ig	sv, ri, ba	R				WA 857482
Querula purpurata	Tf, Vz, Ig	sv, al, ip, an, ri, va	C		MPEG 56469	XC 139222	WA 352003
Perissocephalus tricolor	Tf, Vz	sv, ip	U				
Cephalopterus ornatus	Vz	al, ip, an, ba	U				
Pipritidae							
Piprites chloris	Tf	ba, out	R		INPA 1204		
Platyrinchidae							
Platyrinchus saturatus	Tf	sv	R				
Platyrinchus coronatus	Cm	ri	R				
Platyrinchus platyrhynchos	Tf	sv, ba	U			XC 139263	WA 202577
Rhynchocyclidae							
Mionectes oleagineus	Tf, Vz, Ig	sv, al, ip, ba, va	C		INPA 1547	XC 139221	WA 862784
Mionectes macconnelli	Vz	ca	R		INPA 1833		
Rhynchocyclus olivaceus	Ig	al, ba	R		MPEG 56803		WA 45329
Tolmomyias sulphurescens	Tf, Vz	sv, al, ip, ba	U				
Tolmomyias assimilis	Tf, Vz	sv, al, ip, ba, va	C		INPA 1213	XC 139212	WA 5086
Tolmomyias poliocephalus	Cm, Tf, Vz, Ig	all localities	C		MPEG 56436	ML (C.B.A.)	WA 854718
Tolmomyias flaviventris	Cm, Vz, Ig	ep, al, an, ri, ca, ba, va	U		INPA 1614	ML (C.B.A.)	WA 262705
Todirostrum maculatum	Vz, Ig	ep, al, ip, an, ca, ba	C		INPA A2132	ML (C.B.A.)	WA 181579
Todirostrum cinereum	Cp, Cm	ep, out	C			ML (C.B.A.)	WA 1334742
Todirostrum pictum	Tf	sv	U			XC 138906	WA 820397
Poecilotriccus sylvia	Cm, Vz, Ig	ca, ba	U		INPA A2248	ML (C.B.A.)	
Myiornis ecaudatus	Tf, Vz	sv, al, ip, ba	C			WA 48659	WA 862728
Hemitriccus minor	Vz	al, ip, an	U			XC 138978	
Hemitriccus zosterops	Tf	sv	U			XC 138955	WA 67902
Hemitriccus margaritaceiventer	Cp	ep, ca	C		INPA 1548	WA 62877	WA 16471
Hemitriccus inornatus	Cp, Cm	ep, ri, ba	U		INPA A999	XC 139191	
Lophotriccus galeatus	Tf, Vz	sv, al, ip, ca	C		INPA 1210	XC 139231	WA 181261
Tyrannidae							
Zimmerius acer	Cm, Tf, Vz, Ig	sv, al, ip, an, ca, ba, va	C		INPA 1215	WA 417148	WA 814250
Stigmatura napensis	Vz-is	al, ip, out	C	(VU)	INPA 1559	T.O.L.	WA 781796

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Inezia subflava	Cp, Ig	ep, ri	U		INPA A1876	XC 138893	WA 857469
Ornithion inerme	Tf	sv, al, ba	C		MPEG 56429	WA 360177	WA 325112
Camptostoma obsoletum	Vz, Ig	ep, al, ip, an, ca, ba	C			T.O.L.	WA 273469
Elaenia flavogaster	Cp	ep	C		INPA 1550	WA 62845	
Elaenia parvirostris	Cp	ri	R	AUS			
Elaenia cristata	Cp	ep, ca	C		INPA 1554		WA 272938
Elaenia chiriquensis	Cp	ri, ca	U		INPA A993		
Elaenia ruficeps	Cp	ep, ri, ca	C		INPA 1557	WA 649317	WA 181255
Myiopagis gaimardii	Cm, Tf, Vz, Ig	sv, al, ip, an, ca, ba, va	C			T.O.L.	WA 411491
Myiopagis caniceps	Tf	sv, al	U			ML (C.B.A.)	
Myiopagis flavivertex	Vz, Ig	al, ip, an, ca, ba	C		INPA 1549	XC 139807	WA 8964
Tyrannulus elatus	Cp, Cm, Tf, Vz, Ig	all localities	C			XC 139808	WA 253388
Capsiempis flaveola	Vz, Ig	sv, ep, al, ip, an, ba	C		INPA 1558	XC 138942	WA 281415
Phaeomyias murina	Sv	va, out	R				
Serpophaga hypoleuca	Vz-is	ip, out	R		INPA A8302		WA 781721
Attila cinnamomeus	Vz, Ig	al, an, ri, ca, ba	C		INPA A1004	XC 139224	WA 197829
Attila spadiceus	Cm, Tf, Vz	sv, al, ip, an, ba	C		MPEG 56450	XC 138837	WA 261945
Legatus leucophaius	Cm, Vz, Ig	sv, ep, an, ri, ca, ba	C			T.O.L.	WA 1271477
Ramphotrigon ruficauda	Tf, Vz, Ig	sv, al, ip, ba	C		MPEG 56435	WA 50050	WA 51628
Myiarchus tuberculifer	Cm, Tf, Vz, Ig	sv, ip, ri, ca, ba, va	C		INPA 1564	T.O.L.	WA 119848
Myiarchus swainsoni	Cp	ep, out	R	AUS	INPA A1854		WA 19189
Myiarchus ferox	Vz, Ig	al, ip, an, ba	C		INPA 1563	T.O.L.	
Myiarchus tyrannulus	Cp	ri	R				
Sirystes sibilator	Tf	sv, al	R				
Rhytipterna simplex	Tf, Vz, Ig	sv, al, ip, an, ri, ca, ba	C			WA 50049	WA 51627
Rhytipterna immunda	Cm, Ig	ri, ba	U		INPA A997	XC 138919	WA 44261
Pitangus sulphuratus	All habitats	all localities	C		INPA 1561	ML (C.B.A.)	T.O.L.
Philohydor lictor	Vz, Ig, Aq, At	sv, ep, al, ip, an, ri, ba	C			XC 139247	WA 800187
Myiodynastes maculatus	Vz	sv, al, ip, ba	C	AUS?		ML (C.B.A.)	
Tyrannopsis sulphurea	Cm, Tf	sv, ep, ri	C		INPA 1562	ML (C.B.A.)	WA 282803
Megarynchus pitangua	Cm, Vz, Ig	sv, ep, al, ip, an, ri, ca	C			ML (C.B.A.)	
Myiozetetes cayanensis	Cm, Vz, Ig, Aq, At	sv, ep, al, ip, an, ri, ba	C			T.V.V.C.	WA 814680
Tyrannus albogularis	Cp	ep, out	R	AUS			
Tyrannus melancholicus	Cp, Cm, Vz, Ig, Sv, At	sv, ep, al, ip, ri, ca, ba, va	C	AUS		T.O.L.	WA 814648
Tyrannus savana	Cp, Vz, Ig, Aq, At	ep, al, ri	C	AUS			
Empidonomus varius	Cm, Sv	sv, ba, va	U	AUS			
Conopias trivirgatus	Vz	ip, ba, out	U				
Conopias parvus	Cm, Tf, Vz, Ig	sv, al, ip, ri, ca, ba, va	C		INPA A1000	ML (C.B.A.)	WA 854717
Pyrocephalus rubinus	Cp, At	ep, out	R	INT?			

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Fluvicola pica	Cp	ep, out	R				
Arundinicola leucocephala	Cp, Vz, Ig, Aq, At	ep, al, ca	C				WA 272919
Ochthornis littoralis	Vz, Ig	al, ca	C		INPA A8301	WA 417151	WA 816664
Cnemotriccus fuscatus	Vz	al, ip, an	C		INPA A2173	ML (C.B.A.)	WA 802551
Lathrotriccus euleri	Cm, Tf, Vz	sv, al, ip, ca, ba	U		MPEG 56442	ML (C.B.A.)	
Contopus virens	Vz	al	R	NEA			
Knipolegus poecilocercus	Ig	ri, ba	R				WA 272929
Vireonidae							
Cyclarhis gujanensis	Cp, Cm, Tf, Vz, Ig	sv, ep, al, ip, an, ri, ca, ba	C		INPA 1570	ML (C.B.A.)	WA 197791
Vireo olivaceus	Tf	sv	U	AUS	MPEG 56831		
Hylophilus thoracicus	Tf, Vz	sv, al, ip, ba	C		INPA 1220	ML (C.B.A.)	WA 857498
Hylophilus semicinereus	Vz, Ig	al, an, ri, ca, ba	C		INPA A994	XC 139194	WA 219840
Hylophilus pectoralis	Vz	al	R				
Hylophilus muscicapinus	Cm, Tf	sv, al, ba, va	C		INPA 1221	ML (C.B.A.)	WA 835793
Hylophilus ochraceiceps	Tf	ba, out	R				
Corvidae							
Cyanocorax violaceus	Vz	al, ip	U			ML (C.B.A.)	
Cyanocorax cayanus	Cm	sv, ri, ba, va	C			WA 376414	WA 34375
Hirundinidae							
Pygochelidon melanoleuca	Aq	va, out	R				
Atticora fasciata	Aq	al, ip, ca, ba	C				WA 9742
Stelgidopteryx ruficollis	Aq	sv, al, ri, ca	C		MPEG A8305		
Progne tapera	Aq	ep, al, ip, an, ri, ca	C	AUS		ML (L.N.N.)	WA 411488
Progne subis	Aq	ip, out	R	NEA			
Progne chalybea	Aq	sv, ep, al, ca, ba	C				WA 221243
Tachycineta albiventer	Aq	ep, al, ip, an, ri, ca, ba	C		MPEG 56476		WA 821689
Riparia riparia	Aq	va, out	R	NEA			
Hirundo rustica	Cp, Aq	ep, al, ri, ca, ba	U	NEA	INPA A2093		
Troglodytidae							
Troglodytes musculus	Vz, Ig, At	sv, ep, al, ri, ca, ba	C		MPEG 56813		
Pheugopedius coraya	Tf	sv, al, ca, ba, va	C		INPA 1223	ML (C.B.A.)	WA 50875
Cantorchilus leucotis	Vz, Ig	ep, al, ip, an, ca, ba	C		INPA 1571	ML (C.B.A.)	
Donacobiidae							
Donacobius atricapilla	Aq, At	ep, out	R				

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Polioptilidae							
Microbates collaris	Tf	sv	R				
Ramphocaenus melanurus	Tf, Vz	sv, al, ip, ba	C			XC 139804	WA 282813
Polioptila plumbea	Cp, Cm, Ig	ep, ri, ca, ba	C			WA 62996	WA 1270334
Turdidae							
Catharus fuscescens	Tf	sv, ba	R	NEA	INPA A2229	ML (C.B.A.)	WA 639696
Turdus leucomelas	Cm, Ig, Sv	ep, ri, va	C		INPA A1839	WA 63051	T.O.L.
Turdus fumigatus	Tf, Vz, Ig	sv, al, ca, ba	C		INPA 1575	WA 649315	T.O.L.
Turdus nudigenis	Vz	al	R		INPA 1574	ML (C.B.A.)	
Turdus ignobilis	Cp	ep, va, out	R				
Turdus albicollis	Tf	sv	C			ML (C.B.A.)	
Mimidae							
Mimus gilvus	Cp, Cm	ep, ca	C		INPA 1576	WA 62940	WA 15678
Passerilidae							
Zonotrichia capensis	Sv	va, out	R				
Ammodramus humeralis	Cp, Sv, At	ep, va, out	R			ML (C.B.A.)	
Ammodramus aurifrons	Vz, Ig	al, ip, ca	C		INPA A1017		
Arremonops conirostris	Vz-is	al, ip, an, ba, out	U		INPA 1603	WA 174982	WA 174924
Arremon taciturnus	Tf	sv, al, ba	C		INPA 1605	XC 139006	WA 1334775
Parulidae							
Parkesia noveboracensis	Vz, Ig	al	R	NEA	INPA A2111	ML (L.N.N.)	T.O.L.
Setophaga ruticilla	Cm, Tf	sv, ba	R	NEA			
Setophaga petechia	Vz-is	al, out	U	NEA	INPA A2155	ML (L.N.N.)	
Setophaga striata	Tf, Vz	sv, al, va	U	NEA	INPA 1611		WA 294633
Setophaga fusca	Tf	sv	R	NEA		ML (C.B.A.)	
Geothlypis aequinoctialis	Cm, At	ep, out	R				WA 866293
Icteridae							
Psarocolius viridis	Tf	sv	R				
Psarocolius decumanus	Tf, Vz	sv, al, ip, an, ba	C			T.O.L.	WA 9746
Psarocolius bifasciatus	Tf, Vz, Ig	sv, al, ip, ri, ca, ba	C			WA 417149	WA 325115
Procacicus solitarius	Vz	al, ba	R				
Cacicus haemorrhous	Tf	sv	C		MPEG 56508	XC 138897	T.O.L.
Cacicus cela	Cm, Tf, Vz, Ig, At	all localities	C		MPEG 56509	WA 417139	WA 410879
Icterus cayanensis	Cm	sv, ep, ba	U				WA 1063116
Icterus chrysocephalus	Cm, Tf, At	sv, ep, ri, ba	C			ML (C.B.A.)	WA 181254

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Icterus nigrogularis	Cp, Cm	ep, out	R		INPA 1612	WA 47138	
Molothrus oryzivorus	Cp, Vz, Ig, At	ep, al, ri, ca, ba	U				WA 866273
Molothrus bonariensis	Vz, At	ep, al, ip, an, ca, va	C		INPA 1613	ML (C.B.A.)	T.O.L.
Sturnella militaris	Cp, At	ep, out	R				WA 281858
Mitrospingidae							
Lamprospiza melanoleuca	Vz	va, out	R			ML (L.N.N.)	
Thraupidae							
Coereba flaveola	Cp, Cm, Vz, Ig, Sv, At	sv, ep, al, an, ri, ca, ba, va	C		INPA 1577	ML (C.B.A.)	T.O.L.
Saltator maximus	Vz	al, ip, ba, va	C			ML (C.B.A.)	
Saltator azarae	Cm, Vz	sv, ep, al, ip, an, ba	C		INPA 1608	WA 63003	WA 15677
Saltator grossus	Tf	sv	R		INPA 1231	WA 648555	WA 639973
Nemosia pileata	Vz	al, ip, an	C		MPEG 56846	ML (L.N.N.)	
Tachyphonus phoenicius	Cm	ep, ri, ca	C		INPA 1585	ML (C.B.A.)	T.O.L.
Ramphocelus carbo	Cp, Cm, Vz, Ig, Sv, At	sv, ep, al, ip, an, ca, ba, va	C		INPA 1587	ML (C.B.A.)	WA 817268
Tachyphonus luctuosus	Tf, Vz	sv, al, an, ba	C				WA 222262
Tachyphonus cristatus	Tf, Vz	sv, al, ip, ba	C			ML (L.N.N.)	WA 866596
Tachyphonus surinamus	Tf	sv, ba	U		INPA 1228	ML (C.B.A.)	
Lanio penicillatus	Vz, Ig	al, ip, an, ba	C		INPA 1582	XC 138956	WA 261936
Tangara mexicana	Tf, Vz	sv, ip	U		MPEG 56485	WA 50713	WA 181262
Tangara velia	Tf	sv	U				
Tangara varia	Tf	al, ba	R				
Tangara punctata	Tf	sv	R				
Tangara episcopus	Cm, Tf, Vz, Ig, At	sv, ep, al, ip, an, ri, ca, ba	C				
Tangara palmarum	Cp, Tf, Vz, Ig, Sv, At	sv, ep, al, ip, ca, ba, va	C		INPA 1589	ML (C.B.A.)	WA 51652
Tangara cayana	Cp, Cm, At	ep, ca	C		INPA 1591	T.O.L.	WA 273468
Schistochlamys melanopis	Cp, Cm	ep, ri, ca	C		INPA 1579	XC 139208	WA 326649
Paroaria gularis	Vz, Ig	al, ip, an, ri, ca, ba, va	C		INPA 1607	XC 139256	WA 273448
Dacnis flaviventer	Ig	ba, out	R			WA 417146	
Dacnis cayana	Cm, Tf, Vz, Ig, At	sv, ep, al, ip, ri, ba	C		MPEG 56483	XC 139805	WA 181927
Cyanerpes nitidus	Tf	sv	R				
Cyanerpes caeruleus	Cm, Tf	sv, al, ba	U			ML (C.B.A.)	WA 15673
Cyanerpes cyaneus	Tf	ba, out	R				
Chlorophanes spiza	Tf	sv, ba	U		INPA 1374	WA 50040	
Hemithraupis guira	Vz	al	R				
Conirostrum speciosum	Vz	al	R		MPEG 56812		
Conirostrum bicolor	Vz	al, ip, an	C	NT	INPA 1593		WA 901527
Emberizoides herbicola	Cp, At	ep, ca	C		INPA 1606	WA 62849	WA 272935
Volatinia jacarina	Cp, Vz, Sv, At	sv, ep, al, ba	C		INPA 1594		T.O.L.

Family / Species	Habitat[1]	Locality[2]	Abu.[3]	Status[4]	Specimen[5]	Voice[6]	Photo[7]
Sporophila intermedia	Cp, Vz, At	ep, al, ip, an, ca, va	C		INPA 1512	ML (L.N.N.)	WA 181252
Sporophila plumbea	Cp, At	ep, ca	C		INPA 1514	XC 139210	WA 846967
Sporophila bouvronides	Vz, At	ba, out	R	INT?			
Sporophila lineola	Vz	al	R	AUS		ML (L.N.N.)	
Sporophila nigricollis	Cp, At	ep, ba, out	R				WA 861786
Sporophila minuta	Cp, At	ep, an, ba, out	U		INPA 1596		WA 205166
Sporophila castaneiventris	Vz-is	al, out	R		INPA A2216		
Sporophila angolensis	Cp, Vz, Ig, Sv, Aq, At	ep, al, ca, ba	C		INPA A1860	XC 139209	WA 281859
Sporophila crassirostris	Cp	ep, ba, out	U		INPA 1599	WA 376425	T.O.L.
Dolospingus fringilloides	Cp	ep, ca	U		INPA 1601	WA 649318	WA 21329
Cardinalidae							
Granatellus pelzelni	Tf, Vz	sv, al, ba	U		INPA A2154	ML (C.B.A.)	
Cyanoloxia rothschildii	Tf	sv, ba	C		INPA A2237	XC 139223	WA 51646
Fringillidae							
Euphonia plumbea	Cm	ep, ri, ca	U			WA 649322	WA 806599
Euphonia chlorotica	Cm, Vz	ep, al	R				
Euphonia violacea	Tf, Vz	sv, al, ca	C			XC 139215	WA 18041
Euphonia chrysopasta	Tf	sv, al	U			T.O.L.	WA 50868
Euphonia minuta	Tf	al	R			ML (C.B.A.)	
Euphonia sp. *(cayennensis)*	Tf	sv	R				

[1]Habitats: Cp – *campina*; Cm – *campinarana*; Tf – *terra-firme* forest; Vz – *várzea* (Vz-is – exclusively on Rio Branco islands); Ig – *igapó*; Sv – savanna; Aq – aquatic environment; At – human-altered areas.
[2]Localities: sv – Serra do Viruá; ep – Estrada Perdida; al – Igarapé do Aliança; ip – Ilha do Palhal; an – Boca do Anauá; ri – Rio Iruá; ca – Campinho do Rio Anauá; ba – Trilha do Baruana; va – Vila de Vista Alegre; out – exclusively in areas that are outside the current park boundaries.
[3]Abundance: C – common; U – uncommon; R – rare.
[4]Status: NT – Near Threatened at global level; VU – Vulnerable at global level; CR – Critically Endangered at global level; (VU) – Vulnerable at national level; (DD) – Data Deficient at national level; NEA – neartic migrants; AUS – austral migrants; INT – migrants from other regions; "?" uncertainty on the migratory behavior.
[5]Specimen: Catalogue number from Instituto Nacional de Pesquisas da Amazônia (INPA), Museu Paraense Emílio Goeldi (MPEG), Unversidade Federal do Pernambuco (UFPE), or Museu de Zoologia da Universidade de São Paulo (MZUSP).
[6]Voice: Catalogue number from xeno-canto (XC) or wikiaves (WA); ML with authors initials refers to records obtained by the specified author in cataloguing process at Macaulay Library. Only authors initials refers to those of recordists of species with undeposited vouchers; JPC – undeposited vouchers obtained by Juan Pablo Culasso.
[7]Photo: Catalogue number from wikiaves (WA). Only authors initials refers to those of recordists of species with undeposited vouchers; PNV – photographs obtained by other visitors and available at Viruá National Park archive.

APPENDIX B:

Bird species predicted to occur in Viruá National Park, including habitat, presence in the state of Roraima and status elsewhere. It includes species known from nearby areas, based on Naka *et al.* 2006, Borges *et al.* 2011 and unpublished data.

Species	Habitat[1]	Roraima	Status[2]
Crypturellus variegatus	Tf	X	C / W
Amazonetta brasiliensis	Aq	X	C / W
Botaurus pinnatus	Sv, Aq	X	C / W
Ixobrychus exilis	Aq	X	U / W
Ixobrychus involucris	Aq	X	U / W
Cercibis oxycerca	Sv, Aq	X	R / Lr
Theristicus caudatus	Sv, Aq	X	C / W
Chondrohierax uncinatus	Tf	X	U / W
Helicolestes hamatus	Ig		C / W
Amaurolimnas concolor	Aq		U / Lr
Pluvialis dominica	Aq	X	C / M
Zenaida auriculata	Sv, At	X	C / W
Tyto furcata	At	X	C / W
Dromococcyx pavoninus	Tf	X	U / W
Nyctibius aethereus	Tf	X	R / W
Nyctibius leucopterus	Tf		U / W / Pk
Nyctibius bracteatus	Vz, Ig		R / W / Lo / Pk
Chordeiles minor	Vz, Sv	X	U / M
Chordeiles rupestris	Aq	X	U / W
Topaza pella	Tf	X	U / W
Polytmus guainumbi	Sv	X	C / Lr
Amazilia brevirostris	any	X	C / Lr
Nonnula rubecula	Tf	X	U / W / E
Celeus undatus	Tf	X	C / Lr
Falco deriolеucus	Tf	X	U / W / Lo
Falco femoralis	Sv	X	C / W
Falco peregrinus	Vz, Tf	X	C / M
Pyrrhura picta	Tf	X	C / Lr
Terenura spodioptila	Tf	X	U / W
Myrmornis torquata	Tf	X	U / W
Myrmeciza longipes	Tf	X	C / Lr
Myrmotherula menetriesii	Tf	X	C / W
Thamnomanes ardesiacus	Tf	X	C / W
Conopophaga aurita	Tf	X	C / W
Grallaria varia	Tf		C / W
Hylopezus macularius	Tf	X	C / W
Formicarius analis	Tf	X	C / W
Sclerurus mexicanus	Tf	X	U / W
Sclerurus rufigularis	Tf	X	C / W
Sclerurus caudacutus	Tf	X	C / W
Xiphocolaptes promeropirhynchus	Tf, Vz	X	U / W
Hylexetastes perroti	Tf	X	U / Lr
Microxenops milleri	Tf		U / Lr
Clibanornis obscurus	Tf	X	U / W
Anabacerthia ruficaudata	Vz	X	C / W
Neopelma chrysocephalum	Cp	X	C / Lr
Tyranneutes virescens	Tf	X	C / Lr
Corapipo gutturalis	Tf	X	C / Lr
Iodopleura fusca	Tf	X	R / Lr / Pk
Cotinga cotinga	Tf	X	R / W
Haematoderus militaris	Tf		R / W
Neopipo cinammomea	Tf, Cm		R / W / Pk
Leptopogon amaurocephalus	Vz	X	C / Lr
Lophotriccus vitiosus	Tf		C / Lr
Hemitriccus josephinae	Tf		R / Lr / Lo / Pk
Corythopis torquatus	Tf	X	C / W
Attila citriniventris	Tf, Cm		U / W / Lo
Empidonomus aurantioatrocristatus	Tf	X	C / W
Vireolanius leucotis	Tf	X	C / W
Hylophilus brunneiceps	Cp, Ig	X	C / Lr
Atticora tibialis	Tf	X	R / W
Henicorhina leucosticta	Tf	X	C / Lr
Microcerculus bambla	Tf	X	U / W
Cyphorhinus arada	Tf	X	R / W
Myiothlypis mesoleuca	Tf	X	C / Lr
Polioptila guianensis	Tf	X	C / Lr / E
Tangara gyrola	Tf	X	C / W
Tangara chilensis	Tf	X	C / W
Cyanicterus cyanicterus	Tf, Cm		R / Lr
Dacnis lineata	Tf	X	C / W
Hemithraupis flavicolis	Tf	X	C / W
Sporophila schistacea	Vz, Sv	X	U / Lr
Sporophila americana	Vz, Sv	X	U / Lr
Caryothraustes canadensis	Tf	X	C / W
Peripophyrus erythromelas	Tf		R / Lr / Pk
Lampropsar tanagrinus	Vz	X	C / W

[1]Habitats: cp – *campina*; cm – *campinarana*; tf – *terra-firme* forest; vz – *várzea*; ig – *igapó*; sv – savanna; aq – aquatic environment; at – human altered areas
[2]Status elsewhere: C – common; U – uncommon; R – rare; W – widespread; Lr – limited range in Amazonia; M – migratory; Lo – local occurrence; Pk – poorly known; E – easily overlooked

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SHORT-COMMUNICATION

The Andean Swallow (*Orochelidon andecola*) in Argentina

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ABSTRACT: During ornithological studies in the provinces of Jujuy, Salta, and San Juan, we recorded the Andean Swallow *Orochelidon andecola* at 40 localities. These are the first records in Argentina, and also represent the southernmost for the species. Some of these localities are up to 1500 m lower than the previously known elevational limit (now 800 masl), and up to 1100 km southwards. This is a relatively poorly known swallow, and we present novel natural history data. We found evidence of breeding in five localities. We obtained photographs and tape recordings, and provide details of a specimen.

KEY-WORDS: altitudinal distribution, geographical distribution, *Orochelidon andecola*, natural history, seasonal movements.

The Andean Swallow *Orochelidon andecola* is locally common from Ancash, Perú, to Potosí and Tarija in Bolivia and Tarapacá in Chile. The elevational range extends between 2500-4600 masl, with the lowest elevation records coming from the Austral winter (Ridgely & Tudor 1989, Fjeldså & Krabbe 1990). Turner & Rose (1989) report it as occasional below 2500 masl and Hennessey et al. (2003) report it down do 2300 masl.

Some authors have speculated on its presence in Argentina (Turner & Rose 1989, Fjeldså & Krabbe 1990), but so far, there is no formally published evidence of its presence in the country. During our ornithological studies in the provinces of Jujuy, Salta, and San Juan we recorded the species in numerous localities, confirming pre-existing speculations. In this contribution we describe these records, extending the latitudinal and longitudinal distribution of the Andean Swallow considerably, and provide data on behavior, habitat use, and breeding of the species in Argentina.

Materials and Methods

Data reported in this study were gathered opportunistically during general surveys in northwestern Argentina by all the authors. We report information obtained up to September 2008 (some records were briefly described in Mazar Barnett and Pearman [2001]), including data on a specimen which was collected and deposited at the Museo Argentino de Ciencias Naturales, Buenos Aires (MACN). Sound recordings were made with a Sony TCM-5000 EV tape recorder and a Sennheiser ME-66 shotgun microphone and are deposited in the Macaulay Library of Natural Sounds, Cornell Lab of Ornithology, New York, and in the Colección Nacional de Sonidos Naturales, MACN, Buenos Aires. Coordinates for each locality were obtained with a GPS, through topographical charts, or from Google Earth.

Geographic distribution

We obtained 68 records of Andean Swallows in 40 localities (Table 1). The group observed on 27 September 1997 at Quebrada Sacha Runa (Table 1, record 2) was tape recorded. An adult of unknown sex was collected in this site (specimen number MACN54897), with the following measurements: wing chord: 107.3 mm, bill (tip to base of skull): 10.8 mm, bill (tip to anterior border of nares): 4.8 mm, tarsus: 12.0 mm, and tail: 51 mm. Other documented records include one bird photographed at Río Peñas Negras (Table 1, records 4-6) and several tape-recorded at Santa Ana (Table 1, record 25).

Behavioral notes

The species was generally recorded in small groups of 2-10 individuals, although we also recorded single birds and groups of 40-100 individuals rarely (records 1, 23, 26, and 41). At Valle Colorado we observed approximately 100 individuals at dusk on 16 August 1996, flying 1–4 m above the Valle Colorado River. Here, groups of up to 25 individuals were observed during the day moving over a short section of river back and forth while capturing insects. Every once in a while, they gathered together, flew upwards, and circled while vocalizing, resuming their feeding behavior over the river afterwards. The same pattern was observed the next day, although the large flock now flew 100-200 m above the river.

The vocalizations we heard and recorded were soft warbles, somewhat trilled or of harsh quality: *crruí trr-rluí?* or *t'rluíp tzrruíp?*

On numerous occasions, Andean Swallows were observed together with blue-and-white swallow *Pygochelidon cyanoleuca*, once with a group of Andean swift *Aeronautes andecolus*, and once with barn swallows *Hirundo rustica*. We could always distinguish Andean swallows from blue-and-white swallows by the lack of dark undertail coverts, squarer and less-forked tail, dark throat patch extending into the upper chest, and less vivid blue dorsal coloration in Andean Swallows.

Breeding

We obtained breeding data at five localities (Table 1). Three pairs were thought to be breeding at Molulo in December 1995 (Table 1, record 35). A group at Quebrada Sacha Runa on 27 September 1997 (Table 1, record 2) flew over a territory roughly 500-m long, either close to the water or near the ground on the eastern side of its border. The individuals flew around a hole in the bank, with one of them perching on it once. Given the time of the year, we suspect that the swallows were investigating this hole to breed. We could not confirm if the tunnel was excavated by the swallows or not. The tunnel was located at the base of the cliff, approximately 2 m up, in an area where it became more vertical, just below a rock, where the substrate was more humid and softer. The entrance was sparsely covered by dense moss and lichen which grew on the ground. The shape and placement of the nest agreed with that described by Johnson (1967) and with our previous experience of nesting Andean Swallows in northern Chile. On 16 December 2006 at least five pairs were nesting in low-lying banks at Cochinoca (Table 1, record 24), on 4 August 2007 some adults were feeding fledglings at Morro del Alisar (Table 1, record 40), and on 4 February 2008 some groups contained both adults and juveniles at Abra Honda (Table 1, record 16).

Habitat

The dominant vegetation in areas where we recorded Andean Swallows was low montane scrub, generally open, sometimes dry and degraded. In general, *Baccharis* sp. shrubs were abundant in areas with varying humidity and cover. We also recorded Andean Swallows in small patches of *Polylepis* sp. (scarce in the region due to habitat disturbance by overgrazing and logging), and grasslands of varying humidity depending on local conditions (once in *Cortaderia selloana*), above the treeline ('ceja de bosque'). A few records in foothill and montane Yungas forests are notable. Among the dry areas, we found the swallows in areas within the Puna Plateau, with dry, low, and sparse vegetation, on slopes and rocky slopes with short grass (with some shrubs and *Baccharis* sp. shrubland in areas with higher humidity), and other typical Puna habitats. The southernmost records also deserve special mention, as they occurred in the Monte desert (Cabrera 1971), with creosote *Larrea* sp., *C. selloana*, and *Juncus balticus* along a creek (Table 1, records 66-68).

Most of our records of Andean Swallows came from humid river gullies on the east slopes of the sub-Andean ranges or in humid gullies in other ranges, reaching a total of 26 (65%) localities at the treeline, above the montane Yungas forest (Table 1, Figure 1). However, the species was also found in 14 (35%) localities in the dry Puna or Altiplano between 2550 and 4000 masl (Table 1, Figure 1). This pattern is remarkable, given that the literature only mentions dry Puna habitats for this species (Turner & Rose 1989, Ridgely & Tudor 1989, Fjeldså & Krabbe 1990). This distinction is clearly evident in the shading shown in the map by Fjeldså & Krabbe (1990: 534), which in southern Bolivia includes only the Altiplano. Nevertheless, S. Mayer (pers. comm.) recorded Andean

Swallows in Bolivia in habitats similar to those in which we recorded them in Argentina.

The literature gives a lower altitudinal limit of 2500 masl for Andean Swallows (Turner & Rose 1989, Fjeldså y Krabbe 1990; but down to 2300 m asl in Hennessey et al. 2003). Several of our records represent range extensions of its altitude, with the lowest record at 800 masl (Table 1, record 37). We also extend the southern distribution limit of the species by more than 1100 km (Figure 1). Based on the large number of records presented here, we suggest that the species is fairly uniformly distributed in north-west Argentina, being locally frequent to common. We predict that the species will be found in the provinces of Catamarca, La Rioja, Tucumán, and Mendoza, which intervene the northernmost and southernmost records in Argentina and which have suitable habitats for this swallow.

Seasonality and migration

Records in Argentina spanned all the seasons and occurred over ten months (there were no records for May and June; perhaps due to lack of sampling). We consider the Andean Swallow to be a resident species in Argentina, although it may conceivably make local movements, especially elevationally, depending on climatic fluctuations. Some evidence suggests the existence of at least local movements. At the Cuesta del Obispo, Salta, a locality regularly visited by observers, the species was recorded during only certain visits. The lowest-elevation record at 800 masl in PN Calilegua (Table 1, record 37) came from mid-winter, and occurred during some particularly cold days, which may indicate that some individuals respond to short-term climatic fluctuations. The Andean swallow, and three other swallows recorded at PN El Leoncito, San Juan, were absent during winter in this locality. It is possible that latitudinal movements may explain this pattern, at least in the southernmost populations of the species. Nevertheless, it is difficult to judge the movements of Andean swallows in Argentina, given that our winter records span 800 to approximately 4000 masl.

Final thoughts

Although the species is considered as locally common, it is generally observed in small groups (Ridgely & Tudor 1989, Fjeldså & Krabbe 1990). Hence, the finding of groups of some 40-45 individuals at Laguna Los Enamorados and Cieneguillas, and of over 100 individuals in Valle Colorado and Río Yala, Jujuy, suggest regular formation of flocks before and after the breeding season. A large concentration of several thousands was reported at Laguna Tacahua, Perú (J. Fjeldså in Turner & Rose 1989).

The population in Argentina seemingly belongs to the nominate subspecies based on its geographic proximity. The name golondrina puneña was coined in the past for the species (Mazar Barnett & Pearman 2001), however, we feel that the variety of habitats it uses makes this name inaccurate. We thus suggest the common Spanish name golondrina andina, which better reflects its broader habitats and agrees with its scientific and English names.

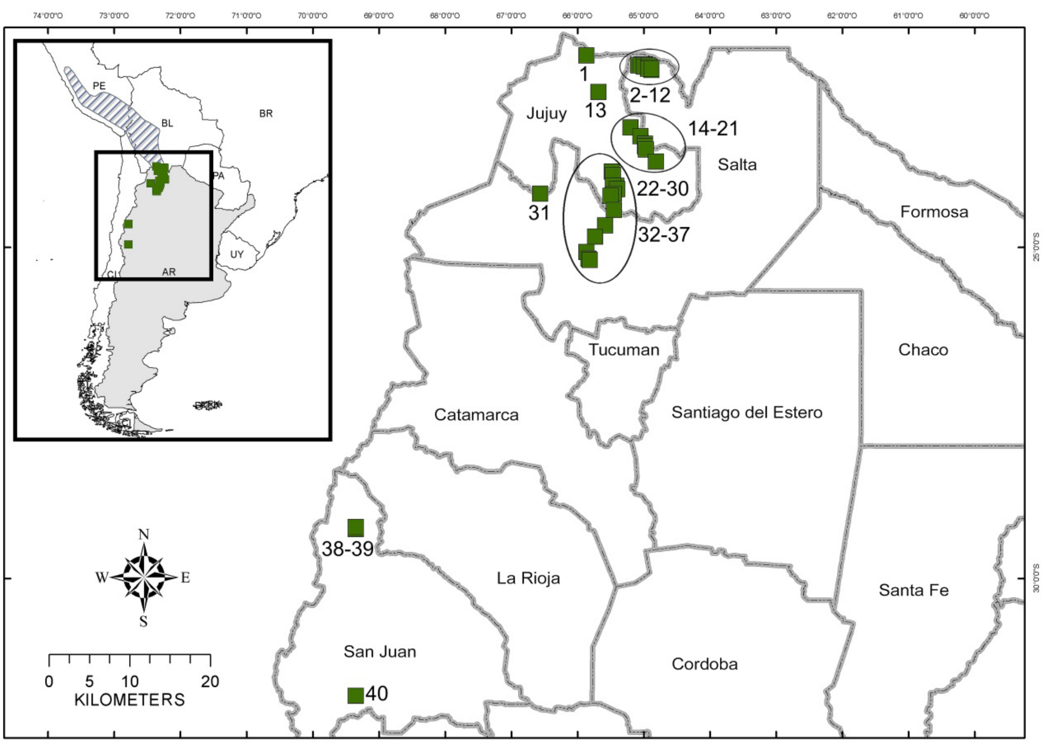

FIGURE 1. Distribution of Andean swallow *Orochelidon andecola* in Argentina. Localities are numbered consecutively from north to south (see Table 1 for details).

TABLE 1. Details of 68 records of Andean swallow *Orochelidon andecola* reported in this work, ordered by increasing latitude. Map number refers to numbers in Figure 1. Numbers of each record are the same as those cited in the text. Habitat column indicates D for dry habitats and H for humid habitats. When D or H is in parentheses it indicates intermediate habitat humidity, but closer to the letter being displayed.

Map	Record	Locality	Geographic coordinates	Elevation (masl)	Date	Number of individuals	Comments	Habitat	Observer
1	1	Cieneguillas, Jujuy	22°06'S, 65°52'W	3680	4 Jul 2007	40-45	Flying over sparse, dry, short shrubs on the outskirts of town.	D	JIA
2	2,3	Quebrada Sacha Runa, Salta	22°14'S, 65°02'W	2900	27 Sep 1997; 1 Dec 2003	5; 5	Over an open *Polylepis* sp. woodland, *Baccharis* sp. shrubland, and ground densely covered by herbaceous vegetation, mosses, lichens, and ferns. The group observed in 1997 kept a territory and visited a nest on a slope; voices recorded and one individual collected (see text).	H	JMB, GP and M. della Seta; JMB
3	4–6	Río Peñas Negras, Salta	22°15'S, 65°05'W	3400	6 Aug 1998; 15 Mar 2001; 29 Oct 2001	6	Over humid grasslands and shrublands above treeline. One individual photographed.	H	MP and R. Johnson; MP; MP
4	7–10	Río Trancas, Salta	22°15'S, 65°03'W	3150; 3350	6 Aug 1998; 13 Aug 2003; 2 Dec 2003 (x2)	4; 6; 5; 2	Last record of two birds at 3350 masl. Similar habitat to previous record.	H	MP and R. Johnson; MP; JMB; JMB
5	11–12	Between Rodeo Pampa and Sta. Victoria, Salta	22°15'S, 65°03'W–22°15'S, 64°58'W	3050–2400	4–6 Aug 2003	2–6	Groups above river gullies, mostly on montane shrubland with few *Polylepis* sp.	H	IR
6	13–15	W of Santa Victoria, Salta	22°15'S, 65°00'W	2650	26 Sep 1997 (x2); 1 Dec 2003	4; 5; 2	Flying over a small shrubby quebrada with a small patch of open *Polylepis* woodland; another group in the higher parts of an abrupt cliff over the Santa Victoria river.	H	JMB, GDP and M. della Seta (x2); JMB
7	16	Abra Honda, Santa Victoria Oeste, Salta	22º15'S 64º56'W	2725	4 Feb 2008	4-13	Flying over a group of houses. Groups with adults and juveniles.	H	FBG
8	17	Between Santa Victoria and Acoite, Salta	*c.* 22°16'S, 65°00'W	2400–2550	7 Aug 1998	15	Disperse individuals.	D	MP and R. Johnson
9	18	Above Piscuno, Salta	22°16'S, 64°55'W	3300	5 Dec 2003	1	Over dry and rocky slopes with short grass.	D	JMB

Map	Record	Locality	Geographic coordinates	Elevation (masl)	Date	Number of individuals	Comments	Habitat	Observer
10	19	El Chorro, Salta	22°18'S, 64°56'W	3200	3 Dec 2003	1	Shallow quebrada with high-Andean vegetation, *Baccharis* sp., and shrubs.	D	JMB
11	20-21	Quebrada del arroyo Cañaní, Salta	22°18'S, 64°54'W; 22°19'S, 64°53'W	2900; 2700	3 Dec 2003; 5 Dec 2003	3	Deep and humid quebrada with humid grasslands in humid patches of *Baccharis* sp. and *Polylepis* sp.	H	JMB
12	22	Tipajo, Santa Victoria Oeste, Salta	22º18'S 64º53'W	2939	7 Feb 2008	3	Above Arroyo Tipajo.	H	FBG
13	23	Laguna Los Enamorados, Abra Pampa, Jujuy	22º43'S, 65º42'W	3470	6 Oct 2003	40-45	In flight over a dry area with few sparse shrubs.	D	JIA
14	24	Santa Ana, Cochinoca, Jujuy	23º11'S 65º12'W	4079	16 Dec 2006	10+	At least 5 pairs nesting on a natural wall c. 3 m high, with holes 2 m above the ground.	D	IR
15	25	Santa Ana, Valle Grande, Jujuy	23°19'S, 65°03'W	3500	20 Aug 1996	8	Over a dry creek; rocky area covered by grasses. Tape-recorded.	D	JMB
16	26-27	Caspalá, Jujuy	23°21'S, 65°5'W	3070	Jan 1996	3; 16		D	HP
17	28–32	Valle Colorado, Jujuy	23°26'S, 64°59'W	1800–1900	16–18 Aug 1996; 21 Jul 2000	10; 25; 20-40 +100 (x2)	From 2 km S of the town, in the town, and on slopes above it. Montane scrub somewhat dry and degraded. In 2000 > 100 individuals, perhaps the same as in 1996.	H	JMB, AB, and G. Bodrati (x3); IR and DM
18	33	Valle Grande, Jujuy	23°28'S, 64°59'W	1650	20 Jul 2000	5	Over disturbed montane forest.	H	IR
19	34	Between Alto Calilegua and Valle Grande, Jujuy	23°31'S, 64°58'W	*c.* 1800	19 Jul 2000	2	On the valley of a creek with dense montane scrub and open montane forest.	H	IR
20	35-36	Molulo, Jujuy	23°34'S, 65° 9'W	3000	Dec 1995	6; 12	Group of six, consisted of three pairs apparently nesting.	H	HP
21	37	Aguas Negras, PN Calilegua, Jujuy	23°42'S, 64°49'W	*c.* 800	6 Aug 2003	2	In flight over a steep wall on a river with pedemontane forest in the Yungas foothills.	H	AB and K. Cockle

Map	Record	Locality	Geographic coordinates	Elevation (masl)	Date	Number of individuals	Comments	Habitat	Observer
22	38	1 km N of Tumbaya, Jujuy	23°51'S, 65°29'W	2150	18 Nov 1997	1	Over humid Prepuna scrubland.	(D)	D. J. Stejskal and J. Rowlett
23	39	Abra de Manantiales,Volcán, Jujuy	23°54'S 65°28'W	2295	19 Mar 2006	24+	Humid scrub, flying over water courses.	H	FBG
24	40	Morro del Alisar, Lozano, Jujuy	24°04'S 65°27'W	1789	4 Aug 2007	18+,6+,15+	Adults feeding young birds, flying over the river.	H	FBG
25	41	Río Lozano, Jujuy	24°04'S, 65°25'W	1550	18 Aug 1993	20	Where the river crosses the Ruta Nacional 9, on somewhat degraded montane forest.	(H)	RC and D. Holman
26	42	La Ollada, Lozano, Jujuy	24°04'S 65°25'W	1976	6 Aug 2007	7,4+	Quebradas de Sevenguillar.	H	FBG
27	43	Salto Alto, Quebrada de Lozano, Jujuy	24°04'S 65°28'W	3320	2 Aug 2008	2-5	On the waterfall.	H	FBG
28	44-45	Río Yala, Jujuy	24°07'S, 65°24'W	1500	12 nov 1995; 26 Mar 2003	20; *c*. 100	First group over the river; second group above the cerros in the quebrada de Yala.	H	RC and D. Finch; RC and M. Mosqueira
29	46	Guerrero, Jujuy	24°11'S, 65°27'W	1550	12 and14 Jul 2003	20	Disturbed transitional scrub around the town.	(H)	GDP, L. Segura and H. Rodríguez Goñi
30	47	Loma del Antigal, Guerrero, Jujuy	24°13'S 65°30'W	2342	31 Jan 2008	6+	Montane prairie.	H	FBG
31	48	Vega del Tocomar, W of Abra de Chorrillos, Salta	24°11'S, 66°34'W	3500	18 Feb 1996	1	Flying over a bog (vega) grazed by lamas (*Lama guanicoe*).	D	RC
32	49	Cerro Alto Campanario, San Antonio, Jujuy	24°26'S 65°27'W	2375	10 Apr 2003	3-7	Flying over the "peña."	H	FBG
33	50	Quebrada Cuesta Grande, Salta	24°40'S 65°35'W	2120	19 Sep 2008	3	Flying over a river slope.	H	FBG

Map	Record	Locality	Geographic coordinates	Elevation (masl)	Date	Number of individuals	Comments	Habitat	Observer
34	51	Cerro Bola, Rosario de Lerma, Salta	24º50'S 65º44'W	2050	18 Sep 2008	1	Prepuna scrub with abundant cacti.	H	FBG
35	52,53	Cerro Malcante, PN Los Cardones, Salta	25°04'S, 65°52'W	*c*. 4000 3500	16 Sep 1994 11 Nov 2003	3,8	Open Puna with rocky ground and sparse dry vegetation.	D	RC, HC
36	54,55	RP 33, Salta, Peña El Caracol, Cuesta del Obispo, Salta	25º10'S 65º50'W	2700 2900	12 Aug 2000 13 Aug 2003	4,2	Near San Martin, on a humid quebrada with *Cortaderia selloana*.	H	MP; AB, and K. Cockle
37	56-62	Cuesta del Obispo	25°11'S, 65°49'W;	2700 2500	24 Apr 2002(x2) 11 Dec 2006, Jan 2007-Jan 2008	10 (x2); 4 10	Flying over slopes with degraded humid montane shrubland and grassland. Generally in pairs or small groups. Together with blue-and-white swallows (*Pygochelidon cyanoleuca*).	H	JMB, GDP, HC, and L. Cuenca (x2); IR and EJ
38	63-64	Paraje Agua del Godo, PN San Guillermo, San Juan	29°15'S, 69°21'W;	3200	2 Apr 1999 (x2);	2; 1 (x2)	Above the arroyo San Guillermo in Puna habitat.	D	AB
39	65	3 km N of PN San Guillermo, San Juan	29°13'S, 69°21'W	3200	3 Apr 1999	2,1	Puna habitat.	D	AB
40	66-68	Arroyo Leoncito, arroyo del Medio, and arroyo de Adentro, PN El Leoncito, San Juan	31°46'S, 69°21'W	2550; 3200	13, 17 and 19 Jan 1999	2; 1; 2	Southernmost records. The first locality was a narrow humid quebrada in the "nacientes" of the creek, with abundant *Larrea* sp., *C. selloana*, and *Juncus balticus*. The last locality is the highest one.	D	AB (x2); AB and E. Mérida

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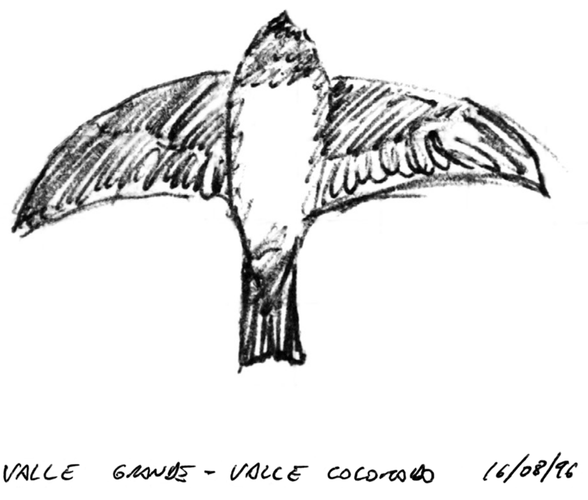

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ARTICLE

Status and distribution of the doraditos (Tyrannidae: *Pseudocolopteryx*) in Paraguay, including a new country record

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ABSTRACT: The doraditos (*Pseudocolopteryx* spp.) are a little-known group of small, yellow-breasted tyrants, distributed mainly in southern South America. All five species occur in Paraguay, including *Pseudocolopteryx citreola*, here documented in the country for the first time. The distribution and habitat preferences of the species in Paraguay are clarified, and well-documented records for the three rarest species *P. acutipennis, citreola*, and *dinelliana* are listed in full. Owing to the difficulty in distinguishing between the species, a field key is provided to assist observers in making correct field identifications.

KEY-WORDS: *Pseudocolopteryx acutipennis*, *Pseudocolopteryx citreola, Pseudocolopteryx dinelliana, Pseudocolopteryx flaviventris*, *Pseudocolopteryx sclateri*, migrant.

INTRODUCTION

The doraditos, genus *Pseudocolopteryx* Lillo 1905, are a group of small tyrants (Tyrannidae) with their center of distribution in the southern cone of South America (Traylor & Fitzpatrick 1982). Though the populations of most species are migratory or undergo local movements, some are resident and others display complex patterns of seasonal movements that differ throughout their range (Fitzpatrick 2004). The doraditos are typically associated with marshes, seasonally inundated natural grasslands, and scrub habitats close to water, but they may also be encountered in a wider variety of drier scrub and grassland habitats and even crop fields (Stotz *et al.* 1996; Fitzpatrick 2004; Roesler 2009).

Five species of doradito are currently recognized (Remsen *et al.* 2013): Subtropical *Pseudocolopteryx acutipennis* (Sclater & Salvin, 1873); Dinelli's *P. dinelliana* (Lillo, 1905); Warbling *P. flaviventris* (Lafresnaye & D´Orbigny, 1837); Crested *P. sclateri* (Oustalet, 1892); and the recently revalidated Ticking *P. citreola* (Landbeck, 1864). They are characterized by their skulking behavior, generic yellow underparts, and greenish or brownish upperparts (Ridgely & Tudor 2009). Observations are often frustratingly brief and species-level identification represents a challenge that is exacerbated by plumage wear and poorly known juvenile plumages.

All doraditos give rather quiet, scratchy calls, but only in the last decade has the importance of these vocalizations for identification become apparent, and vocal analyses were an important factor in the recent revalidation of the cryptic *P. citreola* (Abalos & Areta 2009). Further study of patterns of vocalizations may shed more light on species limits in this complex, with *P. acutipennis* in particular perhaps representing several cryptic species (Bostwick 2004).

Paraguay, with its location in the center of South America, is particularly interesting for the study of migrants, yet it remains one of the most underwatched countries on the continent. Given the paucity of observers, it is no surprise that the secretive doraditos have managed to elude many visitors, and as late as 1940 Laubmann reported only the two most widespread species, *P. sclateri* and *P. flaviventris*, as present in the country (Laubmann 1940). In order to coordinate observer effort and update published distributional data, here we critically review the status and distribution of the genus in the country, confirm the presence of *P. citreola* in Paraguay and provide a basic field key to the species to assist inexperienced observers in making an accurate identification.

METHODS

Records of doraditos in Paraguay were compiled from the published literature, museum specimens, on-line databases (e.g. Worldbirds www.worldbirds.org, eBird www.ebird.org), the Guyra Paraguay Biodiversity Database (www.guyra.org.py), the authors' own field observations and through consultations with ornithologists and birdwatchers. All records with information regarding plumage or vocalizations were reviewed based on current knowledge of key identification features (see field key) and distribution (the latter based on confirmed identifications). Noteworthy distributional records lacking identification details were treated as hypothetical.

RESULTS AND DISCUSSION

Subtropical Doradito *Pseudocolopteryx acutipennis*

Rarely recorded in Paraguay, its distribution is restricted to the Humid Chaco and correlates approximately with the watershed of the Paraguay River. Currently the species is known from just 10 records in 6 localities in Paraguay (Figures 1 and 3).

Short (1972) described the habitat of the species as "brushland and shrubbery in the xeric chaco," and "dry subtropical forest," but all Paraguayan records correspond to marshes and bushy wetlands in Humid Chaco or Pantanal-type habitats, consistent with the habitat preference of

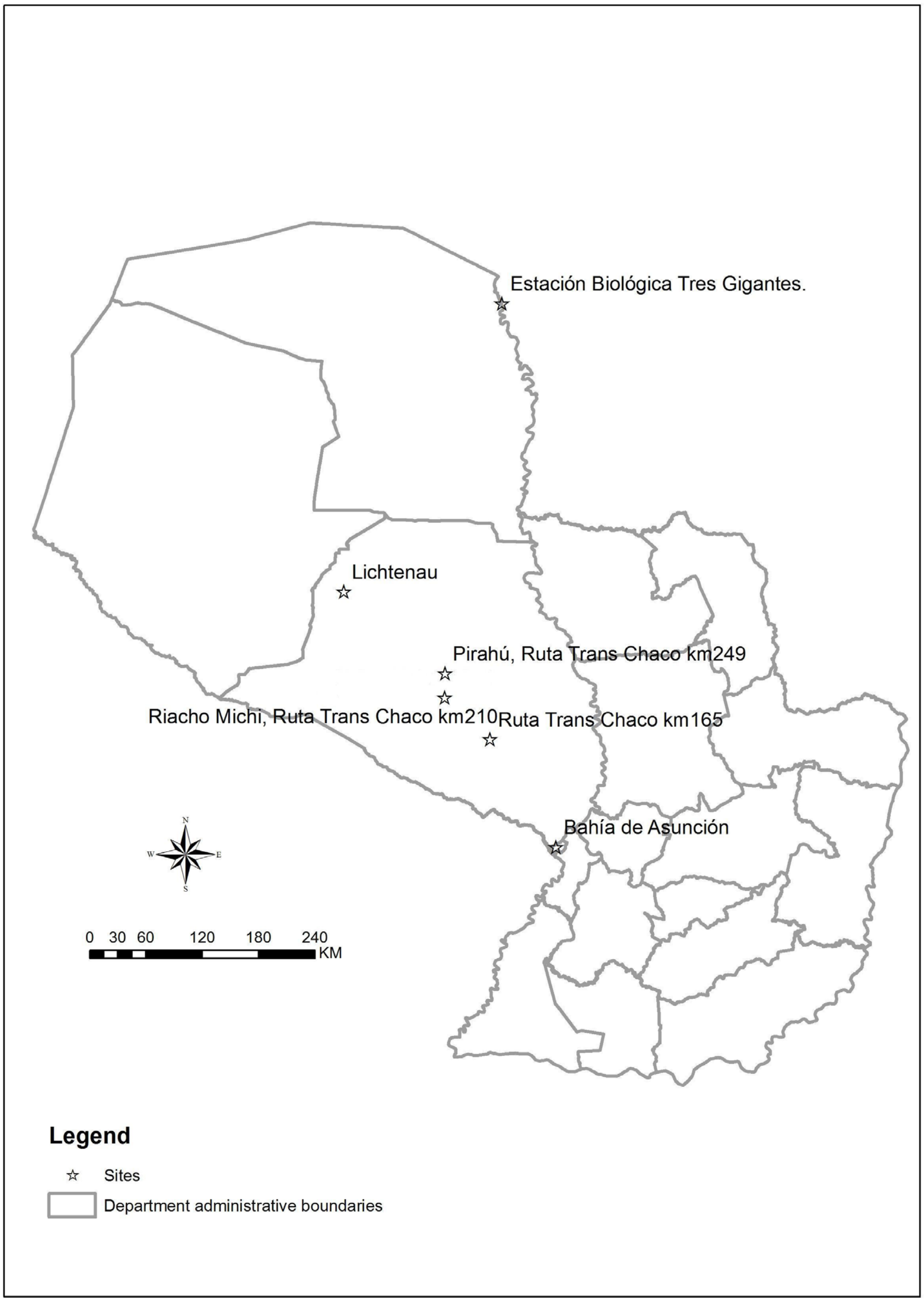

FIGURE 1. Map of localities with Subtropical Doradito *Pseudocolopteryx acutipennis* records in Paraguay.

presumed migrants (Jensen *et al.* 2009). Although Roesler (2009) notes that the species is not closely tied to water during the breeding season in the central Argentine Pampas, the speculation that the species "may breed in the western fringes of the Paraguayan...Chaco" (Short 1972), the most arid part of the Chaco, was presumably based only on this being the part of Paraguay closest to the species' known range at the time (in the Andes). Guyra Paraguay (2004, 2005) list it as a possible resident/breeder in Paraguay based on record phenology, but no breeding activity has ever been reported. Given the possibility that more than one species may be involved in what is currently called *P. acutipennis* (Bostwick 2004), caution is perhaps advisable when interpreting the limited data.

Ticking Doradito *Pseudocolopteryx citreola*

On 5 September 2010 at an extensive Humid Chaco wetland at Km 165 on the Ruta Trans-Chaco (see Figure 1), Departamento Presidente Hayes (24º15'S, 58º16'W), an unfamiliar doradito song was heard from dense marshy vegetation by PS. It had the strange buzzy timbre of *P. dinelliana* but the phrases were different and lacked the high notes characteristic of that species. The bird did not respond to playback of *P. dinelliana*, so playback of the call of other doraditos was attempted. Upon playback of a recording of *P. citreola* a bird resembling a *P. flaviventris* emerged from cover. From this point on the bird did not sing, instead giving only occasional and quiet *tic* calls.

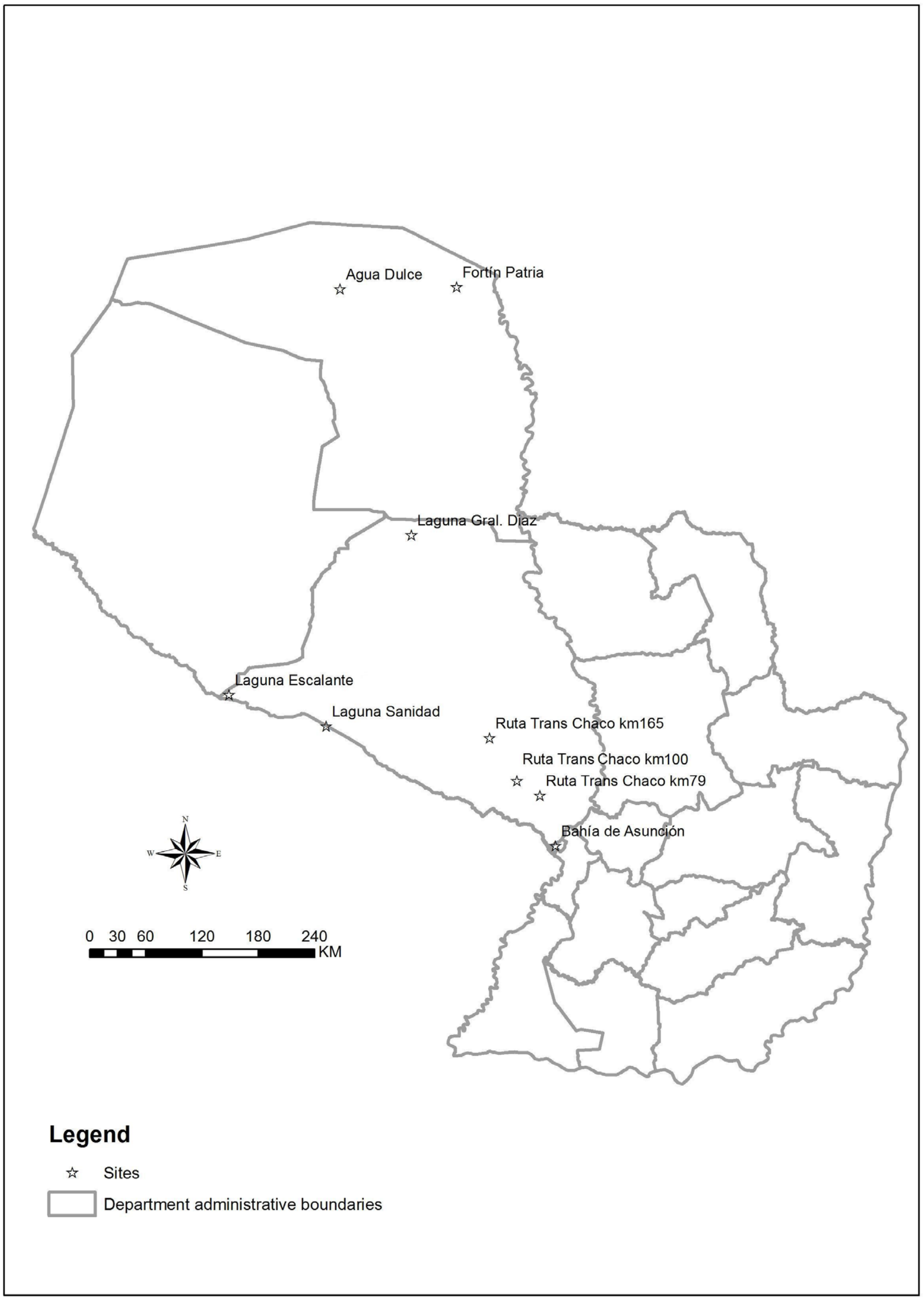

FIGURE 2. Map of localities with Dinelli's Doradito *Pseudocolopteryx dinelliana* records in Paraguay.

Playback of the song of *P. flaviventris* caused the observed individual to lose interest (similar to the behavior noted by Abalos & Areta 2009), but it returned again with the re-playing of the *P. citreola* recording, further supporting its identity. The bird was photographed by PS (Figure 4) and a poor-quality video of it reacting strongly to playback was taken by Robert Wynands (FAUNA Paraguay Photo Database 2013b). Unfortunately no recording equipment was available to the observers to record the vocalizations.

The complex taxonomic history of this form is discussed by the SACC committee in Proposal 420 (Jaramillo 2010). It is indistinguishable from *P. flaviventris* in the field except for its vocalizations, with examined specimens being slightly larger and somewhat longer winged (Abalos & Areta 2009). Abalos & Areta (2009) found the species in different types of habitats including chilcales (*Baccharis salicifolia*), tamariscales (*Tamarix gallica*), brushland of pájaro bobo (*Tessaria absinthioides*) with tamarisks, tamarisks and chilcales, and lagoons with reeds (*Typha* sp. and *Juncus* sp.). The Paraguayan bird was observed in an extensive marsh typical of the Humid Chaco, dominated by *Cyperus giganteus* (Cyperaceae) and *Thalia geniculata* (Maranthaceae).

This observation represents the first record of *P. citreola* in Paraguay and confirms its presence in a fourth country in the Southern Cone in addition to Chile, Argentina, and Bolivia. The record sheds further light on the migratory movements of this species as it shows an eastward movement in addition to the northward migration along the Andes as discussed in Abalos & Areta (2009). Little can be said regarding the status of the species in Paraguay based on this single record, but it may be presumed to occur in passage or perhaps as a winter visitor.

Dinelli's Doradito *Pseudocolopteryx dinelliana*

Pseudocolopteryx dinelliana is a Near Threatened species (Birdlife International 2012) known from a total of 19 confirmed records from 9 localities in Paraguay, all of which are associated with the drainage basin of the Paraguay River (Figures 2 and 5). The majority of these records (11) come from a single well-watched site, the Bahía de Asunción, Departamento Central. Additional published reports from eastern Paraguay are best treated as hypothetical due to a lack of corroboratory documentation combined with the poor understanding of the complexities of doradito identification at the time. These include two sights records (of presumably the same bird) from Estancia San Antonio, Departamento Alto Paraná in July 1992 (Brooks *et al.* 1993), and a third-hand report from Lago Ypacaraí, Departamento Paraguarí on 7 August 1995 (Lowen *et al.* 1996). A report from the Refugio Biológico Mbaracayú, Departamento Canindeyú on 15 September 1993 by Pérez Villamayor & Colmán Jara (1995) was treated as hypothetical by Straube (2003), and later confirmed to be in Brazilian territory (Pérez-Villamayor *et al*. 2014). Though a specimen was collected it has since been lost.

Short (1972) described the habitat of the species

FIGURE 3. Subtropical Doradito *Pseudocolopteryx acutipennis*, Tres Gigantes, Departamento Alto Paraguay, 16 November 2012 (Photo number FPAVE3774PH in FAUNA Paraguay online photo archive www.faunaparaguay.com; Photo by Paul Smith).

FIGURE 4. Ticking Doradito *Pseudocolopteryx citreola*, Km 165 on the Ruta Trans-Chaco, Departamento Presidente Hayes, 5 September 2010 (Photo number FPAVE41PH in FAUNA Paraguay online photo archive www.faunaparaguay.com; Photo by Paul Smith).

as brushland and shrubbery in the xeric Chaco, but the known distribution in Paraguay is associated principally with Humid Chaco or Pantanal-type habitats in the watershed of the Río Paraguay and there are just a handful of records from the xeric Chaco (Ridgely & Tudor 2009; this paper).

Guyra Paraguay (2004) gave the extreme dates for the species in Paraguay as 24 April to 10 August, but an observation at the large wetland at Km 165 of the Ruta Trans-Chaco, Departamento Presidente Hayes (24º15'S, 58º16'W) on 18 October 2004 by PS and RPC extended the later date by more than two months (Guyra Paraguay 2005). In 2009 singing birds were located during six visits to Bahía de Asunción, Departamento Central, between 4 September and 18 October. A peak count of six individuals was made on 20 September (RPC, PS, AJL) and the first photographs (Figure 5) and recordings of the bird's vocalizations in Paraguay were also obtained (FAUNA Paraguay 2013c).

Hayes *et al*. (1994) considered the species to be a southern austral migrant, defined as a species that breeds to the south or west of the country in more temperate areas, and that migrates to Paraguay during the colder

FIGURE 5. Dinelli's Doradito *Pseudocolopteryx dinelliana*, Bahía de Asunción, Departamento Central, 20 September 2009 (Photo number FPAVE1776PH in FAUNA Paraguay online photo archive www.faunaparaguay.com; Photo by Paul Smith).

austral winter months. Guyra Paraguay (2004, 2005) similarly considers the species a winter visitor. The presence of singing birds during the early breeding season suggests that breeding might occur, but doraditos have been recorded singing during migration in northwestern Argentina (K. Roesler in litt. 2013) and so confirmation of the status of Paraguayan populations is required.

Warbling Doradito *Pseudocolopteryx flaviventris*

Considered an uncommon winter visitor to Paraguay (Guyra Paraguay 2005), with extreme dates 23 March to 28 November (Hayes 1995). *P. flaviventris* is fairly widespread in the Humid Chaco, Paraguayan Pantanal, and Oriental region. Short (1972) described the habitat of the species as shrub and brushland in open country, but all Paraguayan records are from marshes and bushy wetlands.

The discovery of *P. citreola* in Paraguay creates uncertainty regarding the precise distribution of this species in Paraguay. The possibility that at least some reports of *P. flaviventris* in fact refer to the cryptic *P. citreola* cannot be discounted and field work is required to better understand the limits of their distributions.

A recently fledged juvenile of the *flaviventris* "morphotype" was captured in a mist net on 25 August 2005 (Figure 6) a few hundred meters from the banks of the Río Paraná at the now defunct Arroyo Mboi Kae (27º21'S, 55º52'W), on the outskirts of Encarnación, Departamento Itapúa (FAUNA Paraguay 2013d; Smith *et al*. 2013). The bird was a weak flyer and is possibly suggestive of local breeding, though the proximity of the site to the Río Paraná introduces the possibility that the bird may have crossed over from Argentina. Based on the known breeding distributions of *P. citreola* and *P. flaviventris* (Abalos & Areta 2009), this individual might reasonably be assumed to be of the latter species. The northern extent of the known breeding range of *P. flaviventris* in Argentina is the Iberá marshes in Provincia Corrientes, but breeding in southern Misiones is also suspected (M. Pearman *pers. comm.*). Belton (1994) considers the species resident in Rio Grande do Sul, Brazil, at approximately the same latitude. This record suggests that the species may breed further north than is currently known and is perhaps even resident in extreme southern Paraguay.

Crested Doradito *Pseudocolopteryx sclateri*

The most widespread and commonly encountered doradito in Paraguay, *P. sclateri* (Figure 7) is associated with reedbeds, wet grasslands, and low shrubbery near water (Short 1972; Fitzpatrick 2004). Considered a breeding resident (Guyra Paraguay 2005), there is some suggestion of seasonality at the Bahía de Asunción, with birds more frequently observed during the austral winter and spring (RPC, AJL). The distribution is to some degree associated with the Río Paraguay, with most records in the western half of the Oriental region and fewer in the Humid Chaco and Pantanal regions. The most easterly record is of a bird at Arroyo Mboi Kae (27º21'S, 55º52'W) observed on the outskirts of Encarnación, Departamento Itapúa, by PS during July 2005 near the banks of the Paraná River (Smith *et al.* 2013). The most westerly record is at Defensores del Chaco National Park, Departamento Boquerón, and the most northerly at Fortín Patria, Departamento Alto Paraguay (19º55'S, 58º 35'W).

Conclusions

FIGURE 6. Warbling Doradito *Pseudocolopteryx flaviventris*, Arroyo Mboi Kae, Encarnación, Departamento Itapúa, 25 August 2005 (Photo number FPAVE1781PH in FAUNA Paraguay online photo archive www.faunaparaguay.com; Photo by Paul Smith).

FIGURE 7. Crested Doradito *Pseudocolopteryx sclateri*, Arroyos y Esteros Km 100, Departamento Paraguarí, 11 November 2008 (Photo number FPAVE3453PH in FAUNA Paraguay online photo archive www.faunaparaguay.com; Photo by Paul Smith).

TABLE 1: Paraguayan records of Subtropical Doradito *Pseudocolopteryx acutipennis*.

Location	Department	Coordinates	Date	Source
Lichtenau	Presidente Hayes	22º50'S, 59º40'W	9 December 1970	AMNH 802830 (Short 1972)
Lichtenau	Presidente Hayes	22º50'S, 59º40'W	27 April 1973	AMNH 810650 (Short 1976)
Riacho Michi, Ruta Trans Chaco km210	Presidente Hayes	23º51'S, 58º28'W	9 December 1988	F. Hayes, D. Snider & R. Perrin sight record (Hayes 1995)
Pirahú, Ruta Trans Chaco km 249	Presidente Hayes	23º37'S, 58º42'W	10 August 1994	F. Hayes sight record (Hayes 1995)
Bahía de Asunción	Central	25º17'S, 57º38'W	28 August 2004	RPC, AJL; sight record of two individuals
Estación Biológica Tres Gigantes	Alto Paraguay	20°04'S, 58°09'W	27 June 2008	S. Centrón; sight record
Bahía de Asunción	Central	25º17'S, 57º38'W	8 May 2009	RPC; sight record
Bahía de Asunción	Central	25º17'S, 57º38'W	27 September 2010	AJL, R.Cardoso, S.Centrón, C. Morales; sight record
Ruta Trans Chaco km165	Presidente Hayes	24º15'S, 58º16'W	11 February 2012	PS; sight record
Estación Biológica Tres Gigantes	Alto Paraguay	20°04'S, 58°09'W	16 November 2012	PS; photograph (Figure 3; FAUNA Paraguay 2013a)

TABLE 2: Paraguayan records of Dinelli's Doradito *Pseudocolopteryx dinelliana*.

Location	Department	Coordinates	Date	Details &Source
Laguna Gral. Diaz	Presidente Hayes	22º18'S, 59º01'W	20 July 1945	FMNH 152593 (Hayes *et al.* 1994)
Laguna Escalante	Presidente Hayes	23º50'S, 60º46'W	3 August 1960	MAK 601593 (Steinbacher 1962)
Ruta Trans Chaco km79	Presidente Hayes	24º48'S, 57º47'W	9 May 1990	P. Scharf; sight record of two birds (Collar *et al.* 1992; Hayes 1995)
Ruta Trans Chaco km 100	Presidente Hayes	24º47'S, 58º23'W	16 June 1990	P. Scharf; sight record of one bird (Collar *et al.* 1992; Hayes 1995)
Fortín Patria	Alto Paraguay	19º55'S, 58º35'W	22 March 2002	J. Klavins, A. Esquivel; sight record
Agua Dulce	Alto Paraguay	19º57'S, 59º42'W	24 April 2004	J. Klavins; sight record
Ruta Trans Chaco km165	Presidente Hayes	24º15'S, 58º16'W	18 October 2004	RPC, PS; sight record
Laguna Sanidad	Presidente Hayes	24º08'S, 59º50'W	9, 10 October 2004	RPC, H. del Castillo, E. Coconier; sight record of five singing birds
Bahía de Asunción	Central	25º17'S, 57º38'W	4 September 2009	RPC, AJL, D. Díaz; sight records of two individuals
			12 September 2009	RPC, AJL; sight records of three individuals
			20 September 2009	PS, RPC, AJL; sight records of six individuals (FAUNA Paraguay 2013c)
			1, 16, 18 October 2009	RPC, AJL; sight records of three, one, and one individuals, respectively
			17, 24 August 2012	RPC, AJL; sight records of three and four individuals respectively
			4, 7, 11 September 2012	RPC, AJL; sight records of two individuals

The information presented here represents a summary of the little that is known about the distribution and seasonality of doraditos in Paraguay. Though certain inferences can be made regarding movement patterns in Paraguay in reference to records in neighboring countries, the scarcity of data available for most species, the confusion created by identification difficulties and the heterogenic seasonal movements that some species exhibit across their wide geographic ranges mean that further study is required to confirm these conclusions. However one clear pattern that emerges is a strong association between the Paraguayan distribution of most species and the watershed of the Río Paraguay, which is presumably due, in part, to the greater availability of wetland and low-lying grassland habitats in this region.

At the local level clarification of the ranges and seasonality of *P. citreola* versus *P. flaviventris* is a priority, whilst confirmation of potential breeding of the Near Threatened *P. dinelliana* would contribute to a better understanding of its status and hence conservation. Significant habitat loss in the nominally protected Important Bird Area, the 522-ha Bahía de Asunción Ecological Reserve (where the species was consistently observed singing and may have bred) during the construction of the Asunción bayside road (Costanera de Asunción) that started in 2010 is cause for concern, and the impact of this loss on Paraguayan populations of the species has yet to be determined. Further research to clarify the specific status of *P. acutipennis* throughout the range would also be desirable in order to begin to interpret the seasonal patterns observed in Paraguay.

Positive identification of doraditos requires familiarity with the species and in particular with their vocalizations. With bird watching still in its infancy in Paraguay, and very few experienced birders active in the field, all species are likely under-recorded, seriously hampering our understanding of the distribution of these species in the country. To date no nest of any species has been reported from Paraguay and, in general, much remains to be learned about the taxonomy, distribution, natural history, and movements of these unobtrusive little flycatchers. It is hoped that this introductory paper will contribute to a better range-wide understanding of the biology and conservation requirements of this charismatic but complex group.

Here follows a basic field key to the species to assist inexperienced observers with identification:

1a Contrastingly dark bifurcate crest	*Pseudocolopteryx sclateri*
1b Crestless	2
2a Head with distinct and contrasting rufous coloration, most notable on the crown	3
2b Head without contrasting rufous tinge, being uniform brownish or greenish	4
3a Vocalizations harsh and scratchy, "tick tick tick tick-tick-tick-you." Head movements accompanying each note first raise the head slowly, and as the velocity of the notes increases, the head is lowered rapidly with shaky movements	*Pseudocolopteryx citreola*
3b Vocalisations weak and squeaky, "u-eet-u, u-eét." Head movements accompanying the song are even and rhythmic	*Pseudocolopteryx flaviventris*
4a Head and upperparts dull greenish-olive, underparts bright golden-yellow. No supercilium and adults do not usually show wing bars (though juveniles have both wing bar AND supercilium!). Scratchy song includes low liquid notes	*Pseudocolopteryx acutipennis*
4b Head and upperparts dull greenish, underparts bright golden-yellow with slight olive tinge on the flanks. Often shows a hint of a supercilium and wing-bars at all ages. Scratchy song ends with high note, "tick-tick-ticktickaZEEP"	*Pseudocolopteryx dinelliana*

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This article is dedicated to the memory of Juan Mazar Barnett, with whom RPC shared several discussions regarding doradito distribution and identification. In fact, the Paraguayan record of *P. citreola* and recent observations of the species in northern Argentina were a topic in our last conversation together. PS would like to thank to Robert and Ulrike Wynands for their company in the field during the observation of *P. citreola* and for having the foresight to video the observed behavior! Hugo del Castillo provided additional data on certain records. Thanks to Kini Roesler and Mark Pearman for sharing their experiences with these birds in Argentina. Special thanks to Fatima Mereles for identifying the plant species associated with the *P. citreola* record.

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SHORT-COMMUNICATION

Noteworthy records and natural history comments on rare and threatened bird species from Santa Cruz province, Patagonia, Argentina

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ABSTRACT: Santa Cruz province is the second largest province in Argentina, and also the least populated. This province makes up the southern tip of continental Argentina. Althought it has low population density and is remote from big cities, in the past it received well-deserved attention from researchers. This was probably due to the presence of many interesting species, among them some threatened, with taxonomic singularities, and/or endemism. The goal of this work is to update knowledge of the distribution and natural history of 21 species from Santa Cruz, including five new to the province.

KEY-WORDS: Argentina, distribution, natural history, new records, Santa Cruz.

INTRODUCTION

Knowledge of the distribution and status of the birds of Argentina has improved substantially since the 1990's, especially after the first edition of Narosky and Yzurieta's (1987) guide "*Birds of Argentina and Uruguay*." That improvement has had a noticeable impact on the quality and quantity of articles and short notes on distribution, biology, and natural history, which increased even more after the publication of the "*Annotated Checklist of the Birds of Argentina*" (Mazar Barnett and Pearman 2001). We base our work on the distribution of rare species within the country on this last Checklist.

For Santa Cruz province, 229 species have been recorded (Darrieu *et al.* 2008, 2009a, 2009b). The diversity on the southern tip of the continent is a consequence of the mixture of several habitat types: Austral *Nothofagus* forest, Patagonia steppe, Magellanic steppe, seashore, highland and lowland lakes and ponds, mountain top habitat, and the last remnants of the Argentinean endemic habitat, the "*monte* desert" (Cabrera 1971). Most of the province is covered by Patagonian steppe, a known low bird diversity habitat. The highest land bird diversity in these latitudes is found in the ecotone between the forest and the steppes, along the Andes. The Atlantic Ocean coast is also important in contributing to biodiversity, with several species of Nearctic migrants that reach South America during the austral summer concentrating in the area (Darrieu *et al.* 2008). This high coastal biodiversity tends to concentrate principally in rather small areas, like river estuaries or sheltered sites. These estuaries are also important for austral migrants that spend their winter there, including the critically endangered Hooded Grebe *Podiceps gallardoi* (Imberti *et al.* 2004; Roesler *et al.* 2012).

Santa Cruz is the southernmost and second largest continental province of Argentina. Although it is the least populated region of the country and far away from the city of Buenos Aires, where most of the important institutions for research and collections are located (e.g., Argentina Museum of Natural Sciences, the non-profit

Aves Argentinas/Asociación Ornitológica del Plata, etc.), it has gained some attention regarding its fauna, mainly because it holds some biologically important sites, like Los Glaciares National Park (hereafter NP), with the superb Perito Moreno Glacier and the Deseado River estuary on the Atlantic Ocean coast. Another important reason why Santa Cruz has managed to call the attention of many naturalists and researchers from all over the world is the presence of populations of some of the most threatened species in Argentina, for example, the critically endangered *Podiceps gallardoi*, the national critically endangered (and probably globally endangered) Ruddy-headed Goose *Chloephaga rubidiceps*, the long-thought-to-be-extinct and nowadays globally vulnerable Austral Rail *Rallus antarcticus*, and the intriguing Magellanic Plover *Pluvianellus socialis*, among others. All these rare species have been the focus of several studies, most of them regarding natural history, distribution, and conservation trends (Fjeldså 1984, 1986; Beltran *et al.* 1992; Ferrari *et al.* 2008; Imberti *et al.* 2007; Roesler *et al.* 2012; Mazar Barnett *et al.* 2013). Also, some important areas and even the complete province has been the focus of research (Imberti 2003; 2005; Darrieu *et al.* 2008; 2009a; 2009b), but its enormous size, the remoteness of the landscape, the inaccessibility of most of its sites, and the extreme climate conditions, still allow for gaps in the knowledge of rare taxa and natural history information of even more common species that are locally distributed or have low natural densities.

The goal of this work is to update the information presented by Darrieu *et al.* (2008; 2009a; 2009b), and improve the knowledge of the natural history of poorly known species. Among the information presented here are anecdotal data about breeding biology, seasonal movements, and habitat use.

METHODS

Study Area

Santa Cruz province comprises the southernmost part of continental Argentina, located between 46° and 52°S and 65° and 73°W. It is limited by the Atlantic Ocean to the east and the Andes mountain range on the west. The climate is temperate cold with mean temperatures of 5°C. Precipitation varies from 100 to 250 mm in the drier steppes up to *c.* 3,000 mm along the Andes, and it occurs mainly during winter and spring seasons, falling as mostly snow (Cabrera 1971). The Andes acts as a natural barrier for the predominant west and southwest wet winds from the Pacific Ocean, which release humidity mostly on the western slopes. The little remnant moisture that reaches the eastern slopes favors the growth of *Nothofagus* forest along a fine strip (< 70 km) from the Chilean border. This forest vanishes quickly to the east, giving way to a different ecotone of open and grassy habitat (for *c.* 20-30 km), with scattered *Nothofagus antarctica* patches. Farther east, the rest of the province is dominated by a desert-like steppe, formed by a mosaic of short grasses, low bushes, and bare soil. In the southern portion (mostly below 51°S) the low elevation of the Andes allows the moisture of the winds to reach farther east, a factor that, combined with lower temperatures and different soil conditions, favors a grassy (mostly *Festuca* sp.) steppe with no bare soil, known as Magellanic Steppe.

An important but little-known habitat is the steppe on the top of the sub-Andean basaltic plateaus (500 to 1,500 m.a.s.l.), present on the western portion of the province. Those plateaus form a parallel line east of the Andes, and are dominated by grasslands, with important botanical influence from high Andean habitats. They are considered part of the austral high Andes district (Cabrera 1971). Also, each plateau has a variable number of lakes and ponds, from just a few (i.e., Vizcachas, Viedma, and El Moro plateaus) up to over a thousand (i.e., Strobel plateau). These wetlands also vary greatly in size, and temporality; most of them are present just after the melting period, while others are permanent. The lakes are used by a large number of water-bird species, including Nearctic waders and flamingoes, but few of those species breed in the area (Lancelotti *et al.* 2009; IR, pers. obs.). In the past, the highland lakes were fishless, but nowadays many of them have been stocked with at least four species of exotic Salmonids, mostly Rainbow Trout *Onchorhynchus mykiss* (Lancelotti *et al.* 2009).

Other important habitats are the valleys of the Santa Cruz, La Leona, Chico, Gallegos, and Deseado Rivers, among others. The flatlands of these valleys are temporarily flooded after the melting period. This regular flooding cycle favors the presence of marshlands, some of them natural but some others are man made for cattle feeding. They are covered principally in lush grasses including occasional stands of taller rushes (*Schoenoplectus* sp.), and some other species of aquatic plants. They are of capital importance for the reproduction of many bird species, including the vulnerable *R. antarcticus* (Mazar Barnett *et al.* 2013). These flatlands along rivers are also the chosen sites where the local "*estancias*" (hereafter Ea.) have their houses, which are usually surrounded by planted trees, also important for many bird species, even for northern vagrant species (i.e., Militello and Schieda 2011).

Sampling Methods

Within the context of the "Hooded Grebe Project" ("*Proyecto Macá Tobiano*") we extensively monitored the western half of Santa Cruz province (Fig. 1), between January 2009 and October 2013. Most of the fieldwork was conducted during the summer, from December to March/April, but at least five winter campaigns and many occasional outings where undertaken in May, June, July, and August. During the five years of research we accumulated over a 1,000 man/days of fieldwork. Also, regular winter censuses of *Podiceps gallardoi* on the three main estuaries of Santa Cruz allowed us to gather information about some migratory habits and some scattered records of uncommon species. We followed the systematic arrangement, taxonomy and English names proposed by Remsen *et al.* (2013).

Species Accounts

Patagonian Tinamou *Tinamotis ingoufi*

Tinamotis ingoufi is uncommon but regular in Santa Cruz. Here we present 22 new records for the province (Table 1), most of them from the western part. The highest elevation records were obtained on the Buenos Aires plateau (northernmost plateau), at 1,220 m.a.s.l. on a grassy steppe (Table 1–13). Although many unique records occurred in areas where we had done extensive fieldwork, we repeatedly gathered multiple observations from the same localities, which could indicate that this species tends to live in established territories. Consistent with Pozzi (1923), our data suggest that while courtship behavior may start as soon as September, the nesting period is mid-late November up to early-mid December (one couple in early December), with hatching in late December and early January. The largest number of chicks we detected was eight (the two adults with 15 young could represent two independent groups), but most of the groups were 4-5 individuals. The biggest flock of adults was on the coastal area, during the winter period, which could represent individuals from that area congregating during the nonbreeding period, or an increase in the number of individuals due to migration from the western part of the province, or even both phenomena combined. The occurrence of aggregations was mentioned by Pozzi (1923), who reported groups of up to 50 individuals in autumn, also in the eastern part of the province (after April). We did not record this species during our winter surveys in western Santa Cruz province, nor on the slopes of the plateaus, but that could just be a consequence of the low sampling effort put forth during that time of the year. The latest inland record outside of the breeding season was a medium/large flock of 17 individuals in mid-April (see Table 1–21), which could represent a winter group similar to the ones observed on the coastal region.

This elusive species has been considered as uncommon but it is probably expanding due to the expansion of the patches of "*mata negra*" (*Verbena tridens*) caused by overgrazing (Cabot 1992). Although we could not fully support nor disclaim this hypothesis, it is interesting that groups were seen repeatedly in sites with large patches of *mata negra*. In concordance with Imberti (2003), we found that the former published elevational range of 200 to 800 m.a.s.l. (Cabot 1992), or up to 1,000 m.a.s.l. (Vuilleumier 1993), was underestimated, which could be a result of the difficulty accessing upper plateau habitat. As mentioned for other tinamous, during breeding season adult *T. ingoufi* seem to move in groups of three individuals (see records on Table 1).

Hooded Grebe *Podiceps gallardoi*

On 10 February 2013 a group of 10 individuals (five breeding pairs) of the critically endangered *Podiceps gallardoi* was found at a 5-ha pond in Ea. Cerro Fortaleza, Mata Amarilla plateau (50°04'06"S, 71°13'42"W; 863 m.a.s.l.; IR, LGP, PH, M. Bertinat). Four of the five nests were successful and four chicks were seen on 5 April 2013 (IR). This pond was the only one of the three suitable in the area where the species was present, and was also the richest in water bird species.

Populations of *Podiceps gallardoi* seem to have decreased greatly since the 1980's (Roesler *et al.* 2012). After five years of research, the actual breeding range of *Podiceps gallardoi* is well known. During our fieldwork we monitored over 400 suitable ponds and lakes on eleven plateaus and some extra-plateau lakes; this population at Mata Amarilla plateau was the only new site we found where it was not recorded during the 1980's and 1990's (*cf.* Roesler *et al.* 2012; Codesido, unpubl. data). This record represents the second plateau east of National Road (NR) 40 with a breeding population of *Podiceps gallardoi*, while the other plateau, Cerro Ventana, does not hold individuals at present, given that most of the lakes and ponds are dry (IR and PH, pers. obs.). Note that the lake on Mata Amarilla plateau is less than 50 km away from the type locality of the species, Escarchados Lake, on Vizcachas plateau, where the species seems to have almost disappeared.

Stripe-backed Bittern *Ixobrychus involucris*

On 16 January 2013, at 0650 h, one individual of *Ixobrychus involucris* was detected calling from the dense marshlands near the main houses of Ea. La Angostura (48°37'43"S 70°38'50"W; 377 m.a.s.l.; LGP). Despite further searches in the same area, we failed to find it again (LGP, IR, JK).

Accordingly to Darrieu *et al.* (2008) this represents the first record for the province. The marshland habitats at Ea. La Angostura are extremely similar to those within the known range of the bittern, and they hold most of the same species, so it is highly likely that the species probably occurs at low densities, but is not a vagrant—just overlooked. This is an important range extension of nearly 1,000 km to the south from the regular known range of the species, in La Pampa and Neuquén provinces (Narosky and Yzurieta 2010; Rodriguez Mata *et al.* 2006; Veiga *et al.* 2005).

TABLE 1. Observations of Patagonian Tinamou *Tinamotis ingoufi* in Santa Cruz province between 2009 and 2013.

#	Date	Locality	No. ind.	Coord.	Elev. (m.a.s.l.)	Comment	Observer
1	21/12/09	Ea. La Julia, NR 288, Gdor. Gregores.	3	49°35'09"S 69°34'12"W	81	2 of them copulates	IR
2	03/01/10	NR 3, north of San Julian	6	48°24'59"S 67°43'50"W	170	Adult and 5 chicks	IR, HC, H. Slongo
3	20/01/10	Ea. La Criolla, Asador plateau	12	47°46'44"S 71°01'34"W	770	Adults (Juveniles?)	HC
4	10/12/10	Punta Gualichu, Calafate	3	50°17'36"S 72°11'37"W	190	Adults	SI
5	06/01/11	Ea. Cerro Ventana, Cerro Ventana plateau	2	48°54'20"S 70°21'50"W	450	Adults	IR, HC, JK
6	23/05/11	Puerto Deseado	23	47°21'06"S 66°51'30"W	162	Adults	IR, SI, PH, D. Punta Fernández
7	13/10/11	RP 71, north of Gdor. L. Piedrabuena	3	49°39'14"S 68°43'30"W	50	Adults	SI
8	12/10/11	Ea. La Estela, Lago Viedma	3	49°47'08''S 72°01'46''W	270	Adults	SI
9	10/12/11	RP 71, north of Gdor. L. Piedrabuena	3	49°39'14"S 68°43'30"W	50	Adults	IR
10	14/12/11	Ea. Las Coloradas, Strobel plateau	9	48°47'42"S 71°00'09"W	800	Adult and 8 chicks	IR, PH, L. Fasola
11	11/02/12	Ea. La Criolla, Asador plateau	6	47°46'44"S 71°01'34"W	770	Adult and 5 chicks	IR, D.P. Fernández, R. Lapido
12	16/02/12	Strobel plateau	3	48°27'26"S 71°18'1"W	943	Adult and 2 young	IR, HC
13	15/01/12	Ea. 9 de Julio, Buenos Aires plateau	6	47°10'13"S 71°12'26"W	1,220	Adult and 5 chicks	IR, HC
14	20/02/12	Ea. El Sauce, Buenos Aires plateau	7	47°14'18"S 71°11'03"W	770	Adult and 6 chicks	IR
15	25/03/12	Ea. Las Coloradas, Strobel plateau	5	48°47'42"S 71°00'09"W	800	Adults (Juveniles?)	IR
16	26/03/12	Ea. La Angostura	3	48°37'43"S 70°38'50"W	420	Adults	IR
17	16/11/12	Strobel plateau	2	48°35'30"S 71°14'06"W	920	Adults	IR, PH
18	Jan. 2013	Ea. 9 de Julio, Buenos Aires plateau	5	47°14'18"S 71°11'03"W	770	2 Adults; 3 chicks	IR, PH
19	11/01/13	Strobel plateau	6	48°35'30"S 71°14'06"W	928	Adult and 5 chicks	IR, JK
20	24/01/13	Asador plateau	17	47°46'44"S 71°01'34"W	770	2 adults and 15 young	LGP, L. Fasola
21	31/01/13	RN 40, 10 km south of Bajo Caracoles	3	47°24'7"S 70°58'13"W	605	Adults	IR, LGP, JK, S. Hardy, L. Fasola
22	17/04/13	Ea. El Sauco	17	47°20'41"S 71°14'19"W	520	Adults	SI

Harris's Hawk *Parabuteo unicinctus*

One individual was observed on 9 February 2013, at the margins of La Lechuza Stream, next to where it flows into the Santa Cruz River (50°11'57"S, 70°55'42"W; 145 m.a.s.l.; IR). The individual was in a patch of forest dominated by *Salix* sp. and *Populus* sp. in an area of abandoned houses of Ea. Condor Cliff. It was a first year individual, with completely marked underparts, and no rufous on the thighs. Further searches during the second week of February didn't detect the species (IR, LGP).

This observation represents the third record for Santa Cruz province, the first being an individual photographed at Río Gallegos city (Alvarado *et al.* 2009) and another individual (without details) at Ea. La Angostura (Darrieu *et al.* 2009b). The individual from Río Gallegos was also a juvenile and remained in that area for a long period. Probably the species' populations are spreading south following human-planted woodlands around ranches and cities. These individuals could represent a dispersal of juveniles from nearby areas where the species is frequent, most likely from southeastern Chubut and Río Negro provinces (IR, pers. obs.). *Parabuteo unicinctus* seems to be increasing its distributional range across Argentina, following cities and other forested areas (IR and LGP, pers. obs.; SH Seipke, pers. comm.). The only raptor census conducted in the area did not mention the species south of La Pampa province (Olrog 1979).

Andean Gull *Chroicocephalus serranus*

On 19 December 2009 two individuals of *Chroicocephalus serranus* in breeding plumage were observed flying over the marshes on the banks of the Chico River at Ea. La Angostura (IR). These two individuals were part of a mixed gull group including individuals of Brown-hooded Gull *C. maculipennis*, allowing direct comparison in the field. They differ from the previous species by the color pattern of the wings, with almost entirely black primaries (which makes it look darker than in *C. maculipennis*) with a white spot on the sub-terminal portion of the last primaries. In later visits to the site (January 2010) we failed to detect *C. serranus* (IR, HC).

There are no previous records of this species for Santa Cruz (Darrieu *et al.* 2008, 2009b) or Chubut (Schulenberg 2010) provinces; the nearest known populations are on Neuquén province (Veiga *et al.* 2005). On the western side of the Andes (Chile), the species reaches further to the south, to the latitude of Río Negro province (Jaramillo 2003; Schulenberg 2010). It is probable that the Andean Gull is much more frequent in lakes and marshlands of northern Patagonia, but might be overlooked because its plumage is similar to the much more common *C. maculipennis*.

Austral Rail *Rallus antarcticus*

After five seasons of fieldwork in Santa Cruz we found *Rallus antarcticus* in only two new localities not reported by Mazar Barnett *et al.* (2013). In January 2011 at least one individual responded to playback on a marshland on provincial road (hereafter PR) 41, four km from the junction with NR 40 (47°20'58"S, 71°0'59"W; 455 m.a.s.l.; SI, IR). In September 2013 one individual on a small marsh 20 km north of Río Gallegos on the side of NR 3 was observed (SI, PH). We visited the PR 41 marshland on several posterior occasions (seasons 2012 and 2013) but no rails were ever detected (IR). The NR 3 marshland had rails at every successive visit (SI). We also looked for the rail in several other suitable sites unsuccessfully (Table 2).

Probably the most interesting finding during our fieldwork was that all sites with adequate habitat (Table 2) hold populations of American mink *Neovison vison* (Fasola and Roesler, unpubl. data.). It is yet unknown the effect of this invasive predator on *R. antarcticus* populations, but it has been considered one of the main potential threats to populations for some time (Fraga 2000; Mazar Barnett *et al.* 2013). It is well known that the American mink has strong negative effects on species that are already declining, being somehow the final stroke for some weak populations, such as the Water Vole *Arvicola amphibius* (Barreto *et al.* 1998). The present distribution of American mink is now known to be much more extensive than previously thought (Fasola and Roesler, unpubl. data), thus proper research is urgently needed to assess the real threat posed by *N. vison*.

Picazuro Pigeon *Patagioenas picazuro*

On 18 February 2013 one individual of *Patagioenas picazuro* was observed in a poplar (*Populus* sp.) and willow (*Salix* sp.) implanted forest, next to the Chalía River valley (49°29'3"S, 71°37'44"W – 262 m.a.s.l.), 18 km (straight line) northwest of Tres Lagos town (IR). The individual was in a group of the more common and widespread Eared Dove (*Zenaida auriculata*).

Although the *P. picazuro* is one of the most abundant pigeon in open (and less open) habitats of central and northern Argentina, this is the first observation for Santa Cruz province (Darrieu *et al.* 2008; 2009b). This species, and probably *Z. auriculata*, is expanding its range to the south, and becoming more abundant following the expansion of croplands and increase of grain production. In Patagonia, vagrants or rare species from more humid areas tend to be associated with human settlements, normally with cities or man-made forest in ranches or "*puestos*" (small houses in isolated areas of the ranches—IR, pers. obs.). The observation of *P. picazuro* could either represent a sign of recent colonization in the area or just a vagrant individual.

Miners *Geositta* spp.

Three species of Miners inhabit western Santa Cruz province. Their habitat is mostly well separated. The Rufous-banded Miner *G. rufipennis* is common in rocky places on the slopes of plateaus or in basaltic formations, principally around lakes or ponds. It seems to prefer areas with higher cliffs, including sedimentary formations between 400 to 900 m.a.s.l., becoming rarer both in lower and higher elevations. The southernmost area where the species is common is in the central part of Los Glaciares NP, the access to the Guanaco area (49°20'01"S 72°52'55"W – 403 m.a.s.l.; SI). During early autumn and winter this species appears in open areas at lower elevations in nearby areas of the plateaus, down to 300 m.a.s.l. The Short-billed Miner *G. antarctica* is the most common Miner on the higher parts of plateaus, up to 1,600 m.a.s.l., but also inhabits lower areas (down to sea level) during the breeding season and it is found there in wintering flocks as well. It seems to prefer grassy and very open habitats, with few or no bushes, including areas with almost no vegetation at all. In early March it forms flocks of 100 (or more) individuals, which disappear from the highland plateaus by late march. Lastly, the Common Miner *G. cunicularia* is more widespread than the previous two species, and although it overlaps in distribution with both of them, it seems to prefer lowland habitats, being common up to 800 m.a.s.l., mostly in bushy habitats with less open ground. The populations of this species migrate to northern and central Argentina, disappearing from Santa Cruz by late April or early May.

The Rufous-banded Miner has been previously recorded at just eight localities in Santa Cruz, including one record in the El Turbio area, which represents the southernmost record for the species (Darrieu *et al.* 2009a). The lack of other previous records is possibly due to the inaccessibility of the upper plateau habitat, where the species is fairly common to common. The other two species are well known for the province (Darrieu *et al.* 2009a), but there is scant information about habitat use and microhabitat preferences.

Straight-billed Earthcreeper *Ochetorhynchus ruficaudus*

The *Ochetorhynchus ruficaudus* was first detected in the province on 6 January 2010 at El Moro plateau (49°04'40"S 71°57'41"W – 1,126 m.a.s.l.), when at least two individuals were seen in a rocky gorge (HC, IR). On that occasion, a nest with similar characteristics to the ones described for the species was detected in the area (IR, pers. obs.). On 23 January 2011 another two individuals

TABLE 2. List of sites where searches of Austral Rail *Rallus antarcticus* were unsuccessful between 2009-2013.

#	Date	Locality	Coord.	Elev. (a.s.l.)	Comment	Obs.
	15/03/09	Ea. La Federica, San Martín Lake	49°01'16"S 72°14'34"W	260	Extremely good habitat. More searches are necessary. American mink was detected.	SI
1	05/01/11	Ea. Cerro Ventana	48°57'30"S 70°13'39"W	236	This place was searched successfully by Mazar Barnett et al. (2013). Mink found near this locality.	HC, JK, IR
2	15/12/12	Ea. La Verde	48°26'47"S 70°32'10"W	455	Small fragment of habitat, but close to La Angostura, one of the most important spots for the rail. American mink (*Neovison vison*) was detected on the nearby Río Chico.	IR, PH, L. Fasola
3	11/02/12	Ea. Valle Chacabuco, XI Región, Chile	47°04'55"S 72°23'37"W	457	Although not in Argentina, this area holds massive extentions of habitat next to the international border. The presence of American mink was detected.	HC, SI, IR
4	23/12/12	Ea. El Sauco	47°20'41"S 71°14'19"W	278	Few patches of good habitat. We detected the presence of American mink. Some patches were overgrazed by cows and horses.	IR
5	13/03/13	Ea. San Carlos, Deseado Valley	46°36'01"S 70°42'32"W	490	Massive patch of good habitat. We detected the presence of American mink.	IR, L. Fasola
6	02/06/13	Ea. Las Tunas, Cardiel Lake	48°49'09"S 71°07'23"W	422	0.5 ha of good marshlands. The search was made in early winter, but the marshland was not frozen.	IR, J. Lancelotti.

were detected on a rocky area covered with small bushes at the Cardiel Chico plateau (49°01'18"S 71°53'18"W – 1,154 m.a.s.l.; IR, HC, SI, JK), a mere 10-km straight-line distance from the first locality. This plateau is the western part of the greater Siberia plateau. On 13 December 2011 a pair was seen (and photographed) on the Ea. Vega del Osco, along the Barrancoso River, Strobel plateau (48°29'25"S 71°17'06"W – 911 m.a.s.l.; IR, PH, L. Fasola). They were on a rocky wall covered with bushes of *mata negra* (*Verbena tridens*) and *calafate* (*Berberis* spp.). On 7 March 2012 one individual was seen (and photographed) on a bare rocky wall at El Islote Lake, Strobel plateau (48°38'15"S 71°24'51"W – 1,100 m.a.s.l.; IR, G. Aprile). During January-March 2013 at least one individual was detected on several occasions on a rocky wall on the C199 Lake, Siberia plateau (49°01'29"S 71°44'00"W – 1,030 m.a.s.l.; JK, IR, LGP, SI). Lastly, on 10 October 2013 a pair was observed on a rocky outcrop near provincial route 41 (47º15'52"S 71º42'17"W – 550 m.a.s.l.). That last record is the lowest elevation where it had been recorded within the study area, and may represent an elevational movement, considering the early date (SI). All localities are shown in Figure 2.

These records represent the first mentions for Santa Cruz province (Darrieu *et al.* 2009a). The distribution of *O. ruficaudus* along the Andes is probably a continuum along the sub-Andean plateaus of western Patagonia. The lack of records may be a consequence of the inaccessibility of this habitat. All (but one) of our records were obtained in localities above (or just around) 1,000 m.a.s.l., indicating that it probably does not inhabit lower elevations during the breeding period.

Thorn-tailed Raydito *Aphrastura spinicauda*

One individual was detected at Punta Bustamante, at the mouth of the Gallegos Estuary on the Atlantic Ocean coast (51°36'36"S 69°00'39"W – 3 m.a.s.l.), feeding around the base of some bushes on 18 May 2010 (SI). Low Patagonian Steppe covers the site, with absence of nearby patches of forest or any tree vegetation.

Although the species is fairly common in open steppe habitat in some parts of its distribution (Fjeldså and Krabbe 1990), it does not have any known regular movements or migration, and there are hardly any records of the species away from this type of habitat in Santa Cruz (Darrieu *et al.* 2009a). This record is the first for the eastern part of the province and the first published for the continental Atlantic Ocean coast.

Austral Canastero *Asthenes anthoides*

Two nests were found in Santa Cruz province: one (probably abandoned) at Reserva Costera Urbana, in Río Gallegos (51°38'29"S 69°09'55"W – 4 m.a.s.l.), on 11 April 2009 in the bottom part of a '*mata verde*' bush (*Lepidophyllum cupressiforme*). This nest was a typical ovenbird nest constructed with sticks, grasses, and had plastics on its interior (entrance opening diameter = 6 cm; tunnel and chamber length = 25 cm). The second nest was found at Ea. La Alice – at 'El Galpón' (50°20'57"S 72°31'32"W – 187 m.a.s.l.), on 26 September 2009. This last was under construction and both individuals were carrying feathers. Single records of individuals far from the econtonal habitat are: one individual at Ea. La Angostura, 22 March 2011 (SI); one individual at 'El Frigorífico', Chico River estuary (49°55'45"S 68°35'15"W – 45 m.a.s.l.), 9 June 2011 (SI); and lastly, a single individual seen at the grasslands of Ea. Vega del Osco (48°29'14"S 71°17'6"W – 900 m.a.s.l.), 27 March 2013 (IR).

Although the species is common in the ecotonal habitat of the western part of the province, these records are at the edge of its formerly known distribution (Darrieu *et al.* 2009a). The biology of this canastero is poorly known, therefore the information presented here, although anecdotal, adds some data that improves our understanding on the breeding behavior of this uncommon species. The observation at Ea. Vega del Osco represents the first record in the grasslands of the highland plateaus.

Cinnamon-bellied Ground-Tyrant *Muscisaxicola capistratus*

On 19 January 2011 a large flock of around 100 individuals of *Muscisaxicola capistratus* was found at a large patch of grasslands in Perito Moreno NP (47°46'18"S 72°05'25"W – 898 m.a.s.l.; IR, HC, JK). Principally juveniles composed this flock. The juveniles were identified by the lack of the contrasting regular pattern of the adults, with less-intense cinnamon coloration on the belly, less-defined black on the forehead, and smaller rufous patch on the crown.

Although this is a single record of a big flock, it is interesting due to the early date in the season (mid summer). This tyrant seems to be one of the first migratory species that leaves the region, particularly the highland plateaus where it breeds. Also it is interesting the fact that this ground-tyrant is one of the species that moves farther north, reaching areas of central Andes, northwestern Argentina and Bolivia (Fjeldså and Krabbe 1990). Although it is probably the most common tyrant of the highland plateaus of western Santa Cruz, there is almost no information about movements and population dynamics.

Southern Martin *Progne elegans*

During our fieldwork we found that *Progne elegans* is a regular summer reproductive visitor of Perito Moreno and Bajo Caracoles towns, and within the town limits the species seems to be present at abundances typical of other localities in northern Patagonia (IR, pers. obs.). In those localities it is found from mid/late November

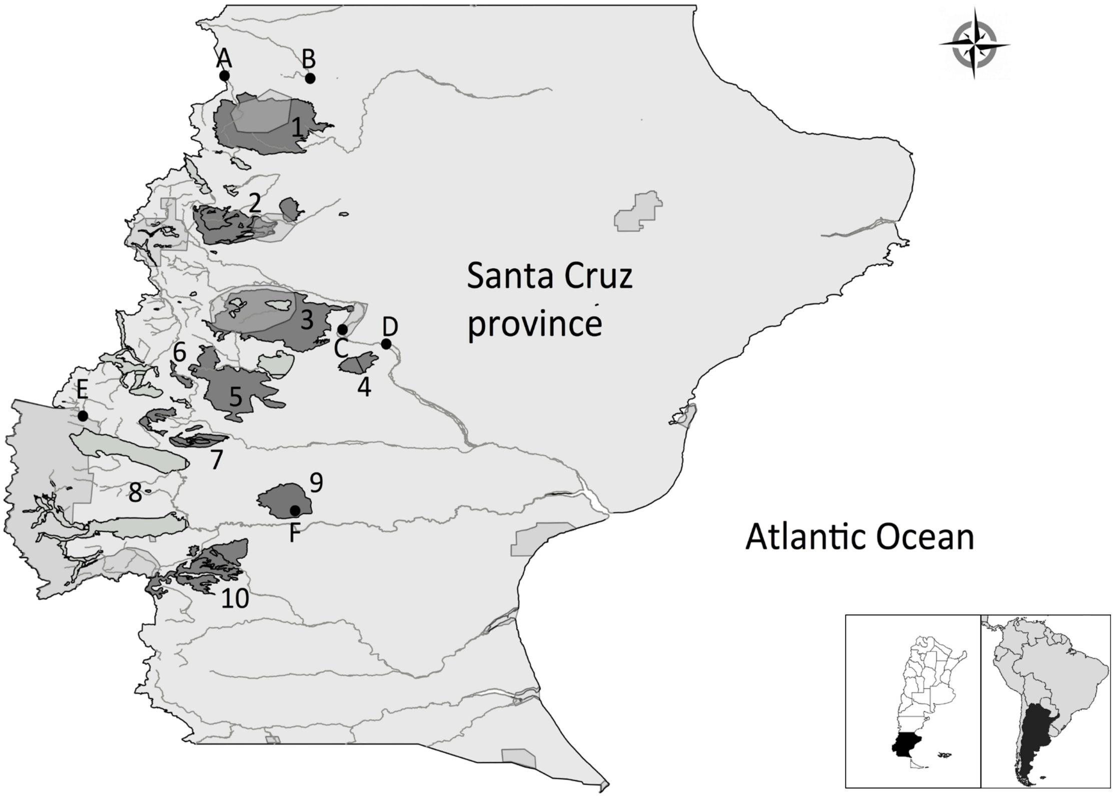

FIGURE 1. Map of Santa Cruz province with important sites. Dark grey, plateaus of western Santa Cruz province: 1) Buenos Aires; 2) Asador (north, central, and southern); 3) Strobel; 4) Cerro Ventana; 5) Siberia; 6) El Moro; 7) Viedma or del Tobiano; 8) La Gringa Lake; 9) Mata Amarilla; 10) Vizcachas. Light grey, Important Bird Areas (IBAs) of Santa Cruz. Medium grey, major lakes. Black dots, important locations mentioned in the text: A) Los Antiguos; B) Perito Moreno; C) Ea. La Angostura; D) Gobernador Gregores; E) El Chaltén; F) La Lechuza Stream, Mata Amarilla plateau.

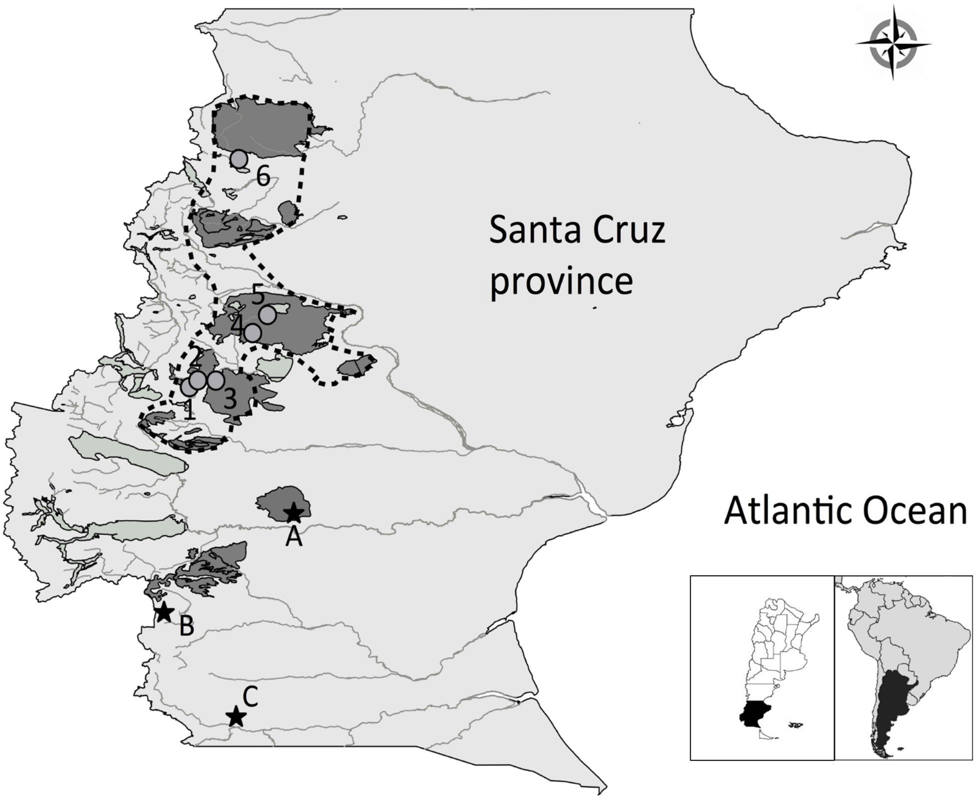

FIGURE 2. Records of Straight-billed Earthcreeper *Ochetorhynchus ruficaudus*, grey dots (arranged south-north): 1) El Moro plateau; 2) Cardiel Chico; 3) C199 Lake; 4) El Islote Lake; 5) Ea. Vega del Osco; 6) RP 41. Greater Yellow Finch *Sicalis auriventris* distribution: open line area shows the continuous distribution and black stars indicate isolated records: A) La Lechuza Stream, Mata Amarilla plateau; B) Los Baguales massif; C) Los Morros.

to late March. It is also regular at the cliffs of the Ecker River valley, at Ea. La Vizcaína and Ea. Rincon de Piedra (47º07'21"S 70º53'25"W – 704 m.a.s.l.), but with no more than 2-3 pairs every season. We also obtained four records from three new localities: a pair at '*puesto de veranda*' ('*puesto*' used during the summer season) in the Ea. 9 de Julio (47°06'53"S 71°09'10"W – 1,196 m.a.s.l.), on 15 January 2012 (IR, H. Slongo); one individual seen on 20 December 2012 (IR) and 18 January of 2013 (probably the same; JK) at Ea. El Sauco; three individuals (two males and a female) seen on 16 January 2013 at Ea. La Angostura (LGP, JK, IR); one male at a marshland next to the NR 40 (at the intersection with RP 41) (47°21'00"S 71°00'32"W – 457 m.a.s.l.).

The former known distribution of *P. elegans* in Santa Cruz province was restricted to the Deseado River valley, and cities north of it, with just three localities south of that area, mostly restricted to the eastern and central part of the province. Our records suggest that it is actually widespread in the west, probably associated with wooded areas around ranches. The new southernmost record is that from Ea. La Angostura, but it probably can also be found at Gobernador Gregores town and other ranches farther south, along the Chico River valley. All the known localities are shown in Figure 3.

Bank Swallow *Riparia riparia*

One pair was observed at S94 Lake, on Strobel plateau (48°35'33"S 71°14'11"W – 916 m.a.s.l.; JK, HC, IR), on 11 January 2011 (Figure 3). The individuals were in a mixed group of swallows, which included Chilean Swallow *Tachycineta meyeni* and Blue-and-White Swallow *Pygochelidon cyanoleuca*.

This observation represents the fourth published record for the province (Darrieu *et al.* 2009a), although there are several scattered unpublished observations (S. Sturzenbaun and A. Morgenthaler, pers. comm.). It is interesting that *R. riparia* is also rare in northern Patagonian provinces, like Chubut and Río Negro, with only one published record (Kirwan 2002).

Hellmayr's Pipit *Anthus hellmayri*

During our fieldwork we detected this species on only three occasions: one individual displaying at El Chaltén (49°19'49"S 72°53'34"W – 950 m.a.s.l.) on 21 December 2009 (IR); at least one individual displaying on several occasions during December 2011 and January 2012 at Ea. La Vizcaína (47°07'29"S 70°56'31"W – 780 m.a.s.l.),

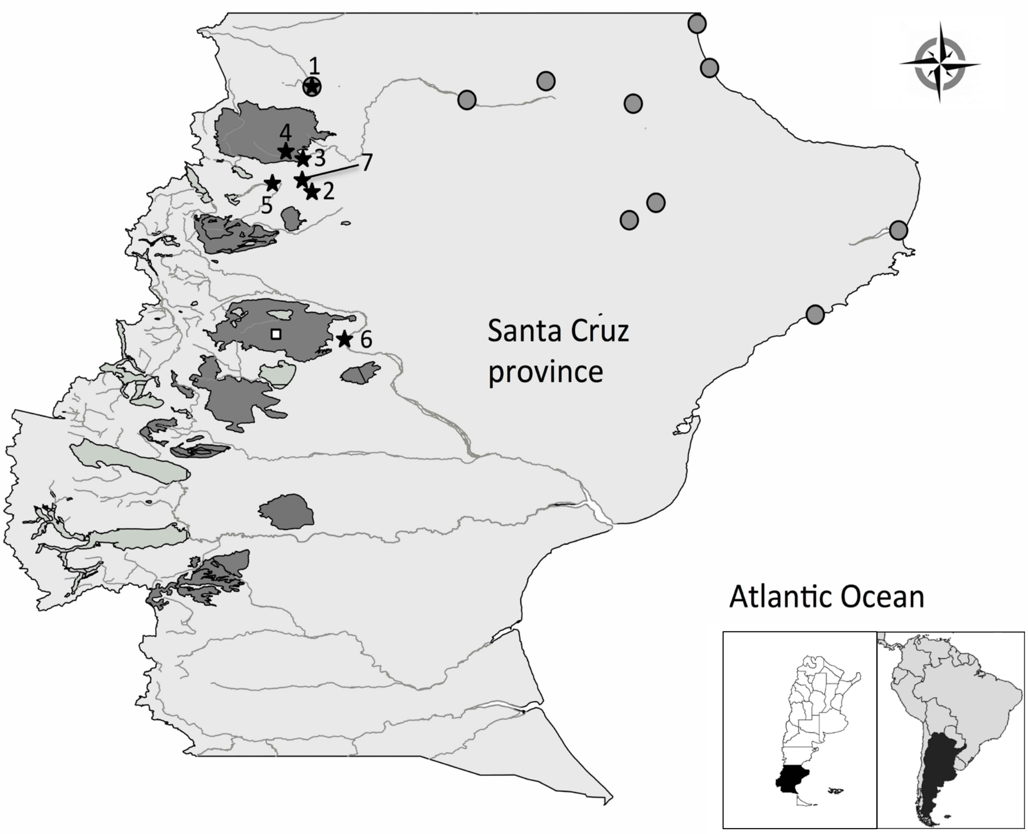

FIGURE 3. Map showing the distribution of Southern Martin *Progne elegans* and Bank Swallow *Riparia riparia* in Santa Cruz province. Grey dots indicate localities previously mentioned for *P. elegans* by Darrieu *et al* (2009a). New localities for *P. elegans* (black stars): 1) Perito Moreno; 2) Bajo Caracoles; 3) Ecker River valley; 4) *puesto* at Ea. 9 de Julio; 5) Ea. El Sauco; 6) Ea. La Angostura; 7) marshland at RN 40. The white square indicates the locality of *R. riparia* at Strobel plateau.

Buenos Aires plateau (IR); and at least two individuals displaying at Ea. La Victorina (48°59'43"S 71°30'28"W – 580 m.a.s.l.), La Siberia plateau, on November 2012 (IR, PH).

Although Hellmayr's Pipit has few published records for the province, most of them are from the southern and eastern part. These records along the plateaus of western Santa Cruz may reflect that it is more widespread than previously thought. All our records were obtained on wet, tall (> 30 cm), dense grasslands, mostly on '*vegas*' (small patches of wet areas with short vegetation) without cattle. Those '*vegas*' could be either natural or artificial, and are created or maintained as important areas for cattle feeding. The repeated observation of displaying individuals may indicate that the species reproduces in those localities.

Blue-and-Yellow Tanager *Pipraeidea bonariensis*

On 16 January 2013 one individual, probably a young male, was detected on the marshlands close to the houses of Ea. La Angostura. Shortly after, it flew towards the implanted woods around the houses of the ranch, and we could not locate it again.

Our conclusion about the age and sex was based on the overall coloration, but especially due to head pattern, which had a tinge of light blue, and the darker coloration on wings coverts. This record represents the first for Santa Cruz province (Darrieu *et al.* 2009a). The fact that this probably was a young male may indicate that it was a vagrant individual dispersing from its breeding grounds.

Greater Yellow Finch *Sicalis auriventris*

This is one of the most common finch species in areas over 700 m.a.s.l. principally around rocky cliffs. It is principally associated with plateau edges, basaltic lagoons, and rocky formations. We found it on all the plateaus we worked. Three juveniles were seen and photographed using a crevasse on 7 January 2013 at a lake on La Siberia plateau (49°05'27"S 71°34'71"W – 999 m.a.s.l.; SI, LGP, and H. Rodriguez Goñi). Apparently they were using it as a roosting place. Two nests were detected in early January 2013 on C199 Lake, also at Siberia plateau (49°01'29"S 71°44'00"W – 1,030 m.a.s.l.; LGP, JK, SI, IR). One of them was located 6 m above the ground on a flat rock wedged inside a crevasse of a 17-m long cliff. It was an open cup made with grass and it had 3 chicks. Fledglings left the nest on the 2 February 2013. The other nest was located on the same rocky outcrop wall, about 100 m from the first one. It contained two chicks, but this one was not monitored. There are several scattered records on the southernmost plateaus, but during our research we only found the species in a gorge of La Lechuza Stream, in Ea. Cerro Fortaleza, Mata Amarilla plateau (50°04'06"S 71°13'42"W – 863 m.a.s.l.) in February 2013 (IR). However, there are records further south on the south side of Baguales massif, Viscachas plateau (50°54'17"S 72°10'29"W – 328 m.a.s.l.) and at the volcanic formations known as 'Los Morros' in Ea. Glencross (51°44'54"S 71°32'19"W – 244 m.a.s.l.; SI), near the border with Chile. Estimated distribution in Santa Cruz is showed in Figure 2.

As mentioned above, the *Sicalis auriventris* is one of the most common finches of the upper plateau habitat in Santa Cruz province, being present in almost all the basaltic lakes, and in most rocky areas visited. Under 500 m.a.s.l. it becomes much rarer, at least in the northern part of the province, and this could be the reason why it was first mentioned for the province in 2003 (Imberti 2003) and only mentioned for six further localities (Darrieu *et al.* 2009a), while much less abundant in western Santa Cruz, the Patagonian Yellow Finch *Sicalis lebruni*, is well known due to it inhabits lowlands steppes. The scarcity of past records is certainly due to the inaccessibility of the habitat where *S. auriventris* mainly inhabits, being most of the places mentioned by Darrieu *et al.* (2009a) at low elevation. It is interesting that the lowest records are the ones in the southern part of the province.

Grassland Yellow Finch *Sicalis luteola*

One individual was detected in a grassland habitat next to the extensive marshlands of Ea. La Angostura, on 19 December 2009 (IR).

The species is common elsewhere in northern Argentina, but it has only five previously known localities in Santa Cruz province (Imberti 2003; Darrieu *et al.* 2009a), two of them close to the location of our record. It is odd that we found a lonely individual of this gregarious species, thus it could be a vagrant individual.

Shiny Cowbird *Molothrus bonariensis*

During our fieldwork we found this widespread cowbird on three occasions: a pair observed flying over the farmland area of Los Antiguos city (46°33'03"S 71°36'44"W – 212 m.a.s.l.), on 24 January 2011 (IR); at least another two in Ea. El Rincón (46°56'24"S 70°48'55"W – 725 m.a.s.l.), 23 January 2012 (SI); and lastly, three individuals (two males and a female) observed also in Los Antiguos city on 11 October 2013 (HC).

Molothrus bonariensis seems to be spreading south, and it has already reached the northern area of Los Glaciares NP (Imberti 2005; Darrieu *et al.* 2009a) where it is now observed regularly. It is also regular on the Atlantic Ocean coast at Piedra Buena city (N. Moreno, pers. comm. 2009) and in Monte León NP (E. Militello, pers. comm.). There are also records further south in Chile (Venegas and Sielfeld 1998). It seems that either its population remains restricted to human settlements or it has not succeeded establishing a regular population in the province. Although we regularly visited farmlands and towns during our surveys, we failed to obtain further observations, including in those areas where the species has already been seen (i.e., Perito Moreno NP). Further records will be necessary to assess the situation of the species in Santa Cruz.

DISCUSSION

The observations presented here contribute to the knowledge of the distribution and natural history of the birds of Santa Cruz. We presented data of 21 rare or threatened species, five of which were new to the province. Many of the observations of the poorly known (or new) species for the province could represent actual range expansions of their populations, principally in the cases of the *Molothrus bonariensis*, *Patagioenas picazuro*, and *Parabuteo unicinctus*. The new localities for two threatened species, *Podiceps gallardoi* and *Rallus antarcticus*, brings hope for the future, indicating that perhaps there are still some other unknown localities. In the case of *Podiceps gallardoi*, the lake at Mata Amarilla plateau is of capital importance because it is the closest to the almost extinct population that was initially found on the Vizcachas plateau (Roesler *et al.* 2012). In the case of *Rallus antarcticus*, the relationship between unsuccessful searches in proper habitats and the presence of American mink must be studied in a deeper way. The distribution of the American mink seems to be much more extensive than previously thought within continental Patagonia (Fasola and Roesler, unpubl. data), so the impact of this invasive species on the rail's population could be bigger than previously thought (Mazar Barnett *et al.* 2013). Further studies on the avifauna of Santa Cruz will clarify the situation of several of the species mentioned in this article, but we consider that special emphasis must be given to those areas that still support rare and threatened species.

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Tachyeres
(b.) leucocephalus

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ARTICLE

Observations on the breeding biology of the Pygmy Nightjar *Nyctipolus hirundinaceus* in the *Caatinga* of Bahia and Ceará, Brazil

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ABSTRACT: We present the first details of nesting sites, eggs, and chicks of the Pygmy Nightjar (*Nyctipolus hirundinaceus*), a small nocturnal bird endemic to northeastern Brazil. We conducted behavioral observations near Curaçá in northern Bahia, and at Potengí, southern Ceará, both located in the heart of the Brazilian *Caatinga*. We found four 'nests' in Bahia and another five in Ceará. In all cases, a single egg was laid, and only the females took care of the chick during the day. Pygmy Nightjars in both places bred mostly during the rainy season, as do most of the bird species in the region. By gathering breeding data from throughout the species distribution, we observed that although most populations (*c.* 75 %) breed during the rainy season, some populations of the race *cearae* also seem to breed during the dry season.

KEY WORDS: Brazil, Caprimulgidae, eggs, nesting biology, reproduction.

INTRODUCTION

The family Caprimulgidae, which contains nighthawks and nightjars, includes cryptically colored, mainly nocturnal species that are often difficult to find and observe. More commonly heard than seen, several basic aspects of their biology remain poorly known, especially for the Neotropical members of the family (Cleere 1998, 1999; Holyoak 2001). Their breeding biology is particularly under-studied; the most recent monographs on the family have pointed out that ~70% of all species had either 'no breeding information' or their breeding biology was 'poorly known' (Cleere 1998, 1999; Holyoak 2001).

Among the least known species in the family is the Pygmy Nightjar (*Nyctipolus hirundinaceus*), endemic to the Brazilian northeast, where three described allopatric subspecies (*hirundinaceus*, *cearae*, and *vielliardi*) occupy open areas in light woodland, scrubland, and areas with xeric vegetation locally known as *Caatinga* (*hirundinaceus* and *cearae*), as well as areas with xeric vegetation on inselbergs in the Atlantic Forest (*veilliardi*; Cleere 1999). As the name suggests, the Pygmy Nightjar is among the smallest Neotropical members of the family (16 – 20 cm), and seems to prefer to some extent the vicinity of flat rocky outcrops (*lajeiros*) both in the *Caatinga* and the Atlantic Forest (Sick 1997; Vasconcelos & Lins 1999; Ingels *et al*. 2014).

The evolutionary relationships of this nightjar are only now starting to be unveiled. Formerly located in the genus *Caprimulgus*, the Pygmy Nightjar was recently placed in an expanded genus *Hydropsalis* by the Comitê Brasileiro de Registros Ornitológicos (2014), following the taxonomic recommendations of Han *et al.* (2010). More recently, the South American Checklist Committee (Remsen *et al*. 2014) decided to resurrect the genus *Nyctipolus*, including both *N. hirundinaceus* and the Blackish Nightjar (*Nyctipolus nigrescens*), following the recent findings of the first available molecular sequences of Pygmy Nightjar (Sigurdsson & Cracraft 2014).

During January and February 1997, JMB, LNN, and ALR spent several weeks in the *Caatinga* of Curaçá, located in the interior of the Brazilian state of Bahia (see Mazar Barnett *et al.* 2014 for a more detailed description of this site). During that time, while working for the Spix's Macaw Project (*Projeto Ararinha-azul*), they observed and documented the breeding behavior of 29 different species of birds (Mazar Barnett *et al.* 2014), including several with undescribed nests at the time, such as the Cactus Parakeet (*Aratinga cactorum*; Naka 1997), the Lesser Nighthawk (*Chordeiles pusillus*; Leite *et al.* 1997), the Scarlet-throated Tanager (*Compsothraupis loricata*; Mazar Barnett *et al.* 2014), and the Pygmy Nightjar, of which four 'nests' were found around the Spix's Macaw Project headquarters, at Fazenda Concordia. Although some basic information from these observations has been reported elsewhere (Cleere 1998, 1999; Holyoak 2001), detailed information on the breeding biology of the Pygmy Nightjar remains lacking. More recently, JLGL found, and reports here on, five eggs in southern Ceará, some 250 km north of Curaçá.

Here, we present the first detailed description of the 'nest,' eggs, and chicks of the Pygmy Nightjar, including observations on the general breeding behavior of this Brazilian endemic nightjar. We discuss the timing of breeding in relation to rainfall, and compare our data with newly available breeding information obtained from throughout the species' distributional range.

METHODS

We studied the breeding behavior of Pygmy Nightjars at Fazenda Concórdia (09°09'S, 39°45'W), situated *c.*25 km south of Curaçá in northern Bahia (Mazar Barnett *et al.* 2014) and at Sítio Pau Preto (07º04'S, 40º05'W), located *c.*5 km west of Potengí in southern Ceará. Both regions are covered by scrubland and dry woodland. Fazenda Concórdia is covered by open xeric vegetation, dominated by bushes and small trees such as, *Cnidoscolus phyllacanthus* (Euphorbiaceae), *Jatropha mollissima* (Euphorbiaceae), *Caesalpinia pyramidalis* (Caesalpinoideae), and several species of cacti. Along the seasonal streams filled during the rainy season grows riparian forest dominated by tall *Tabebuia caraiba* (Bignoniaceae) trees. Sítio Pau Preto is known for having an artificial pond that provides water to the town of Potengí. Both areas present clayish soil with abundant gravel, pebbles, and rocks, although Sítio Pau Preto seems to have more rocky outcrops. The natural vegetation cover of both areas has been severely modified. Fazenda Concórdia has been subjected to heavy grazing by goats and cattle, resulting in a heavily eroded land, whereas corn and bean plantations were the main economic activities at Sítio Pau Preto. Although both sites are located in the heart of the semi-arid interior of the *Caatinga*, Curaçá is better known for the presence, until recently, of the last surviving wild Spix's Macaw (*Cyanopsitta spixii*) (da Ré 1995, Mazar Barnett *et al.* 2014).

Observations around Fazenda Concórdia near Curaçá were made between 2 January and 3 February 1997 by JMB, LNN, and ALR, whereas observations at Sítio Pau Preto near Potengi were made by JLGL between November 2013 and May 2014. To evaluate whether there is a seasonal pattern in the breeding behavior of the Pygmy Nightjar, we gathered additional data from an online source, namely WikiAves (www.wikiaves.org), where dated and georeferenced photographs of both eggs and chicks were available (Table 1). To determine the breeding time of the species from available photographs, we used the date when the egg was photographed. For the chicks, we estimated their age in days, and then calculated the date the eggs were likely laid using a 16-day incubation period, as has been previously reported for similar-sized nightjars (Cleere 1999). Although the accuracy of this method is not ideal, we believe it is accurate enough to shed light on the general breeding patterns of the species. Because there is considerable geographic variation in the patterns of rainfall throughout the distribution range of the Pygmy Nightjar, we obtained rainfall data for each locality, when available. When these data were not available for the exact location where the eggs and chicks were photographed, we used rainfall data from the closest locality available (Table 1). Rainfall data (1911-2009) for Bahia, Paraíba, Rio Grande do Norte, and Ceará were obtained from the Departamento de Ciências Atmosféricas (DCA), Universidade Federal de Campina Grande (http://www.dca.ufcg.edu.br/clima); data for Minas Gerais were obtained from the Instituto Nacional de Pesquisas Espaciais (INPE), Centro de Previsão de Tempo e Estudos Climáticos (CPTEC) (http://www.cptec.inpe.br/cidades/). We considered records prior to the two rainiest months as early rainy season, during the two rainiest months as rainy season, and after the two rainiest months as late rainy season. We considered the first month of drought as early dry season, the last month of drought as late dry season, and all months in between as the dry season.

RESULTS

General observations

Although no quantitative estimates of density or abundance of the Pygmy Nightjar were made either at Fazenda Concórdia or Sítio Pau Preto, we noted that several individuals or pairs lived in close proximity, and we believe the species was fairly common in both areas, as individuals were seen on a daily basis. At Fazenda Concórdia, feeding bouts at night were observed as described by Vasconcelos and Figueiredo (1996; Figure

1), with birds sallying *c.* 0.5 to 1.0-m upwards from the ground and landing back on the same spot. We also noted individuals that appeared to be feeding while flying very low over large areas of open ground, mostly in circles or loose figures. Once, a female was observed sitting in the middle of the road, making sharp sideward movements with her head, apparently capturing tiny coleopterans that swarmed in myriads around her. At Sítio Pau Preto, where rocky outcrops are more abundant, Pygmy Nightjars were seen exclusively in these locations.

No body mass data are available for this species (Holyoak 2001). An adult male captured at Fazenda Concórdia weighed 32 g. The length of his wings and tail, 133 and 92 mm respectively, seems to place it near the nominate race, for which Cleere (1998) gives ranges of 119-130 mm and 77-94 mm.

Description of the nest, egg, and chick

As is the case for the rest of the family, no actual nest is built by Pygmy Nighjars. Four eggs of at least three breeding pairs were found in January 1997 at Fazenda Concórdia. Three nests (nests A, B, and C) were found on the side of an unpaved road used occasionally by vehicles and pedestrians, and one nest (nest D) was found *c.* 15 m-away from the same road and within meters of a rocky outcrop. Nest A was situated near a house surrounded by lush woody vegetation. Nests B and C were found in an area of open *Caatinga* with sparse low vegetation and large areas of bare soil and stony ground. The two roadside nests B and C, and nest D were within 15 to 20 m of each other, whereas nest A was *c.* 350 m from the other ones. Most observations were made at nest A. We presume that the four eggs belonged to three different pairs: nest A belonged to one pair, nests B and C probably to a second pair, and nest D to a third one. The egg of nest C is presumed to be a replacement clutch for the egg of nest B, which was abandoned and likely eaten by a predator.

All nests contained a single egg, laid directly on the sandy to stony ground. The area immediately around the eggs was cleared of small gravel, probably as a result of comfort movements when an adult installs itself on the egg. All eggs had a pale buffy-cream ground color, with irregular rufous reddish spots and dark blotches, similar to other eggs of this species found elsewhere in the *Caatinga* (Figure 1). Three eggs measured 24.1 x 18.3 mm, 24.3 x 18.0 mm, and 24.7 x 17.4 mm.

The egg of nest A was found on 6 January 1997 and was probably laid a few days earlier. A second egg (nest B) was found in early January, but it already seemed abandoned and remained unattended for about two weeks, when it finally disappeared. The egg of nest C was found on 24 January, whereas the egg of nest D was found broken, with an almost fully-grown chick inside, on 3 February.

FIGURE 1. Egg of Pygmy Nightjar (*Nyctipolus hirundinaceus*) found in a depression filled with vegetal litter, gravel, and rock debris on rocky outcrop (*lajeiro*) Morada Nova (Ceará, 05°07'S, 38°23'W). Photograph by Arthur Grosset.

Two of the eggs found eventually hatched. A chick, estimated to be 2-4 days old, weighing 4 g was found at nest A on 24 January. It was covered with grayish white down with a pattern of rufous-brown lines. On 28 January, when we estimated the chick was 6–8 days old, it weighed 7.5 g, and the first feather shafts appeared, rufous on the scapulars, and dark in the wings and tail (see Figure 2 for a similar looking chick). A day later it weighed 9 g. The egg of nest C apparently hatched on 3 February, but we could only find the two halves of the eggshell, with no sign of a hatchling or any of the adults. Given that an egg of a few days old was found on 6 January at nest A and a 2-4 days old chick was found there 18 days later, we believe that the incubation period lasts at least 16 days.

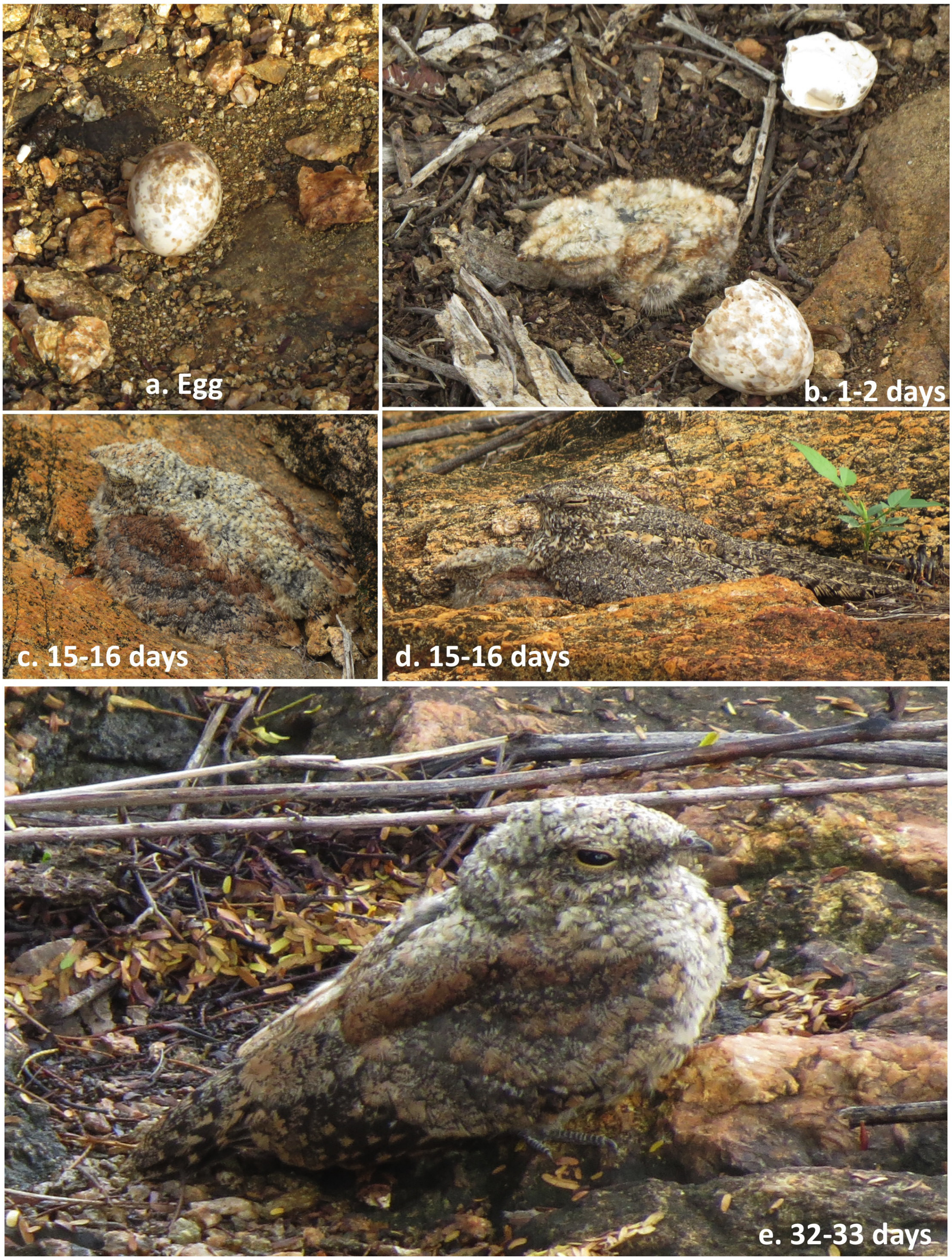

FIGURE 2. Temporal series of an egg, chick, and young of Pygmy Nightjar (*Nyctipolus hirundinaceus*) at Sítio Pau Preto near Potengí. A) First egg found at site (18 November 2013); B) chick of 1-2 days old (1 February 2014); C) chick of 15-16 days old (16 February 2014); D) same chick with adult female (16 February 2014); E) young bird of 31-32 days old (4 March 2014).

Five eggs were found at Sítio Pau Preto between November and May, 2014. All eggs were found on three rocky outcrops; 3 on rock 1, and 1 on rock 2 and 3, respectively, located some 300 m apart. All rocky outcrops were relatively small: rock 1 measured 40 x 40 m (~1600 m^2), rock 2 measured 26 x 15 m (~340 m^2), and rock 3 measured 40 x 20 m (~800 m^2). A first egg (Figure 2a) was found in a crack on rock 1 on 18 November 2013, a couple of weeks before the beginning of the rainy season, which arrived on 16 December in that particular year. The fate of that egg was not followed, but on 1 February 2014 a recently hatched chick (Figure 2b) was found on the same rock, 5 m from the site where the above mentioned egg was found, but obviously from a different egg, although likely from the same breeding pair. That same chick, with an estimated age of 16 days old (Figure 2c), was observed on 16 February being protected by an adult female (Figure 2d). Presumably the same young bird was observed again on 4 March at an estimated age of 32-33 days (Figure 2e). All observations were done on the some rocky outcrop and an adult bird was always found in the area. On 4 March, four adult birds were observed at the outcrop. A new visit to rock 1 on 23 March resulted in the finding of a third egg, laid at exactly the same place where the chick was found on 16 February. Although it is likely that this third egg was laid by the same pair, several adult birds were seen on rock 1, and the use of the same place for breeding by different pairs cannot be discarded. This egg could not be relocated on subsequent visits to the rock. On 26 March 2014 another egg was found at rock 2, and on 31 May 2014 a fifth egg was found on rock 3 (Figure 3). In all cases, the eggs were laid directly on the bare rock (Figs. 2 and 3).

Behavior of the chick

Our observations suggest that a chick remains around its nesting site for at least four weeks after hatching. At Curaçá, during the first days after hatching, the chick of nest A remained in the immediate vicinity of the nest site, never moving more than 0.5 m away from that spot. These movements were apparently not related to the availability of shade. Six to eight days after hatching, the chick had moved 2.5 m away from the original nesting

FIGURE 3. Rocky outcrop (*lajeiro*) at Sítio Pau Preto (rock 3) near Potengí and egg of Pygmy Nightjar (*Nyctipolus hirundinaceus*) found on 31 May 2014.

site. At Potengí, the chick found in February remained on the rocky outcrop until at least 32 days old, only moving 1 m away from the egg shells after two weeks, and *c.*10 m after 4 weeks.

Detailed observations at Curaçá revealed that at dusk when the adults became active, the chick stretched and walked around. On occasions, it also made short jumps like the adults do when alarmed. It always remained in the open, but quickly ran to the edge of dense grass to seek cover, when the breeding adult was flushed by approaching humans. When the adult returned and while still approaching, the chick sometimes ran up to it, seeking cover under its raised breast feathers. Food begging was by means of tapping the bill of the adult. When handled, the chick uttered soft alarm calls.

Behavior of the adults at the nest

During daytime, only the female was seen incubating the egg or brooding the chick, both at nest A (at Curaçá) and rock 1 (at Potengí). We never saw the male attending the nest before dusk. At Curaçá, throughout the incubation period, the egg remained almost at the same spot, moving only a few cm sometimes, probably as a result of an adult turning it. When the female was flushed during the day, it took her only *c.*1 to 2 min to return to the nest site, and even less, once the chick had hatched. To return, the adult usually landed 1 to 2 m away from the egg or chick, slowly approaching it by walking in a semi-circle.

The male that we assumed to be associated with nest A roosted within *c.*5 to 15 m from the nest, in the cover of light leguminous shrubs or trees, as noted by Vasconcelos and Figueiredo (1996). Normally, the male was observed taking over the nest at dusk, and was more shy and nervous than the female, as he was probably less used to our presence. The male also gave alarm calls more often. On occasions, he performed a distraction display by walking short distances with fanned tail and spread wings raised slightly in V-shape. The female performed a different distraction display by flattening her body against the ground and flapping her wings while crawling away from the nest site, a display resembling a 'broken wing display.' The male was seen to do a similar display only once. Both adults responded vigorously to the playback of the chick's calls, with the female once flying very close, producing dry sounds by clapping her wings.

Annual rainfall and breeding season

Five of the nine eggs found during our studies were laid during the early rainy season before the heavier rains arrived, three during the rainy season, and only one egg was laid before the arrival of the rainy season (Table 1). We obtained data for 7 additional eggs and 11 chicks found throughout the distribution range of the Pygmy Nightjar. Surprisingly, we found reports of nesting birds from throughout the year. The only months lacking nesting records are August and December. Thus, breeding records include all seasons, from the early dry to the late rainy season (Table 1).

DISCUSSION

The clutch of the Pygmy Nightjar consists of a single egg. Our own observations and 18 additional records report a single egg or chick (Table 1). Although it has been claimed that the clutch size of the Pygmy Nightjar is one or two eggs (Cleere 2010; WikiAves 2013), we have not found any evidence of more than one egg. On the other hand, although we did not mark adult breeding birds, our observations from Potengí suggest that a single pair laid three eggs during five months (November, January, and March) at two individual spots located 5 m apart.

Comparing available pictures (Table 1), egg coloration seems very similar throughout the range of the species, which is in contrast to the large color variation found in the adults. Although the Pygmy Nightjar is considered a rocky outcrop specialist (Ingels *et al.* 2014) our data from Curaçá demonstrate that this species can breed away from these substrates, using bare ground. On the other hand, it seems that when rocky outcrops are available as in Potengí, Pygmy Nightjars will lay their eggs exclusively on these outcrops. A detailed study of rocky outcrop availability and nesting site selection by this species may shed a light on this issue.

A striking feature of our observations at Fazenda Concórdia was the close proximity of three of the Pygmy Nightjar nests. Sick (1997) mentions that Little Nightjars (*Setopagis parvulus*) and Sand-colored Nighthawks (*Chordeiles rupestris*) occasionally breed in groups, while Cleere (1999) noted that some caprimulgids breed in a semi-colonial or even colonial way. The Blackish Nightjar, the closest relatives of the Pygmy Nightjar, is known to breed in an almost colonial way on inselbergs in primary rainforest in the Guianas (Ingels *et al.* 1984, 2009; Cleere & Ingels 2002). Unfortunately, the small number of nests with detailed observations does not allow a conclusion about communal nesting by Pygmy Nightjars.

The breeding of nightjars is often linked to moon phases and annual rainfall (Cleere 1999). In most cases, this is likely related to the abundance of food resources, particularly insect abundance. The *Caatinga* is an extremely seasonal environment, and most breeding seems to take place during the beginning of the rainy season, when insect abundance peaks in the region (Vasconcelos *et al.* 2010). The rainy season in Curaçá, which lasts a few months, seems to be the preferred season to breed for most species (Mazar Barnett *et al.* 2014), including the Pygmy Nightjar. From the 27 breeding events we report

TABLE 1. Breeding records of the Pygmy Nightjar (*Nyctipolus hirundinaceus*) currently available, including estimated date, coordinates, season when it was laid, and references. Date of eggs is represented by the actual date when they were found and photographed, whereas date of chicks represents our estimate of the date when the egg was laid, considering a 16-day incubation period.

Race	Locality	State	Coordinates	Date	Year	Season	Author	Reference
Eggs								
hirundinaceus	Curaçá	Bahia	09°09'S, 39°45'W	6 January	1997	Early rainy	This study	
			”	8 January	1997	Early rainy	This study	
			”	24 January	1997	Early rainy	This study	
			”	3 February	1997	Early rainy	This study	
cearae	Morada Nova	Ceará	05°07'S, 38°22'W	20 October	2008	Dry	A. Grosset	Ingels et al. 2014
			“	20 October	2008	Dry	A. Grosset	Ingels et al. 2014
cearae	Ipueira	Rio Grande do Norte	06°28'S, 37°23'W	1 September	2009	Dry	T. Silva	WA59203
cearae	São Mamede	Paraíba	06°56'S, 37°06'W	1 July	2009	Early dry	J. Medkraft	WA32531
cearae	Massapê	Ceará	03°31'S, 40°20'W	1 November	2010	Late dry	A. Netto	WA232763
hirundinaceus	Manoel Vitorino	Bahia	14°08'S, 40°14'W	14 January	2012	Late rainy	O. Borges	WA548127
cearae	Jaguaribara	Ceará	05°40'S, 38°37'W	28 May	2013	Late rainy	K. Serra	WA973865
cearae	Potengi	Ceará	07°04'S, 40°05'W	18 November	2013	Late dry	This study	WA1156756
			”	23 March	2014	Rainy	This study	
			”	26 March	2014	Rainy	This study	
				31 May	2014	Late rainy	This study	Fig. 3
Chicks								
hirundinaceus	Mamonas	Minas Gerais	16°08'S, 43°32'W	6 March	2005	Rainy	E. Luiz	WA172359
hirundinaceus	Boa Nova	Bahia	14°21'S, 40°12'W	20 February	2007	Late rainy	E. Luiz	WA167354
			”	24 February	2007	Late rainy	E. Luiz	WA167358
cearae	Massapê	Ceará	03°31'S, 40°20'W	12 October	2009	Dry	A. Netto	WA75163
cearae	Quixadá	Ceará	04°58'S, 39°00'W	29 June	2009	Late rainy	R. Bessa	WA182099
cearae	Equador	Rio Grande do Norte	06°56'S, 36°43'W	15 February	2009	Early rainy	L. Gonzaga	WA343446
cearae	São Mamede	Paraíba	06°56'S, 37°06'W	21 April	2009	Rainy	J. Medkraft	WA22688
			”	17 May	2009	Late rainy	J. Medkraft	WA26653
			”	13 February	2010	Rainy	J. Medkraft	WA118078
cearae	Quixadá	Ceará	04°58'S, 39°00'W	9 June	2011	Late rainy	C. Albano	WA390021
cearae	Parelhas	Rio Grande do Norte	06°41'S, 36°39'W	21 April	2011	Rainy	L. Gonzaga	WA355490
cearae	Potengi	Ceará	07°04'S, 40°05'W	1 February	2014	Early rainy	This study	WA1285132

in this paper (Table 1), 20 (*c.*75%) occurred during the early rainy, rainy, or late rainy seasons. One case occurred during the early dry, four during the dry, and two during the late dry season (Table 1). Interestingly, all of the seven dry-season breeding records were observed in Ceará, Paraíba, and Rio Grande do Norte, within the range of the race *cearae*. None of the nesting records further south (presumably within the range of the nominate race) were found during the dry season (Table 1). But this does not seem to be the rule, as rainy-season breeders have also been reported in all regions (Table 1). On the other hand, none of the breeding records of the nominate race were found during the dry season.

Rainfall in the *Caatinga*, however, can be dramatically erratic, and can sometimes fail to arrive in any given year (Ab'Saber 1977). This region is well known for long and fierce draughts that can extend for up to two years. It is possible that local changes in the seasonal patterns of rainfall may explain these differences, and it would be necessary to collect rainfall and breeding data in the same years to make warranted correlations. On the other hand, ground-nesting nightjars must deal with the danger of heavy rainfall, which may drown the chick or cool the eggs. Blackish Nightjars living on *inselbergs* in French Guiana and Suriname only breed during the dry season, refraining form breeding when monthly precipitation exceeds *c.* 300 mm of rain (Ingels *et al.* 1984). In the case of the Pygmy Nightjar, it seems that the total annual rainfall in the *Caatinga* is low enough and it rarely rains more than 200 mm/month, so that avoiding the rainy season may not be necessary.

Data on the breeding of the Atlantic Forest race (*vielliardi*) are not yet available, but given the isolated nature of the three allopatric populations of Pygmy Nightjar, the seasonal timing of reproduction may represent an important pre-zygotic isolating mechanism worth exploring in future studies.

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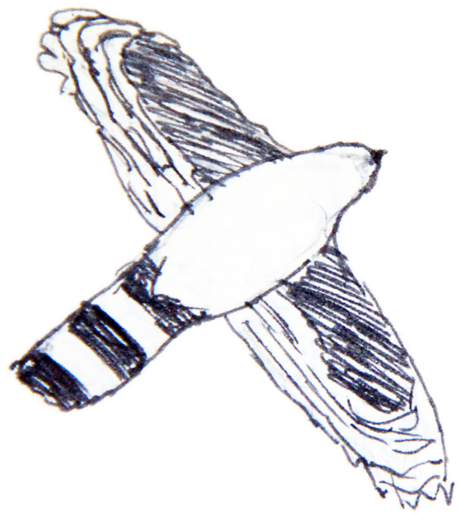

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ARTICLE

The habitat preference of the endemic Pygmy Nightjar *Nyctipolus hirundinaceus* (Caprimulgidae) of Brazil

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ABSTRACT: We discuss the choice of habitats for roosting and breeding by the Pygmy Nightjar (*Nyctipolus hirundinaceus*), a Brazilian endemic from the eastern part of the country. We observed that the choice of nesting and roosting sites of this nightjar is closely connected to open gravelly and stony areas (*lajeiros*) in the Caatinga and to rocky outcrops (*pedras*) in the Atlantic Forest, which allows us to conclude that the Pygmy Nightjar is a rupicolous nightjar, preferring rocky substrates for roosting and breeding.

KEY-WORDS: Caprimulgidae, habitat choice, nesting sites, rocky substrate, roosting sites.

INTRODUCTION

The Pygmy Nightjar (*Nyctipolus hirundinaceus*) is one of the smallest Neotropical nightjars (16-20 cm, Cleere 1998; 16.5-19 cm, Holyoak 2001), endemic to eastern Brazil, where it is found east of approximately 46°W (Cleere 1998, Holyoak 2001). Until recently, this nightjar was considered a species typical of the Caatinga in north-eastern Brazil, where two subspecies occur: nominate *hirundinaceus* from southern Piauí south-eastwards to central Bahia and northern Minas Gerais, and *cearae* from Ceará to extreme northern Bahia. Both are found in open areas in the xerophytic, deciduous and spiny shrub and tree formations, often on or near more or less extensive, low granite-quartz outcrops called *lajeiros* (Sick 1993, Cleere 1998, Holyoak 2001, Sigrist 2009).

In 1995, a third subspecies *vielliardi* was described from a specimen collected on a granite-gneiss outcrop near Colatina in Espírito Santo (Ribon 1995). Later it was also discovered in extreme eastern Minas Gerais, close to Espírito Santo (Vasconcelos & Lins 1998, 1999). On these granite-gneiss outcrops or inselbergs in the Atlantic Forest called *pedras*, it is mostly found among xeric vegetation resembling the north-eastern Brazilian Caatinga (Ribon 1995, Vasconcelos & Lins 1998, 1999).

The dorsal plumage color of nightjars is well adapted to the habitats in which they live (see pp. 306-307 in Cleere 1999). The upperparts of the nominate form *hirundinaceus* are described as light grayish brown, while *cearae* has a somewhat paler and *vielliardi* a darker plumage (Ribon 1995, Cleere 1998, Holyoak 2001). These differences in general plumage color of the three subspecies are well illustrated by photos in Cleere (2010, see pp. 180-181).

We document and discuss the apparent preference of the Pygmy Nightjar for open gravelly and stony areas in the Caatinga and rocky outcrops in the Atlantic Forest.

MATERIALS AND METHODS

Roosting and nesting Pygmy Nightjars were found by random searching during the day at eight localities in eastern Brazil. Observations at night were made at two localities. Details about these localities are given in Appendix 1. An individual is described as roosting when it is sitting crouched down with eyes (almost) closed and we consider roosting as a daytime activity. Observations made at four localities have already been published. At four other localities we made previously unpublished observations.

Furthermore, we checked 209 photos of Pygmy Nightjars made during daytime and published on the Brazilian site WikiAves (2013) for the environment in which they were photographed and for the substrate they were roosting or breeding on: plant litter, bare soil, gravel or rock. These photos were made in the following Brazilian states: Ceará (83), Bahia (60), Paraíba (14), Rio Grande do Norte (6), Piauí (5), Pernambuco (5) and Alagoas (2) in the Caatinga, and Espírito Santo (23) and Minas Gerais (11) in the Atlantic Forest. WA voucher numbers of photographs with an egg or a chick can be found in Mazar Barnett *et al*. (this volume, Table 1).

RESULTS

Choice of habitat by each subspecies

Nyctipolus hirundinaceus cearae

Between 13 and 17 June 1995, M. F. V. studied this nightjar at the Estação Ecológica de Aiuaba near Aiuaba in south-western Ceará (Vasconcelos & Figueiredo 1996). The region is covered by Caatinga, with large areas of bare soil. Pygmy Nightjars were found roosting during daytime in open areas with bare soil, along dirt roads and on rocky areas in the grounds of the ecological station. At night, they were seen hunting for insects by sallying from the ground in open areas, from dirt roads and from the paved roads around the headquarters.

On 20 October 2008, A. Grosset and C. Albano (Grosset 2005) found a dozen individuals of this subspecies among xeric vegetation on a rather flat, stony outcrop or *lajeiro* called Morada Nova in northern Ceará (Figure 1). They also found two nests, depressions in the rock filled with vegetal litter, gravel and/or rock debris, each with one egg incubated by an individual (Figures 2 & 3).

Nyctipolus hirundinaceus hirundinaceus

Between 2 January and 3 February 1997, J. M. B. studied Pygmy Nightjars on Fazenda Concórdia, *c*.30 km from Curaçá in northern Bahia, a region of semi-desert scrubland and dry woodland. The fazenda presents open xeric vegetation, locally called *sertão*, dominated by several species of cacti (Cactaceae: *Cereus jamacaru, Pilosocereus gounellei*), and bushes and small trees (Euphorbiaceae: *Cnidoscolus phyllacanthus*, *Jatropha mollissima*; Caesalpinoideae: *Caesalpinia pyramidalis*), on soil with abundant gravel, pebbles and rocks. The vegetation was subject to heavy grazing by goats and cattle. Pygmy Nightjars were fairly common around the fazenda. Four nests, each with one egg, were found in an area of open Caatinga with sparse low vegetation and large areas of bare soil and stony ground. Eggs were laid directly on the substrate. Three nests were found at the side of a dirt road, a fourth one *c*.15 m away from this dirt road and a few meters from a rocky outcrop (Mazar Barnett *et al*. this volume).

On 4 December 2006 during daytime, M. F. V. observed one individual roosting on a rocky outcrop intermixed with arboreal caatinga in the margins of Cachoeira do Pajeú, Monte Azul, northern Minas Gerais. This bird was flushed three times and it always alighted on the rocky outcrop. The observation of this subspecies is the second for this Brazilian state (Kirwan *et al*. 2004).

FIGURE 1. *Lajeiro* Morada Nova (Ceará, 04°50'S, 38°37'W) where Pygmy Nightjars (*Nyctipolus hirundinaceus cearae*) were breeding. Photo by A. Grosset.

FIGURE 2. Nest site of Pygmy Nightjar (*Nyctipolus hirundinaceus cearae*) with an egg (arrow), found near vegetation on *lajeiro* Morada Nova (Ceará, 04°50'S, 38°37'W). Photo by A. Grosset.

FIGURE 3. Close-up of the egg of Pygmy Nightjar (*Nytipolus hirundinaceus cearae*) of Figure 2, laid among fallen cactus thorns on a layer of fine gravel and vegetal litter on *lajeiro* Morada Nova (Ceará, 04°50'S, 38°37'W). Surprising how well the color pattern of the egg blends with its surroundings. Photo by A. Grosset.

On 5 May 2008 at night, M. F. V. observed at least three individuals foraging for insects along a gravel road at the base of the massif of Morro do Chapéu in Jacaraci, southern Bahia. This road was adjacent to a quartzite outcrop.

On 25 and 26 September 2010, A. Grosset (pers. comm.) found Pygmy Nightjars on a *lajeiro* near Boa Nova in northern Bahia. This rocky outcrop was partly covered with low xeric vegetation, e.g. cacti (Cactaceae: *Melocactus* spp.) (Figure 4).

Nyctipolus hirundinaceus vielliardi

On 19 September 1993, Ribon (1995) collected the first specimen of this subspecies on a *pedra* near Colatina in Espírito Santo. The region of Colatina is characterized by relatively dry vegetation, quite different from the surrounding Atlantic Forest. The region has a remarkable extent of rocky outcrops, providing a particular habitat where Pygmy Nightjars are found (Figure 5) (R. Ribon pers. comm.).

FIGURE 4. *Lajeiro* Boa Nova (Bahia, 14°22'S, 40°10'W) where Pygmy Nightjars (*Nyctipolus hirundinaceus hirundinaceus*) were found. Photo by A. Grosset.

FIGURE 5. A *pedra* at Fazenda Bernardina (19°32'S, 40°36'W) between Colatina and Barbados, Espírito Santo, with its particular xeric vegetation forming the typical habitat of the subspecies *Nyctipolus hirundinaceus veilliardi* of the Pygmy Nightjar. Photo by R. Ribon.

During 7-8 July and 12-14 September 1997, M. F. V. studied Pygmy Nightjars on two *pedras*, Pedra do Resplendor and Pedra Lorena, near Aimorés in eastern Minais Gerais. Although situated in the Atlantic Forest, they were covered by xeric vegetation that resembles the north-eastern Brazilian Caatinga, with the occurrence of cacti (Cactaceae: *Opuntia brasiliensis*, *Pereskia aculeata*, *Coleocephalocerus fluminensis*), bromeliads (Bromeliaceae: *Encholirium horridum*), low shrubs (Velloziaceae: *Nanuza plicata*; Euphorbiaceae: *Jatropha* sp., *Euphorbia phosphorea*), ferns (Pteridaceae: *Notholaena eriophora*; Selaginellaceae: *Selaginella sellowi*), and other species of shrubs and trees of the families Anacardiaceae, Bignoniaceae, Malvaceae, Clusiaceae, Fabaceae and Myrtaceae.

Choice of nesting and roosting sites

On 25 November 2013, WikiAves (2013) had 209 photos published related to the Pygmy Nightjar.

Nesting sites

Five photos show a single egg, and one photo an egg in front of an adult. Two of these eggs are seen to be simply laid in a small, shallow depression in rock. The other five are laid on a mixed layer of gravelly material and vegetal litter, mostly among rock debris (Figure 6).

Ten photos show a single chick, and one photo a chick next to an adult. Chicks are estimated to be between 2 and 15 days old. They are nearly always found among pebbles and/or rock debris in gravelly or rocky areas.

Roosting sites

Eleven photos each show a pair roosting on rock near vegetation, sometimes among plant litter, mostly among gravel and rock debris.

FIGURE 6. Incubating Pygmy Nightjar *Nyctipolus hirundinaceus cearae* on *lajeiro* Morada Nova (04°50'S, 38°37'W). The crouched nightjar with its cryptic colors blends perfectly well with the rocky surroundings.

A single roosting adult is seen on 181 photos. In the Caatinga, Pygmy Nightjars are mainly found in open areas with *lajeiros*, and in the Atlantic Forest, this nightjar is only found on *pedras*. They mostly roost on bare parts of these rocky outcrops, away from any vegetation (77 photos) or near vegetation (64 photos). To a lesser extent, they roost among gravel, pebbles and rock debris on rock (26 photos). And rarely, they roost on vegetal litter accumulated in depressions on a rocky substrate (8 photos), or among gravel on a sandy substrate (6 photos).

DISCUSSION

Only two nightjars in the world, the Freckled Nightjar (*Caprimulgus tristigma*) of the Afrotropics and the Blackish Nightjar (*Nyctipolus nigrescens*) of the Neotropics, have previously been found to be rupicolous in their choice of substrate for roosting and breeding (Jackson & Ingels 2010). It was implied by Dowsett-Lemaire & Dowsett (2006) that the Golden Nightjar (*Caprimulgus eximius*) of Africa may also be rupicolous, but investigation showed that only the Mali deme of this species has a preference for rocks (Jackson 2011).

Despite the possibility that field observations of nightjars may be biased by the accessibility of the areas visited by observers, and the fact that this nightjar is also found in open gravelly areas or on bare soil, it is obvious from our observations and the many photos on WikiAves that Pygmy Nightjars have a preference for rocky areas (*lajeiros*) in the Caatinga and inselbergs (*pedras*) in the Atlantic Forest.

Clutch size of the Pygmy Nightjar is one egg. On WikiAves (2013), 18 photos show one egg (7) or one chick (11). The origin of the statement that clutch size is one or two eggs (Cleere 2010), or even two eggs (WikiAves 2013) is unclear, and most probably in error. Although eggs are sometimes laid in a small, shallow depression on bare rock, they are more often laid among rock debris on a mixed layer of vegetal litter and gravel near vegetation on *lajeiros* and *pedras* (Figures 2 & 3). These surroundings help greatly to camouflage the egg.

Chicks are usually found among pebbles and/or rock debris in gravelly or rocky areas, where their crouched form and cryptic grayish dorsal plumage helps greatly to mislead predators relying on vision to find prey. As chicks of ground-breeding nightjars are semi-precocial (Cleere 1998, Holyoak 2001), we suppose that chicks which did not hatch in such surroundings, can find more suitable habitat within a day or two of hatching.

Both Caatinga subspecies (nominate and *cearae*) living on the lighter coloured substrates of the *lajeiros* (Figures 1 & 4) show a paler plumage, while the subspecies *veilliardi* living on the darker granite-gneiss substrate (Figure 5) of the *pedras* presents a darker plumage.

From our observations, it is clear that roosting and breeding of Pygmy Nightjars are closely connected with *lajeiros* in the Caatinga and *pedras* in the Atlantic Forest. This preference for rocky habitats within which to roost and breed allows us to recognise the Pygmy Nightjar (*Nyctipolus hirundinaceus*) as one of only three nightjar species in the world that are rupicolous.

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APPENDIX 1:

Eight localities in eastern Brazil where detailed information about the choice of roosting and/or nesting sites of Pygmy Nightjars (*Nyctipolus hirundinaceus*) were obtained.

Locality	State	Coordinates	Subspecies	Reference
Aiuaba	Ceará	06°40'S, 40°14'W	*cearae*	Vasconcelos & Figueiredo 1996
Morada Nova	Ceará	05°07'S, 38°23'W	*cearae*	Grosset 2005
Curaçá	Bahia	09°09'S, 39°45'W	*hirundinaceus*	J. M. B. pers. obs.
Monte Azul	Minas Gerais	15°15'S, 42°51'W	*hirundinaceus*	M. F. V. pers. obs.
Jacaraci	Bahia	14°52'S, 42°30'W	*hirundinaceus*	M. F. V. pers. obs.
Boa Nova	Bahia	14°22'S, 40°10'W	*hirundinaceus*	A. Grosset pers. comm.
Colatina	Espírito Santo	19°32'S, 40°36'W	*vielliardi*	Ribon 1995, R. Ribon pers. comm.
Aimorés	Minas Gerais	19°29'S, 41°03'W	*vielliardi*	Vasconcelos & Lins 1998

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ARTICLE

First description of the eggs, chick, and nest site of the White-winged Nightjar *Eleothreptus candicans*

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ABSTRACT: We provide the first description of the nest site, eggs, and chick of the globally threatened White-winged Nightjar *Eleothreptus candicans*, based on observations in Aguara Ñu, Mbaracayú Forest Nature Reserve, Paraguay, made during November-December 1997. Two eggs were laid directly on the ground at the edge of a small clearing in *campo-sujo* grassland. Only the female appeared to attend the nest, undertaking a distraction display when the nest site was closely approached. Just one egg hatched, after a period of at least 16 days.

KEY WORDS: Caprimulgidae, *Cerrado*, distraction display, parental care, Paraguay.

INTRODUCTION

The White-winged Nightjar *Eleothreptus candicans* is one of the rarest caprimulgids in the Americas, considered Endangered by BirdLife International (2013). Until recently, White-winged Nightjar was also one of the least known of Neotropical caprimulgids. Cleere and Nurney (1998) considered the adult female plumage, chick, nest site, and eggs to be unknown. A population of the species was discovered at Aguara Ñu, Mbaracayú Forest Nature Reserve in 1995 (Lowen *et al*. 1997), and studies there have documented the female plumage (Capper *et al*. 2000), male display behavior (Clay *et al*. 2000), and breeding biology (Pople 2014). Here we provide details of the first known nest site, eggs, and chick of the species. These were previously briefly summarized in Cleere (1999), with additional data presented in Pople (2003).

The study site and methods

From July-December 1997 we undertook a study of the White-winged Nightjar population at the Mbaracayú Forest Nature Reserve, located in an area of palm savanna known as Aguara Ñu (see Clay *et al*. 1998). Aguara Ñu (centered on 24°10'S, 55°16'W) is a low plateau bordered by two rivers—the Arroyo Guyrakeha and the Río Jejuimí—and contains 5,487 ha of *Cerrado* habitats (a mosaic of deciduous and gallery forest, savannas, and grasslands). The variety of *Cerrado* habitats in Aguara Ñu includes *campo-sujo* grasslands with scattered *Yata'i* palms (*Butia paraguayensis*), dense *Yata'i campo cerrado*, wet grasslands and marshes, xerophytic woodlands and gallery forest. The southern border of the plateau is formed by a series of low ridgelines separated by valleys whose floors contain saturated grasslands around small water courses which run into the Arroyo Guyrakeha. Palm density is highest on the center of the plateau and along the crests of the ridgelines. On ridge slopes the campo grassland is more open, with few palms.

At 2030 h on 22 November 1997, EZE flushed a caprimulgid from an area of *campo-sujo* grassland on the southern edge of Aguara Ñu. On searching, two eggs were found on bare ground, partially concealed by the surrounding vegetation. On 23 November, JMB, RPC, and EZE returned to the nest and were able to confirm the identity of the incubating bird as a female White-winged Nightjar. The bird was identified as this species due to the head and upperpart plumage being similar to that of adult male White-winged Nightjar. Previously (on 21 November) a gravid White-winged Nightjar was caught, confirming the plumage to be that of a breeding female. Intermittent observations were conducted at the nest during November and December.

Description of the nest site and location

As with other Caprimulgid species, no nest was constructed, with the two eggs laid on an area of bare earth, of total diameter approximately 30 cm. This patch of earth was largely exposed from above, although the eggs were placed to one side, partially covered by a small herb *Mimosa dollens* (Figure 1). The surrounding vegetation was primarily herbaceous and 30-50 cm in height, with *Campomanesia adamantium* (Myrtaceae) among the dominant species.

The nest site was located just above the head of a small valley in *campo-sujo* grassland on a slope of 8°, and an aspect of 220°. The general area had a relatively higher density of *Yata'i* palms compared to adjacent male display arenas (see Clay *et al.* 2000), or the pure grasslands of the valley sides and bottom. However, the nest site was located in a small clearing amongst the palms, with only 14 *Yata'i* palms and 4 saplings within a radius of 14 m of the nest-site (Figure 2). Of the 14 palms, 11 were less than 1.5 m in height, and all were under 2 m. There was also a comparatively high density of dicot herbs in the *campo-sujo* of this area.

FIGURE 1. View from above of *Eleothreptus candicans* nest-site (Photo: Juan Mazar Barnett)

FIGURE 2. Immediate surroundings of *Eleothreptus candicans* nest-site (Photo: Juan Mazar Barnett)

Description of the eggs

The two eggs measured: 28.9 mm x 21.4 mm and 28.7 mm x 21.3 mm, with weights of 7.6 g and 7.5 g, respectively. Both eggs were quite uniform in width, pale creamy-brown in color, and with a fairly uniform light covering of darker brown and some greyer speckling. The slightly larger egg had uniform spotting over its whole surface, with grey spots and speckles overlaid with small dark brown spots. The slightly smaller egg had larger spots concentrated at the obtuse end, and fine elongated spots at the acute end (Figure 3).

FIGURE 3. *Eleothrepus candicans* egg (Photo: Juan Mazar Barnett)

Observations at the nest

During November, diurnal checks were made on the nest during the morning of 23 November, and the afternoons of 27 and 29 November. On all three days, the female was found to be present at the nest (although not always incubating the eggs). The nest was also watched on the evenings of the 25, 26, and 27 November. On all three nights, only the female was observed attending the nest, and no males were even seen in its vicinity. On the 26 November, the female was not present at the nest prior to dusk, arriving 27 minutes later and shortly prior to the onset of rain. Initially, the female sat in front of the eggs (apparently after first moving them), but as the intensity of the rain increased she gradually moved to cover, first one, and then both the eggs.

On the 27 November, ten minutes after the incubating female left the nest, a female was caught approximately 100 m from the nest site (at 2030 h). This bird was banded, and a black mark made on her rectrices to enable identification in the field. At 2300 h this same female was found close to the nest, when she performed an apparent injury-feigning distraction display. The display consisted of the bird rapidly moving away from the nest through and over the vegetation, with much wing flapping. Once away from the nest, the female flew up high, with strong, powerful wing beats, and circled back around toward the nest. On the afternoon of the 29 November, this same female was observed incubating the eggs. Similar distraction displays were also observed during the daytime, especially once a single chick hatched, when they became more frequent and vigorous. The typical daytime reaction was for the female to jump forward, outstretching its wings and fanning its tail.

Description of chick

By 10 December, one of the eggs had hatched and a young chick was present. Although the second egg was still present, it did not hatch in the subsequent days and was presumed infertile. A description of chick was taken the day after its discovery (when it was believed to be two to three days old). The down feathers were largely uniform dark brown, with inconspicuous buffy-brown and cinnamon spots (Figure 4). The spotting was densest

FIGURE 4. Two to three days old *Eleothreptus candicans* chick (Photo: Juan Mazar Barnett)

FIGURE 5. Female and juvenile *Eleothreptus candicans* at nest-site, about one month after hatching (Photo: Juan Mazar Barnett)

on the crown, giving a slightly capped appearance, whilst the flanks and vent were a paler grey-brown. The irises were dark brown, and the bill blackish.

Due to inclement weather, no visits had been made to the nest site in the days prior to 10 December, but the hatching date was estimated to be 7-8 December (judged from the development of the chick when first found). This suggests an incubation period of at least 16 days, which falls within the 16-22 days of most other Caprimulgidae species (Cleere 1999). A recently fledged juvenile was observed in the vicinity of the nest site during early January (Figure 5).

The observations of female only parental-care, combined with the apparent clustering of male display territories led to Clay *et al.* (2000) suggesting that the Aguara Ñu population of White-winged Nightjars might exhibit a lek or "landmark" mating system, a hypothesis further supported by the studies of Pople (2003, 2014).

Documentation of White-winged Nightjar nesting habitat has been a key factor in informing management recommendations for the Cerrado at Aguara Ñu, which is threatened by too frequent burns and exotic invasive grasses (both spreading into the reserve from neighboring properties; Capper *et al.* 2000).

ACKNOWLEDGEMENTS

Allocation of White-winged Nightjar to the genus *Eleothreptus* is somewhat contentious, but is used here in memory of Juan, with whom we first realized the morphological and plumage similarities between *E. candicans* and Sickle-winged Nightjar *E. anomalus*. Permission to work within the Mbaracayú Forest Nature Reserve was kindly granted by the Comité de Asuntos Científicos of the Fundación Moisés Bertoni (FMB). Thanks are also due to several other FMB staff (current and former), particularly Alberto Yanosky, René Palacios, Claudia Mercolli, and Tito Fernández. The reviewers, Marcelo Ferreira de Vasconcelos, Catherine Bechtoldt and Luciano Naka provided comments that greatly improved the manuscript.

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ARTICLE

Breeding biology of the White-winged Nightjar (*Eleothreptus candicans*) in eastern Paraguay

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ABSTRACT: Breeding biology of the White-winged Nightjar (*Eleothreptus candicans*) in eastern Paraguay. I present the first detailed description of the breeding biology of the White-winged Nightjar (*Eleothreptus candicans*), based on data collected over three breeding seasons during 1998-2001 at Aguará Ñu, Canindeyú, eastern Paraguay. Male nightjars defended small territories situated on the upper slopes of ridgelines. Each territory contained one or more "display arenas" at which the male performed nuptial display flights. Aggregation indices confirmed that the primary display arenas of males were significantly clustered within the survey area. Within their territories, males apparently selected display arenas on the basis of their structural characteristics: mounds used as arenas were significantly lower and broader than random mounds. Males engaged in display activity from late August to early January. On average, males performed 0.54 ± 0.04 display flights per minute during nocturnal focal watches, but there was considerable intra-male variation in display rate. Following a burst of activity immediately after their arrival at display arenas at dusk, male display rate was best explained by ambient levels of moonlight. Males produced a previously undescribed insect-like "tik tik" call when inactive on their territories. Females made two nesting attempts per season, using a different site (360 ± 31 m apart) for each attempt. The clutch of two eggs was laid directly on the ground, adjoining a small access "clearing", in either campo cerrado or wet grassland vegetation. The first egg was laid within two days of a full moon for all seven clutches for which laying date was confirmed. Incubation, brooding and chick provisioning duties were carried out exclusively by the female. The incubation period was 19 days and the nestling period *c.* 19-20 days. Overall, my data are consistent with polygyny – and even an exploded lek or "landmark" mating system – in this population of White-winged Nightjars.

KEY-WORDS: Caprimulgidae; *Caprimulgus candicans*; cerrado; male display behaviour; nesting biology

INTRODUCTION

Owing largely to their cryptic plumage and crepuscular or nocturnal habits, the Caprimulgidae (true nightjars) are comparatively under-studied. Their breeding biology in particular is poorly known, and for many species the only published data are anecdotal or based on single nesting attempts. Studies of the better-known species show them to be generally ground-nesting, with clutches of one or two eggs, and an essentially monogamous breeding system (Cleere 1999, Holyoak 2001). The Caprimulgidae are also one of only a few bird families in which lunar synchrony in reproduction has been documented (Murton & Westwood 1977, Holyoak 2001).

The White-winged Nightjar (*Eleothreptus candicans*) is one of the rarest caprimulgids in the Americas, considered Endangered by BirdLife International (2013). Research in Paraguay since the discovery of a population in 1995 at Aguará Ñu, Mbaracayú Forest Nature Reserve (Lowen *et al.* 1997), has clarified some aspects of its breeding biology, including the nest site, eggs and chick (Capper *et al.* 2000, Clay *et al.* 2014) and male display behaviour (Clay *et al.* 2000). Male White-winged Nightjars were found to perform ritualised display flights at small arenas – low anthills or termite mounds – located on the upper slopes of ridgelines in areas of open grassland. Although males were present near these arenas throughout the night, display activity was highest under cloudless conditions on moonlit nights. Display flights were accompanied by a dull "tk…grrrrrt" sound (recording in Ranft & Cleere 1998), perhaps produced by movement of air through the outer primaries.

Based on the apparent clustering of male display arenas at Aguará Ñu, Clay *et al.* (2000) suggested that this population of White-winged Nightjars might exhibit a lek or "landmark" mating system. Leks can be broadly defined as any aggregation of males visited by females primarily for the purpose of copulation, whereas landmark species are characterised by the use of a specialised habitat as encounter sites for mating (Höglund & Alatalo 1995). Four criteria were proposed by Bradbury (1981) to distinguish "classical" leks from other lek-like mating systems: (1) lack of male parental care; (2) aggregation of males at an arena to which females come for mating; (3) arenas containing no resources required by females (*e.g.* nest sites, food) except males themselves; and (4) free mate choice by females visiting an arena. Lekking has been suggested to occur in at least three other species of caprimulgid (see Holyoak 2001). However, no nightjars were included on a list of 97 lek-mating bird species compiled by Höglund & Alatalo (1995).

Here I present the first comprehensive description of the breeding biology of the White-winged Nightjar, on the basis of data collected during a three-year study in Paraguay, including male display behaviour, the distribution of male territories and details of nesting biology based on data from multiple nesting attempts. I use these and other data to assess whether the study population exhibits a polygynous or lekking mating system, and consider the implications for the species's conservation.

METHODS

Fieldwork was conducted over three breeding seasons (September-January) between October 1998 and January 2001 at Aguará Ñu (24°10'S, 55°17'W), a *c.* 5500-ha area of open-country habitats within Mbaracayú Forest Nature Reserve, Canindeyú department, eastern Paraguay. Aguará Ñu is a low plateau, 170-270 m above sea level, which forms a natural island of cerrado vegetation, flanked by forest to the south and west, and isolated from Paraguay's main areas of cerrado in the departments of Concepción and Amambay to the north-west (Jiménez & Knapp 1998).

Most fieldwork was focused on an area of *c.* 400 ha in southern Aguará Ñu, where a series of shallow valleys drain southwards into the Arroyo Guyrá Kehá. The seasonally wet grasslands of the valley bottoms and lower slopes are dominated by grass and sedge species, and woody vegetation is almost entirely absent. The drier soils of the upper slopes and ridge-tops support "campo cerrado" vegetation, consisting primarily of grasses and herbs, but with a scattering of shrubs (*e.g. Cochlospermum regium*, *Caryocar brasiliense*), Yata'i palms (*Butia paraguayensis*), saplings and the occasional fully grown tree. Palm density is lowest at the tips of the ridges in the south, where the campo cerrado is relatively open. Termite mounds, 15-90 cm in height, are present throughout the campo cerrado and wet grassland, and low anthills occur occasionally in the campo cerrado.

I identified breeding seasons by their principal year, so the season from September 2000 to January 2001 is termed the "2000 season". Adult White-winged Nightjars were captured, sexed and ringed, and lightweight (1.3-2.5 g; <5% of adult body weight) radio-transmitters were attached to certain individuals, including all adult females captured (see Pople 2003 for details).

Male territories and display arenas

I use the term "territory" to describe the relatively small area within which a male nightjar conducted all his breeding-season display activity (as per Clay *et al.* 2000). Each territory contained a primary "display arena" at which the male carried out most display activity, but some also contained one or more secondary arenas, which were used more sporadically, for example when the male was disturbed from its primary arena (Clay *et al.* 2000). For simplicity, the location of each territory was defined by its primary display arena. Radio-telemetry showed that *c.* 95% of nocturnal breeding-season fixes for radio-tagged males fell within 100 m of their display arenas (Pople 2003). In occasional cases when the primary display arena of a territory changed between or, more rarely, within seasons, the display arena used for longer was selected for subsequent analyses.

The study site was surveyed for displaying males each season between August and December. Males were initially located by the "tk…grrrrrt" sound produced during display flights, which was often audible from up to *c.* 200 m. Surveys were mainly conducted on dry, relatively still, moonlit nights, when male display activity was at its highest (Clay *et al.* 2000). Once a displaying male was detected, it was observed for 10-15 minutes to identify its primary display arena, the precise location of which was recorded using a Magellan 2000 XL GPS receiver. It was then captured and fitted with an individually numbered metal tarsus ring, a coloured plastic ring, and a small, uniquely shaped piece of reflective tape, affixed to the dorsal side of one of the non-central tail feathers. This tail mark was unobtrusive when birds were at rest during the day, but conspicuous when illuminated with a torch at night. Territories were repeatedly revisited to study male display behaviour. During these visits, the identity of the male and the location of the display arena(s) were confirmed.

To investigate aggregative tendencies in displaying males, nearest-neighbour analysis (Clark & Evans 1954, Krebs 1989) was used to quantify the spatial distribution of territories (see also Höglund & Stöhr 1997). The distance from each primary arena to its nearest neighbour (i.e. the measure used herein to represent distances between territories) was derived from GPS locations, and the average nearest-neighbour distance (NND) within each season was calculated. Estimates of expected NND were then obtained (Clark & Evans 1954), assuming a random distribution of males within the survey area. The latter was defined by a convex polygon (of *c.* 400 ha) encompassing the zone surveyed most thoroughly for territories (see Results). Since the small sample sizes in the current study prevented the use of a boundary strip, estimates of expected NND were corrected using Donnelly's (1978) adjustment for edge-effect bias. An index of aggregation (R) was obtained for each season by dividing the mean observed NND by the mean expected NND. When R = 1.0 the observed spatial distribution does not deviate from random, whereas values of R between 1 and 0 indicate an increasing degree of clustering (Krebs 1989).

The gross topographical characteristics of male territories and an equal number of random points were measured using a digital version of a 1:50000 Paraguayan Instituto Geográfico Militar map, imported as a layer into a geographical information system (GIS) in ArcView 3.2 (ESRI 1999). The following variables were recorded for each site: (i) *gradient*, to nearest 1°; (ii) *altitude*, to nearest 5 m above sea level; (iii) *altitude difference*, from nearest "spot height" (peak local altitude); (iv) *distance to spot height*, to nearest 25 m; (v) *distance to stream*, to nearest 25 m; (vi) *aspect*, allocated to one of four quadrants (north-east, south-east, south-west and north-west).

Qualitative observations suggested that males did not select display arenas at random, even within territories. To determine how mounds used as display arenas differed from available mounds, the structural characteristics of nine display arenas used during the 2000 season were measured and compared to those from a sample of random mounds. The arenas included seven primary arenas and two (regularly used) secondary arenas of seven males. For each mound I measured: (i) *maximum height* (including any "towers"), to nearest 5 cm; (ii) *modal height*, *i.e.* height of the majority of the mound (excluding any "towers"), to nearest 5 cm; (iii) *basal "circumference"*, to nearest 0.1 m; (iv) *maximum basal chord*, across the longest axis of the mound, to nearest 0.1 m; (v) *presence/absence of "towers"*, *i.e.* free-standing vertical structures projecting above the modal level of the mound (see Figure 3a). For each display arena, four random mounds were selected by walking 20 m from the display arena on each of the four cardinal points of the compass, and then identifying the nearest mound. On two occasions it was not possible to locate a mound, hence the total number of random mounds measured was 34.

Male display behaviour

To collect quantitative and qualitative data on male display behaviour, 30-minute focal watches were conducted on dry, relatively still evenings at the primary display arenas of territory-holding males. Focal males were monitored from *c.* 10-20 m away with the aid of a torch set on diffuse beam. Individuals did not appear to be disturbed by the presence of an observer, and on other occasions continued to display when I was just 5 m away. Nautical twilight (the time at which the sun is 12° below the horizon) was used as the point delineating dusk or dawn from true "night" (Brigham & Barclay 1992). Until this point, lunar illumination is exceeded by residual solar light (Austin *et al.* 1976). Seventy-one per cent (64 of 90) of focal watches were begun before the end of nautical twilight, and thus termed "dusk watches". The remaining 26 watches were conducted under truly nocturnal conditions and termed "night watches".

During dusk watches, the observer arrived at the observation point shortly after sunset, and the watch commenced when the focal male arrived at the display arena. The number and time of all displays were then recorded, as well as details of any interactions with other individuals. A "display" was defined as any flight up from the display mound accompanied by both the "tk" and "grrrrrt" sounds. Following the completion of the watch, the identity of the focal male was confirmed based on its reflective tail mark and/or colour rings.

Potential environmental correlates of male display rate were investigated using a multiple regression model, with the following variables: (i) *time*, in minutes, in relation to nautical twilight; (ii) *temperature*, minimum recorded during the watch; (iii) *moon phase*, proportion of the moon face illuminated (MFI); (iv) *moon height*, estimated degrees above the horizon; (v) *moonlight*, estimated lunar illuminance (see below). Ambient temperature was measured every 15 minutes with an electronic logger. Details of astronomical phenomena (i.e. MFI, times of sunrise/sunset, moonrise/moonset and twilights) were obtained from astronomical almanacs. Moon phase and height significantly influence overall lunar illuminance (Austin *et al.* 1976), but neither factor shows a simple linear relationship with illuminance (R. Willstrop *in litt.*), so their combined effects were estimated, using information in Austin *et al.* (1976), and treated as a separate measure: "moonlight".

Tape recordings of male display sounds and other "vocalisations" were made at the display arenas of marked males, from distances of *c.* 5-10 m, during the 1999 and 2000 breeding seasons. Recordings were later digitised and spectrograms of male display sounds generated in Avisoft using the following settings: FFT-length = 128; frame size = 100%; window = Blackman; overlap = 75%. These settings provided sufficiently fine temporal resolution (8 ms) to distinguish the separate elements of the "grrrrrt" sound. The following temporal measures were obtained using the on-screen cursors (Figure 1): interval between "tk" and "grrrrrt" components (INT); length of "grrrrrt" component (GTLEN); number of elements constituting "grrrrrt" component (GTNUM). Frequency measures were not taken, however, given the relatively poor resolution (31 Hz) and limited frequency range of display sounds.

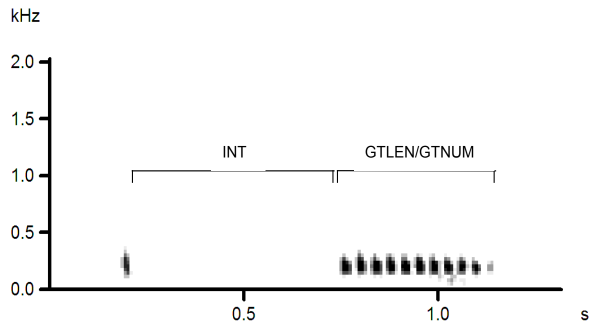

FIGURE 1. Spectrogram of male White-winged Nightjar display sound showing "tk" and "grrrrrt" components and the three temporal variables measured for each recording (see text for definitions).

Nesting biology

Nest sites were located by monitoring radio-tagged females and checking their daytime "roosts" for eggs every *c*. 2 days during the breeding season. The "initiation date" for a nesting attempt was defined as the date on which the first egg was laid: presence of eggs was the only factor reliably distinguishing nest sites from roost sites. Once a nest was initiated, its precise location was recorded using a GPS receiver. Gross topographical characteristics of nest sites and an equal number of random sites were measured as described above for male territories. To ensure that random sites reflected those available to, but not used by, nesting females, they were selected to fall within 400 m of the nest sites with which they were paired. Two radio-tagged females monitored during the 2000 breeding season ranged up to 403 ± 33 m from the centre of their breeding ranges (pers. obs.).

The following variables were recorded for each site: (i) *gradient*, to nearest 1°; (ii) *altitude*, to nearest 5 m above sea level; (iii) *distance to nearest stream*, to nearest 25 m; (iv) *distance to nearest male display arena*, to nearest 10 m; (v) *aspect*, allocated to one of four quadrants (north-east, south-east, south-west and north-west); (vi) *habitat*, classified as one of two dominant types (campo cerrado and wet grassland). Habitat type was determined from a simplified habitat map of the study site, added as a layer to the GIS (see Pople 2003 for details).

The mass of freshly laid eggs was measured to the nearest 0.5 g. Measures of length and maximum breadth of eggs were taken to the nearest 0.1 mm. Egg volume was estimated following Hoyt (1979), using the equation: volume = 0.51 × length × (maximum breadth)^2. During the egg stage, nests were visited every three to five days to confirm the sex of any adults present. These "spot-checks" were carried out at various times of day and night, independent of ongoing radio-telemetry fixes taken to characterise the home range and movements of individuals. Although radio-tracking equipment was sometimes used to confirm an adult's identity, the bird's location was not known prior to any spot-check.

Hatching success was calculated as the percentage of eggs laid that hatched successfully. This method can bias values for hatching success upwards, as it takes no account of nests failing before they are found (Beintema & Müskens 1987). However, my method of nest location reduced this risk, and the sample size was insufficient to use the daily exposure method (Mayfield 1961, 1975). Nests were visited every two to four days after hatching, and chicks were weighed (to nearest 0.5 g) to obtain data on their growth and development. Chicks were ringed at *c*. 10 days old, when their tarsus width was similar to adult birds. Younger chicks were individually marked with non-toxic white correction fluid on their feet.

During the nestling period, nocturnal focal watches of 50-255 minutes were conducted at nests to characterise the division of chick brooding and provisioning duties by the parents. Nest sites were monitored from distances of *c*. 10-20 m, using a head-torch with diffuse beam to obtain eye-shine from adults without disturbing them. The duration (to nearest five seconds) of each visit was recorded, along with the sex of the visiting adult. Radio-tracking equipment was occasionally used to confirm the identity of tagged birds, but monitoring was primarily visual. The data collected were used to calculate mean visit rates and average times spent at, or away from, the nest site. A small number of daytime spot-checks were conducted to assess parental allocation of diurnal brooding duties.

Statistical analysis

All data were tested for normality and homoscedasticity, and then analysed using standard parametric or non-parametric univariate tests, as appropriate. If appropriate, data were subsequently also analysed using multivariate techniques. When the dependent variable was continuous (*e.g.* male display rate), multiple linear regression was used to investigate the effects of potential covariates. Analyses were conducted using a forward stepwise procedure with entry and removal probabilities set at P = 0.05. At each step, the variable with the most significant score statistic was entered into the model, provided that its inclusion significantly improved model fit: significance was tested using partial F-tests (Hair *et al.* 1995). This process was repeated until no further variables met the criteria for entry or removal, at which point the model was considered final.

When the dependent variable could be allocated to one of two discrete categories (*e.g.* male territory or random site, display mound or random mound), binary logistic regression was used to identify which combination of variables best distinguished between the two categories. Analyses were conducted using a forward stepwise procedure as outlined above, but with significance tested using likelihood ratio tests in which the difference in deviance (-2 × $\log_e$ likelihood) between models with and without the variable was treated as χ^2, with degrees of freedom (df) equal to the number of parameters being added (Manly *et al.* 1993). When comparing display mounds and random mounds, the inclusion of secondary mounds for two males raised the possibility of pseudoreplication. To address this, parameter estimates produced by the model were jack-knifed following Sokal & Rohlf (1995), taking the male as the sampling unit. Jack-knifed parameter estimates did not differ significantly from those of the original model, suggesting that pseudoreplication was not a major problem.

Categorical data were analysed using the G-test of independence. A form of the G-test for goodness of fit, adjusted using the Williams correction for the two-cell case (Sokal & Rohlf 1995), was used to compare the observed sex ratio of adult captures with that expected on the basis of a 1:1 sex ratio. Statistical significance was set at $P < 0.05$ unless otherwise specified, and means are given ± one standard error (SE). Since the repeated use of a statistical test increases the probability of committing a Type I error, the sequential Bonferroni technique was employed to adjust the initial a level when making many simultaneous comparisons (Rice 1989).

RESULTS

Forty-nine White-winged Nightjars (34 adult and 15 young birds; Table 1) were captured and ringed between 1998 and 2001. The sex ratio of captured adults was biased towards males in all three field seasons, and the overall ratio of 3.25:1 male:female differed significantly from parity. The four females captured in 1998 were all caught late in the breeding season, and none of them was confirmed to (re-)nest that season; two individuals captured in late December had already begun post-nuptial moult. Hence, all data on nesting biology were obtained from females caught during the 1999 and 2000 breeding seasons.

Male territories

Breeding-season territories were identified for 10 males in 1998 and eight males in each of 1999 and 2000. One territory, discovered late in the 2000 breeding season, was excluded from the nearest-neighbour analysis as it was located outside the normal survey area (Figure 2). The remaining territory-holding males occurred at a mean density of one male per 50 ± 5 ha (n = 3 seasons) within the area surveyed. The closest male display arenas were just 70 m apart (in 1998), but the average nearest-neighbour distance across all three seasons was 254 ± 8 m. Aggregation indices confirmed that primary display arenas were significantly clustered within the survey area in all three seasons (Table 2).

In total, 13 distinct territories were identified between 1998 and 2000: five of these were occupied in all three breeding seasons, and a further three were occupied in at least two. The ownership of certain territories changed both between and, less frequently, within seasons, probably owing to the death or emigration of the original territory-holding male. In nine of 11 such changes in territory ownership, the original male was never recorded again; in two instances the male moved to a territory vacated by another "missing" male.

Male territories were located almost exclusively on the upper slopes of ridgelines running perpendicular to the main Arroyo Guyrá Kehá valley (running north-west to south-east across the lower half of the maps in Figure 2). Preliminary analysis of gross topographical characteristics using univariate tests suggested that territories differed significantly from random points for only one variable (Table 3). A binary logistic regression model, explaining *c.* 27% of the deviance in site use, also revealed that

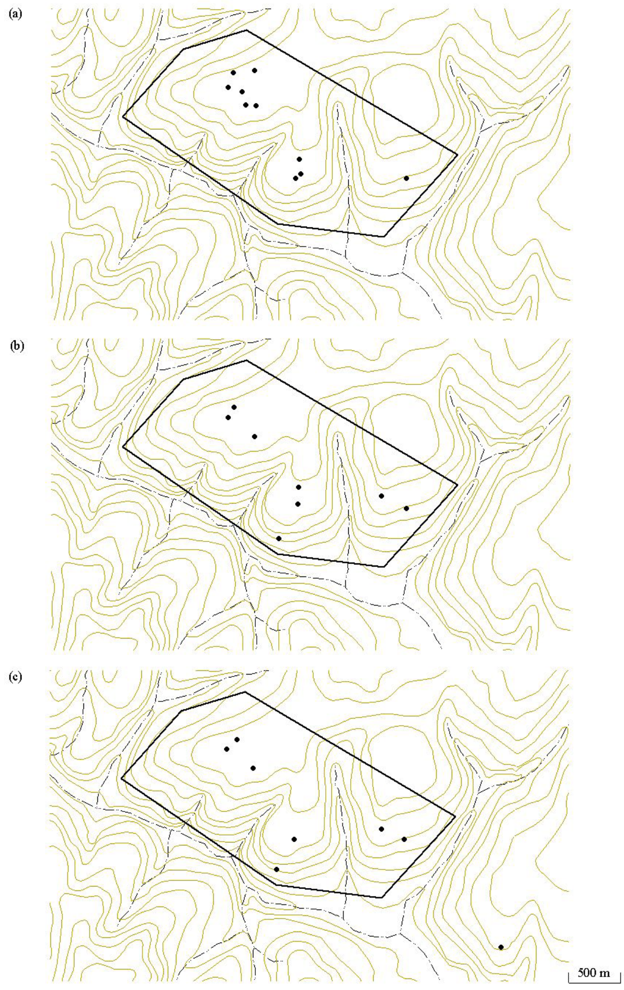

FIGURE 2. Location of male White-winged Nightjar territories (closed circles) during: (a) 1998; (b) 1999; and (c) 2000 breeding seasons. Pale brown lines are contours, dashed lines are watercourses. The polygon represents the *c.* 400-ha survey area.

"distance to stream" was the only significant predictor (likelihood ratio test: $\chi^2 = 9.89$, df = 1, P < 0.005): on average, male territories were further from streams than random points. The model correctly reclassified 69% of sites overall, with an equal degree of classification success for territories and random sites. Aspect was not entered into the model, but univariate tests suggested that male territories were more likely to have a westerly than easterly aspect compared to random points (11 of 13 *versus* 5 of 13; G-test: G = 5.80, df = 1, P < 0.05).

At a finer scale, preliminary analysis of the structural characteristics of mounds used as display arenas in 2000 suggested that they differed significantly from random mounds for a number of variables (Table 4). However, a binary logistic regression model, explaining 25% of the deviance in mound use, showed "modal height" to be the only significant predictor (likelihood ratio test: $\chi^2 = 11.01$, df = 1, P < 0.001): on average, display mounds were lower than random mounds. The model correctly reclassified 91% of random mounds, but only 22% of mounds used as display arenas, resulting in an overall correct reclassification rate of 77%.

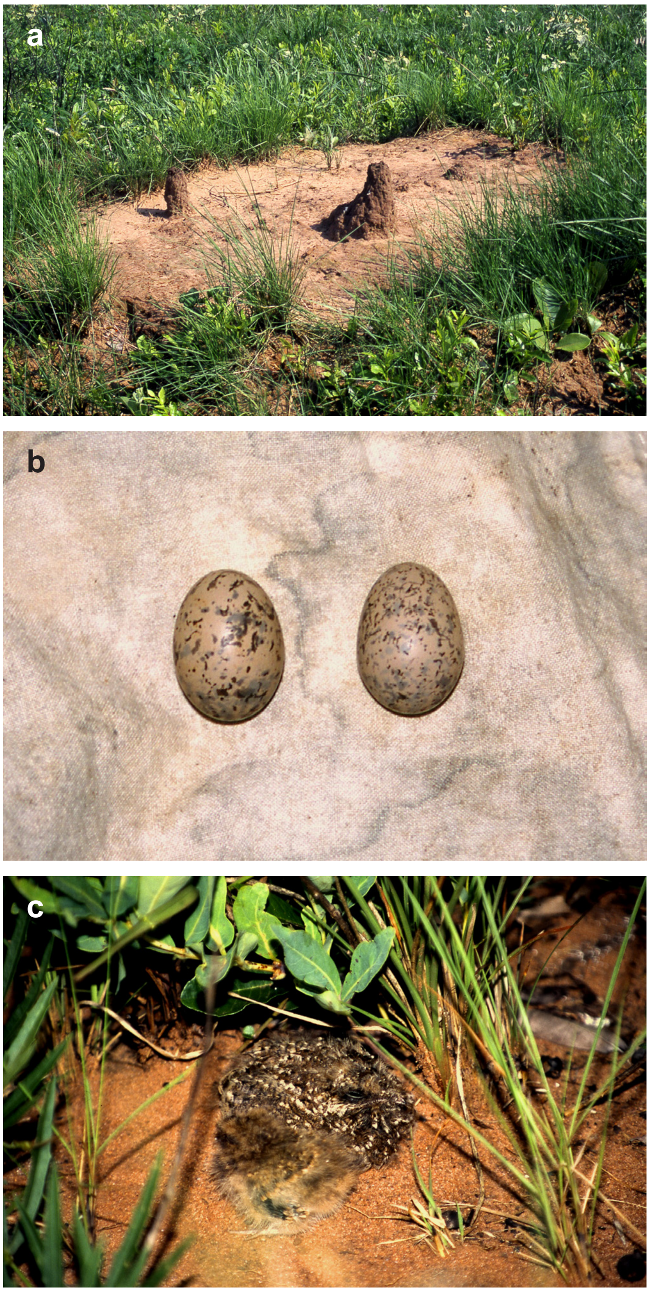

FIGURE 3. Typical male display arena with "towers" (a), eggs (b) and chicks aged 14 days old (c) of White-winged Nightjar at Aguará Ñu.

Male display behaviour

In both 1999 and 2000, sporadic display activity was noted on certain nights leading up to the August full moon, but male display activity did not commence in earnest until September. Activity levels remained high through to December, but subsided soon after: the latest date on which display activity was noted was 6 January.

Although an attenuated version of the mechanical "grrrrrt" sound was occasionally heard at the start of foraging sallies, the full "tk… grrrrrt" display sound was only ever noted during male display flights at arenas. Of 132 display flights by five males in 2000, the majority (63%) were initiated from a nearby perch, but 23% immediately followed the return of the male from a foraging sally, and the remaining 14% involved males already sitting on their display arena. In these latter cases, the male was observed to jump up and down on the display arena to produce the "tk" (probably by contact with the mound), before flying up with the "grrrrrt" sound as per usual. Display activity was not solely restricted to males in "definitive" plumage. A young male moulting into definitive plumage, but still retaining five or six (brown) juvenile outer primaries, was observed to display on two nights in early November 1998 (see below).

Recordings of 8-19 display sounds were obtained for eight marked males during the 1999 and 2000 breeding seasons. Spectrograms showed that display sounds had a relatively fixed structure, with the "tk" and "grrrrrt" components separated by 500 to 700 ms, but with broadly similar frequency ranges (*c.* 100-400 Hz; Figure 1). The display sounds produced by the pre-definitive male in 1998 were of a noticeably higher frequency, but a recording of its display was not obtained for direct comparison. Two of the three temporal measures (GTLEN and GTNUM) were highly correlated (Spearman rank correlation: $r_s = 0.96$; n = 103; P < 0.001). Only GTNUM was considered further, as it was judged to be less susceptible to measurement error. Males showed significantly more inter- than intra-individual variation for both INT (Kruskal-Wallis test: H = 57.82, df = 7, P < 0.001) and GTNUM (H = 60.40, df = 7, P < 0.001), suggesting consistent inter-individual differences in these temporal measures.

A total of 90 focal watches was conducted at male display arenas over the course of three breeding seasons (1998: n = 10; 1999: n = 20; 2000: n = 60). No significant

TABLE 1. Sex and age composition of White-winged Nightjars captured.

Season	Males	Females	Young birds	Total	Sex ratio (males/female)	G	P
1998	20	4	3	27	5.00	11.41	< 0.001
1999	14	3	5	22	4.67	7.50	< 0.01
2000	9	3	9	21	3.00	3.01	ns
Overall [a]	26	8	15	49	3.25	9.89	< 0.005

(a) Column totals do not equal "Overall" total due to recapture of certain individuals between seasons.

TABLE 2. Mean ± SE nearest-neighbour distances (NND) and degree of aggregation for breeding-season territories of male White-winged Nightjars.

Season	No. male territories	Observed NND (m)	Expected NND (m) [a]	Aggregation index (R)	Significance [b]
1998	10	253 ± 97	372 ± 69	0.68	z = -1.71, P = 0.044
1999	8	241 ± 35	425 ± 89	0.57	z = -2.07, P = 0.019
2000	7	268 ± 34	460 ± 103	0.58	z = -1.87, P = 0.031

(a) Assuming random distribution of males within 406 ha survey area (see Methods).
(b) P-values from one-tailed z-tests (Campbell 1996).

TABLE 3. Mean ± SE values of topographical variables for male White-winged Nightjar breeding-season territories and an equal number of random points.

Variable	Male territories (n = 13)	Random points (n = 13)	Significance [a]
Gradient (°)	2.2 ± 0.6	4.5 ± 0.7	W = 220, P = 0.023
Altitude (m)	232 ± 4	214 ± 6	t_{24} = -2.51, P = 0.019
Altitude difference (m)	11 ± 3	29 ± 7	W = 220, P = 0.023
Distance to spot height (m)	406 ± 77	683 ± 110	t_{24} = 2.06, P = 0.050
Distance to stream (m)	567 ± 74	310 ± 46	W = 122, P = 0.007
Aspect – *number of sites facing*:			
NE (0-90°)	0 (0%)	0 (0%)	
SE (90-180°)	2 (15%)	8 (62%)	
SW (180-270°)	6 (46%)	2 (15%)	
NW (270-360°)	5 (38%)	3 (23%)	

(a) From unpaired t-tests or Mann-Whitney U-tests. Values underlined indicate table-wide significance at an adjusted initial a level of 0.01 (Rice 1989).

TABLE 4. Mean ± SE values of the structural characteristics of male White-winged Nightjar display arenas used during 2000 breeding season compared to a sample of random mounds.

Variable	Display arenas (n = 9)	Random mounds (n = 34)	Significance [a]
Maximum height (m)	0.42 ± 0.10	0.61 ± 0.04	W = 831, P = 0.014
Modal height (m)	0.24 ± 0.03	0.51 ± 0.05	W = 842, P = 0.006
Basal "circumference" (m)	6.0 ± 0.8	3.7 ± 0.5	W = 665, P = 0.013
Maximum basal chord (m)	2.1 ± 0.3	1.1 ± 0.1	W = 654, P = 0.005
"Tower(s)":			
present	3 (33%)	8 (24%)	G = 0.32, ns
absent	6 (67%)	26 (76%)	

(a) From Mann-Whitney U-tests or G-test. Values underlined indicate table-wide significance at an adjusted initial a level of 0.01 (Rice 1989).

differences in display rate were apparent between seasons (Kruskal-Wallis test: $H = 1.18$, $df = 2$, $P > 0.05$), so data were pooled for subsequent analyses. On average, males performed 0.54 ± 0.04 displays per minute during focal watches, although considerable variation in display rate was apparent (range: 0.00-1.37 displays/min; n = 90). However, when comparing the six males for which five or more focal watches were conducted, no evidence was found for consistent inter-male differences in display rate ($H = 5.95$, $df = 5$, $P > 0.05$).

On average, males arrived at their display arenas 26.6 ± 0.6 minutes after sunset and 27.9 ± 0.7 minutes before the end of nautical twilight. On arrival, males showed a burst of high display activity. The mean display rate in the first half of dusk watches was more than twice that in the second half (0.75 ± 0.06 *versus* 0.35 ± 0.04 displays/min; Wilcoxon signed ranks test: $T = 1742$, $n = 64$, $P < 0.001$), whereas there was no significant difference between the two halves of night watches (0.50 ± 0.07 *versus* 0.54 ± 0.06 displays/min; paired t-test: $t_{25} = -1.01$, $P > 0.05$). When considering night watches alone, "moonlight" was the only environmental variable that explained a significant amount of the variation in display rate (overall fit of model: $R^2 = 0.166$, $F_{1,24} = 4.77$, $P < 0.05$). Display rate was positively related with this estimate of overall lunar illuminance, reflecting a tendency for males to display more when the moon was fuller and higher in the sky (Figure 4). However, even when conditions were not suitable for display activity, males were generally still present – either sallying or resting – on their territories. There was no significant relationship between display rate and sallying rate during focal watches in which the latter was measured (Spearman rank correlation: $r_s = -0.26$; $n = 36$; $P > 0.05$).

During one display watch in November 1998, the focal male produced a previously undocumented, insect-like "tik tik" call whilst perched in the vicinity of its display arena. This vocalisation (or a single "tik" equivalent) was subsequently recorded on several occasions during display watches (see Figure 5 for spectrogram), and was only observed from males perched in or near their display arena. The thin, high-pitched nature of the call made it difficult to detect under certain conditions, but it was apparently produced at rates of 1.24 ± 0.20 "tik tiks" per minute (range: 0.00-3.33 calls/min; data from 26 display watches). There was no significant correlation between the rate of "tik tik" production and male display rate during display watches (Pearson correlation: $r = 0.31$, $n = 26$, $P > 0.05$).

Aggressive interactions between males were observed during 14 focal watches (30% of watches for which details were noted) and on various occasions during *ad hoc* observations at display arenas. Interactions typically comprised rapid chases, sometimes involving up to three males, and occasionally also physical contact. A soft, liquid "gurgling" call produced during chases was noted on a number of occasions. Aggressive interactions were observed most frequently at one particular display arena (11 of 14 watches), and this bias was significant when allowing for the distribution of watches among display arenas (G-test: $G = 7.64$, $df = 1$, $P < 0.01$). There was a non-significant trend for higher rates of display activity during watches that included male–male chases compared to during those that did not (0.74 ± 0.10 *versus* 0.53 ± 0.06 displays/min; unpaired t-test: $t_{44} = -1.76$, $P = 0.085$).

It was not possible to record female visits to male display arenas reliably, owing to difficulties in distinguishing unmarked females from juveniles or from females of other similar-sized species (*e.g.* Little Nightjar *Setopagis parvulus*). However, during one dusk watch in October 1998, five nights prior to full moon, a female visit and presumed copulation were documented. Over the course of *c.* 20 minutes, the female landed on the display arena at least twice, and three presumed copulation attempts by the focal male were witnessed. Prior to one

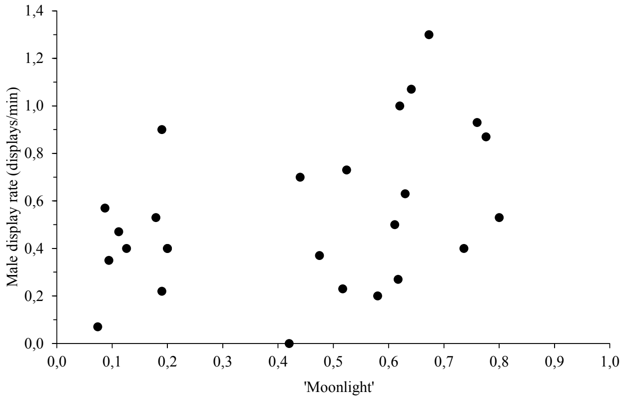

FIGURE 4. Male White-winged Nightjar display rate in relation to "moonlight", an estimate of lunar illuminance. Data from "night" watches only (Pearson correlation: $r = 0.41$, $n = 26$, $P < 0.05$).

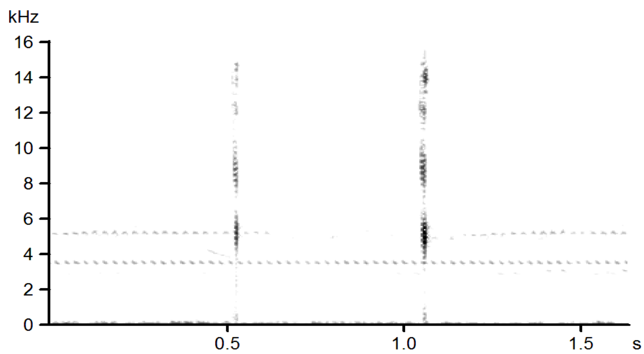

FIGURE 5. Spectrogram of previously undescribed, insect-like "tik tik" call given by male White-winged Nightjars when inactive in vicinity of display arenas. Note background insect noise at *c.* 3.5 and 5.0 kHz. Recordings made by M. C. Velázquez at Aguará Ñu in December 2000.

attempt, the male appeared to display to the female whilst they were both perched on the arena, by spreading its wings and cocking and splaying its tail. When the female left the display arena after copulation, the male followed and flew parallel to her, with wings raised, in a slow buoyant flight, conspicuously different to the rapid flight typical of male–male encounters. On another occasion, in December 2000, a male was observed to conduct a similar "escort" flight, with raised wings, for a presumed female flying through his territory.

Nesting biology

I documented nine breeding attempts by four different females : five in 1999 and four in 2000 (Table 5). A fifth female captured in early December 2000 was heavily gravid, but not subsequently relocated. Eggs were laid directly on the ground, in campo cerrado (six nests) or wet grassland (three nests) vegetation, within a small "tunnel" between tussocks of grass or herbaceous plants and facing onto a small area of bare earth (*c*. 25-50 cm in diameter),

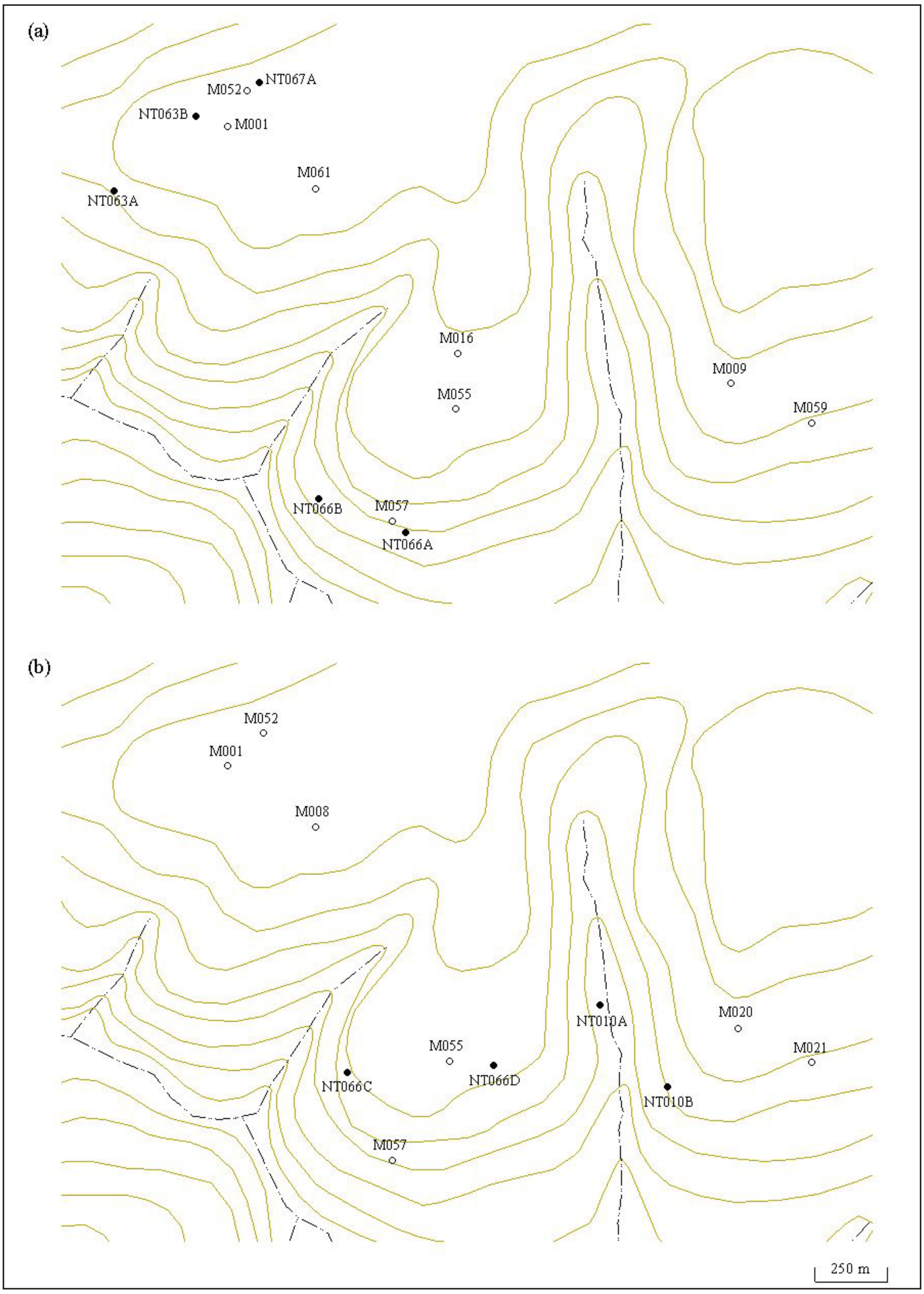

FIGURE 6. Distribution of White-winged Nightjar nest sites in relation to male display arenas during: a) 1999 and b) 2000 breeding seasons. Nest sites displayed as filled circles; multiple nesting attempts distinguished by "A", "B", etc. Display arenas displayed as open circles; labels refer to the territory-holding male. Note the territorial fidelity in successive seasons shown by males M001, M052, M055, and M057.

the latter apparently serving as a "runway" for the adult bird (as at roost sites; pers. obs.). There was no evidence to suggest that the gross topographical characteristics of nest sites differed significantly from those of random sites available to nesting females (Table 6).

Initiation date was confirmed for seven clutches, and consistently fell within two days of a full moon (1.3 ± 0.3 days; range: 0-2). The earliest initiation date observed was 25 September (in 1999), although two chicks discovered on 13 October 2000 were estimated to be approximately 10 days old, and had probably hatched from eggs laid around the full moon of 14 September. Females made two nesting attempts per season, using a different site for each attempt (mean distance between nest sites: 360 ± 31 m, range: 296-461 m, n = 4; Figure 6). The female (F067) captured in late November 1998, whilst brooding a single chick, was probably making a second breeding attempt (Table 5).

Clutch size was two for all seven clutches discovered at the egg stage. It was not possible to check each nest daily, but the second egg was generally laid within 24 hours of the first, although in one case there was a delay of at least 30 hours. Eggs were pale cream-beige, with variable dark brown and mauve-grey speckling and blotching (Figure 3b). Differences in egg patterning were observed within most clutches, with one egg being more densely and uniformly covered in fine markings, and the other showing fewer, larger markings, often with a subapical ring of grey blotches at the obtuse pole. Egg morphometrics are summarised in Table 7. Both eggs of a clutch weighed on day 1 and day 18 of incubation decreased in mass by 0.7 g (11% and 12%) during the intervening period.

Incubation began with the laying of the first egg, and was carried out exclusively by the female: no male was ever found at the nest site. Thirty-four spot-checks carried out at seven nests during the incubation period found the female in attendance during 100% (20 of 20) of daytime and 57% (8 of 14) of nocturnal checks. During nine daytime checks, the female was present but sitting slightly behind one (n = 3) or both (n = 6) of the eggs. There was no significant difference in ambient air temperature on these occasions compared to 11 occasions when the female was incubating both eggs (unpaired t-test: 23.4 ± 1.8°C *versus* 23.7 ± 1.3°C; t_{18} = -0.13; P > 0.05). Although I could not confirm the hatching date for every clutch, the modal incubation period was 19 days, and chicks probably hatched within 24 hours of each other.

Hatching success was 86% (12 of 14 eggs) for the seven nests for which initial clutch size was known. At hatching, chicks had open eyes and were covered in a pale buff-coloured down, with greyish legs and pale-tipped greyish bill. The average mass of four chicks (from two clutches) on day of hatching was 5.2 ± 0.1 g. Clear asymmetry in growth rate was observed in two broods: in one (circular symbols in Figure 7), the larger chick (26.3 g) weighed more than twice its sibling (10.9 g) by day 10 (see also Figure 3c). The latter had disappeared by day 15.

Nocturnal focal watches conducted at six nests (of four females) showed that chick brooding and provisioning was undertaken solely by the female. In almost 25 hours of monitoring (mean watch length: 113.6 ± 17.3 min, n = 13), no male visits were observed, whereas 67 female visits were recorded, at a mean rate of 3.04 ± 0.80 visits/hour (range: 1.20-4.94; n = 4 females). Females spent on average 7.7 ± 1.3 minutes (range: 0.1-46.0 min; n = 58) at the nest during each visit, and 11.8 ± 1.3 minutes (range: 1.5-59.9 min; n = 55) away from the nest between visits. It was not possible to confirm whether chicks were provisioned on every visit. Time spent at the nest during nocturnal focal watches was negatively correlated with minimum ambient temperature (Spearman rank correlation: r_s = -0.81, n = 13, P < 0.005). In 100% (10 of 10) of daytime checks during the chick period, the female was present at the nest site, either brooding or immediately adjacent to the chicks.

Females displayed a range of anti-predator behaviours whilst incubating or brooding. When initially approached, they relied on their cryptic plumage, crouching motionless with eyes closed to slits. If the intruder approached to within 0.5-2.0 m, they would shuffle forward into the adjacent clearing in preparation for take-off. On one occasion, a female incubating a single, recently laid egg performed a presumed threat display: drooping the wings slightly, puffing up the body

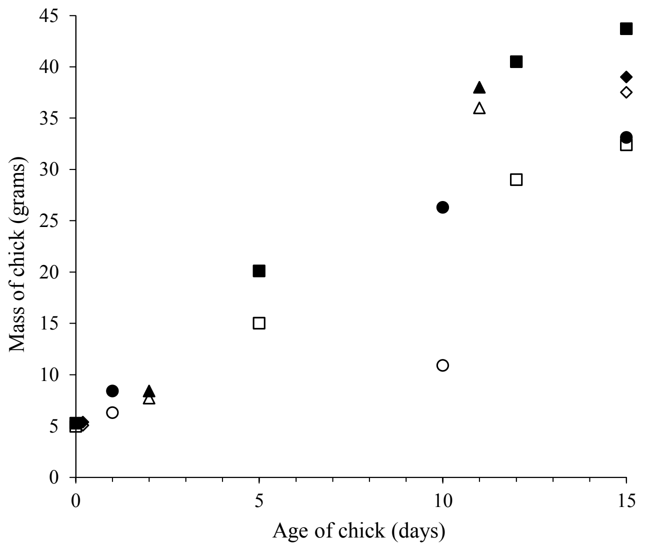

FIGURE 7. Growth rate of eight White-winged Nightjar chicks between hatching and 15 days of age. Each brood represented by different shape; open and closed symbols represent two chicks within same brood. Four chicks weighed on day 0 had masses of *c.* 5 g (square and diamond symbols).

feathers, raising and slightly splaying the tail, whilst rocking the body and tail from side-to-side. When eventually flushed (off eggs or chicks), females typically performed an injury-feigning distraction display, flying 5-10 m away from the nest with a low, laboured flight, before landing clumsily in the vegetation. If approached again, the female would fly off normally, although on most occasions she was subsequently found to have remained near the nest site.

At one week old, chicks were already beginning to lose their natal down and attain the juvenile plumage pattern. After about 10 days, the developing flight feathers began to project from their feather sheaths. Although I could not confirm the exact age of fledging, extrapolation of observed growth rates suggests that chicks attain mean adult mass (*c.* 50 g) at *c.* 19 days. The sole surviving chick of one clutch present on day 18 could not be relocated on day 20.

Owing to uncertainty over the fate of most broods, I could not estimate fledging success or overall nesting success. I recorded two instances of predation (once of eggs, once of chicks; Table 5), but could not identify

TABLE 5. Summary of White-winged Nightjar nesting attempts during 1999 and 2000 breeding seasons.

Season	Female	First nesting attempt				Second nesting attempt			
		Date first egg laid	Incubation period	Hatching date	Chicks last seen at nest site	Date first egg laid	Incubation period	Hatching date	Chicks last seen at nest site
1999	F063	26 September	– [a]	–	–	25 October	19 days	13 November	1 December [b] †
1999	F066	25 September	19 days	14 October	25 October [c] †	21 November	19 days	10 December	14 December [d]
1999	F067	–	–	–	–	–	–	– [e]	10 December †
2000	F010	–	–	– [f]	18 October [g] †	12 November	19 days	1 December	14 December †
2000	F066	11 October	17 days	28 October	– [h]	13 November	19 days	2 December	17 December †

(a) Eggs taken by unknown predator within one week of laying.
(b) Smaller of two chicks disappeared during afternoon of 28 November; larger chick no longer present by 3 December.
(c) Nest not checked for five days; no sign of chicks on 31 October.
(d) Both chicks still present – no further fieldwork in 1999.
(e) Single chick discovered on 23 November; estimated by mass and stage of feather development as approximately 10 days old.
(f) Two chicks discovered on 13 October; estimated by mass and stage of feather development as approximately 10 days old.
(g) Female and chicks found to have moved to new site by 20 October; not seen subsequently.
(h) Chicks disappeared, presumably taken by a predator, within one week of hatching.
(†) Denotes chick(s) believed to have fledged successfully.

TABLE 6. Mean ± SE values of topographical variables for White-winged Nightjar nest sites and an equal number of random sites.

Variable	Nest sites (n = 9)	Random sites (n = 9)	Significance [a]
Gradient (°)	5.6 ± 1.2	4.8 ± 0.9	t_{16} = -0.52, ns
Altitude (m)	218 ± 5	217 ± 5	t_{16} = -0.07, ns
Distance to nearest stream (m)	306 ± 61	319 ± 54	t_{16} = 0.17, ns
Distance to nearest male display arena (m)	227 ± 49	208 ± 56	t_{16} = -0.25, ns
Aspect – *number of sites facing*:			
NE (0-90°)	1 (11%)	0 (0%)	
SE (90-180°)	1 (11%)	1 (11%)	
SW (180-270°)	5 (56%)	6 (67%)	
NW (270-360°)	2 (22%)	2 (22%)	
Habitat – *number of sites in*:			
Campo cerrado	6 (67%)	8 (89%)	
Wet grassland	3 (33%)	1 (11%)	

(a) From unpaired t-tests.

the predator on either occasion. One female and her chicks were found to have moved to a new clearing, *c*. 10 m from the original nest site, when the chicks were about 10 days old. Assumptions about the fate of other broods, based solely on the disappearance of chicks from the original nest site, therefore seem inappropriate. Of 11 chicks ringed at the nest site, I did not recapture any (post-fledging) before the end of my fieldwork in June 2001. However, one chick ringed in October 2000 was subsequently recaptured as a yearling male in December 2001 (J. Mazar Barnett *in. litt.*).

TABLE 7. Summary of morphometrics of 14 White-winged Nightjar eggs from seven clutches.

Measure	Mean ± SE	Range
Mass (g) [a]	6.7 ± 0.1	5.8-7.5
Length (mm)	27.7 ± 0.3	26.7-29.9
Maximum breadth (mm)	21.0 ± 0.1	19.8-21.7
Volume (cm^3)	6.2 ± 0.1	5.4-7.1

(a) Mass provided only for eggs weighed within two days of laying (n = 10).

DISCUSSION

During the breeding season, male White-winged Nightjars defended small territories on the upper slopes of low ridgelines in the southern sector of Aguará Ñu. The patterns of territory use and ownership I observed supported the suggestion that male territories are traditional (Clay *et al*. 2000). Territories were significantly aggregated within the survey area, with the primary display arenas of neighbouring males separated on average by distances of *c*. 250 m. Males played no part in the parental care of eggs or chicks, and females were only rarely observed near display arenas, with anecdotal evidence suggesting that they mainly visited around full moon when assessing males and seeking copulations. Nest sites were on average 227 m from the nearest display arena, with no evidence to suggest that they fell within the boundaries of male territories. Chick paternity analyses using the amplified fragment length polymorphism (AFLP) technique (Vos *et al*. 1995) suggested that the nearest territory-holding male was not always the father of a brood, and that one male sired the chicks of at least two different females during 1999 (K. Dasmahapatra *in litt*.).

The timing of White-winged Nightjar nesting attempts showed remarkable synchrony with the full moon. A relationship between nest initiation date and moon phase has been demonstrated for a number of nightjar species (*e.g.* Jackson 1985, Mills 1986, Vilella 1995, Perrins & Crick 1996, Pichorim 2002), and authors typically emphasise the advantages of moonlight for foraging during the first two weeks of the nestling period. The modal incubation period of 19 days resulted in chicks hatching between the new moon and first quarter, and hence during a period of increasing moonlight. However, with male investment in reproduction apparently limited to genes, it might also be argued that females use nights with high moonlight to assess the quality of males before securing copulations (although these two considerations are not incompatible).

Male White-winged Nightjars displayed for a relatively prolonged period between late August and early January, broadly coinciding with the vocal activity of other nightjar species breeding at the study site (*e.g.* Common Pauraque *Nyctidromus albicollis*, Little Nightjar, Spot-tailed Nightjar *Hydropsalis maculicauda* and Rufous Nightjar *Antrostomus rufus*). The considerable variation in display rate within this period was likely due more to environmental conditions than to consistent differences between males. The usually rather short-lived high levels of activity observed when males first arrived at display arenas at dusk were perhaps analogous to the dawn peak of song activity noted for many diurnal birds. Following this initial burst, male display rate was best predicted by ambient levels of moonlight. Increases in vocal activity under conditions of increased moonlight have been noted for various nightjar species (*e.g.* Cooper 1981, Mills 1986, Wilson & Watts 2006), so it is not surprising that a similar relationship should exist for a species with such a strong visual component to its display. The "tik tik" call produced by males while in the vicinity of their display arenas seems likely also to play a role in mate attraction or territory defence.

My results support previous suggestions that the "tk" and "grrrrrt" components of male display sounds are both mechanical, rather than vocal, in origin (Clay *et al*. 2000). Careful observation indicated that the "tk" sound was not produced by clapping of the wings below the body, as postulated by Clay *et al*. (2000), but probably by contact with the display mound. However, there was little doubt that the "grrrrrt" sound was produced by the wings during the male's near-vertical ascent from the display mound. Although not as highly modified as those of the Sickle-winged Nightjar *Eleothreptus anomalus* (which is known to produce mechanical wing sounds; Straneck & Viñas 1994), the rigid, curved outer primaries of definitive male White-winged Nightjars probably play a key role in generating the "grrrrrt" (Clay *et al*. 2000, Pople 2003). The production of mechanical sounds is relatively rare in birds (Bostwick 2000), but its evolution is often associated with acrobatic, polygynous courtship displays (Prum 1998), as occur in the White-winged Nightjar system.

Overall, my results indicate that the population of White-winged Nightjars at Aguará Ñu employs a polygynous mating system. Although the breeding biology of most nightjar species remains poorly known, polygyny is apparently relatively uncommon in the Caprimulgidae, and has only been demonstrated convincingly for two other species: the Standard-winged Nightjar *Macrodipteryx longipennis* and Pennant-winged Nightjar *M. vexillarius* (Fry *et al.* 1988, Holyoak 2001, Jackson 2004). Male emancipation from parental care is an important prerequisite for any form of polygyny (Höglund & Alatalo 1995), but is unexpected in altricial bird species if fledging success is limited by the amount of food brought to the nestlings (Oring 1982). Snow & Snow (1979) proposed three ecological attributes that favour the evolution of male emancipation in altricial bird species: frugivory; the ability to regurgitate food; and roofed nests (in rainy season breeders). Nightjars are well known to regurgitate food for their chicks (*e.g.* Cramp 1985, Sick 1993, Cleere 1999), and this ability probably facilitates maximal provisioning efficiency per trip away from the nest. In addition, for species living in savanna habitats, such as the White-winged and Standard-winged Nightjars, the mass hatches of winged termites and ants that occur during summer rains (*e.g.* Jackson 2000, Pinheiro *et al.* 2002) could be analogous to the periodic super-abundance of food associated with frugivory.

Although the population of White-winged Nightjars at Aguará Ñu appeared to fulfil all four of the criteria stipulated by Bradbury (1981) for lek-mating species, the exact nature of the mating system remains uncertain. The inter-male distances I recorded far exceed those typical of so-called "classical" lekking species, but were within the range observed for other "exploded" or "dispersed" avian leks (*e.g.* Théry 1992, Alvarez Alonso 2000, Gray *et al.* 2009). Moreover, the question of whether males were aggregated for sexual reasons, or solely as a result of the patchy availability of suitable display habitat, remains unanswered. If the latter is true, and males were spaced regularly within the available habitat (*e.g.* Pruett-Jones & Pruett-Jones 1982), the study population might best be described as exhibiting a "landmark" mating system. This term has traditionally been reserved for insect species in which males aggregate on hilltops or in forest clearings (*e.g.* Alcock 1981), but is applicable to any taxon using a specialised habitat to provide encounter sites for mating (Höglund & Alatalo 1995). Although the evolutionary causes of aggregation in landmark species differ from those for classical lekking species, females of the former do also visit male aggregations primarily for the purpose of mating, and hence the phenomenon still fits the broad definition of lekking proposed by Höglund & Alatalo (1995).

My results have various implications for the conservation of the White-winged Nightjar and the management of its habitats. The sex-ratio bias of adult captures is likely to have been an artefact of the greater conspicuousness of males (particularly during the breeding season), rather than a true reflection of a skewed population sex ratio. However the finding that the study population probably exhibits a polygynous, possibly even lekking, mating system does have potential consequences for reproductive skew and effective population size (Sutherland 1998). Furthermore, if male display arenas are located at traditional sites, these areas could be of special importance to the population, with limited possibilities for relocation if they are destroyed (Clay *et al.* 2000). As with most species of grassland bird at the study site (pers. obs.), the White-winged Nightjar nests between September and December, on the ground amongst campo cerrado or wet grassland vegetation. Any wildfires during the nesting period would have a major impact on breeding success, and extensive burns in the latter half of August could also disrupt nesting if vegetation did not regrow sufficiently before the onset of breeding activity. Wildfires are a regular occurrence at Aguará Ñu, particularly during the austral spring (*e.g.* August and September), so my findings add weight to recommendations elsewhere for more active fire management within the few protected areas where this globally threatened species is known to persist (*e.g.* Rodrigues *et al.* 1999, Capper *et al.* 2000, Pople 2003).

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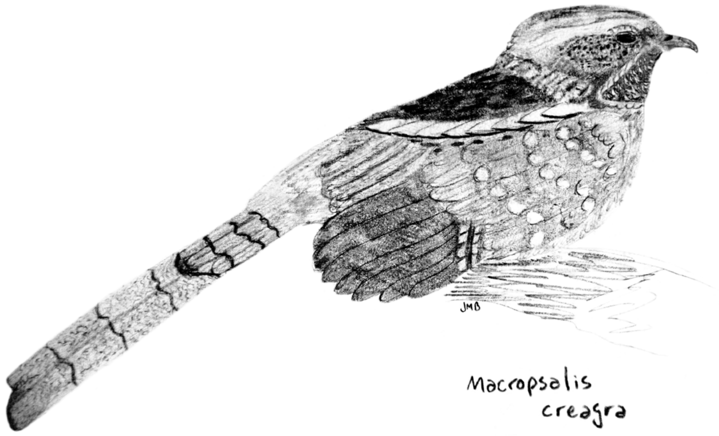

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SHORT-COMMUNICATION

Ecological notes on Seriema species in the Paraguayan Chaco, with observations on *Chunga* biology

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ABSTRACT: I studied the ecology of Black-legged (*Chunga burmeisteri*) and Red-legged (*Cariama cristata*) Seriemas in the central Paraguayan Chaco from September 1989 to August 1990, including observations of a baited family group of *Chunga*. Both species are allotopic in habitat use, with *Chunga* typically associated with drier forested areas and *Cariama* inhabiting savanna and wetland periphery. Interspecific territories were overlapping. Wind velocity and temperature correlated significantly with activity of *Cariama* and baited *Chunga*, respectively. The average density of *Chunga* was 0.38/km^2. Reptiles are an important prey item and I describe an interesting feeding behavior. The breeding season in *Chunga* takes place during the Paraguayan summer (November – March). Bonding and courtship occurred around November and December, and the following 13 weeks were used for nest building, incubation, hatching, and chick development.

KEY-WORDS: Black-legged Seriema; breeding cycle; Chaco; habitat allotopy; Paraguay; Red-legged Seriema; tool use

Black-legged (*Chunga burmeisteri*) and Red-legged (*Cariama cristata*) Seriemas represent the family Cariamidae (Remsen *et al.* 2014), which is somewhat poorly known. Alvarenga (1982) indicated they are the closest living relatives of giant predatory Cenozoic birds (i.e., *Brontornis* and *Mesembriornis*) similar to *Diatryma*. Despite their large size, loud vocalizations, and overall conspicuousness, relatively little has been published on this family, which is surprising considering how common they are in many areas of South America (Redford and Peters 1986). This is especially true for *Chunga*, for which comparatively little is known relative to *Cariama* (c.f., Gonzaga 1996). Most of the information published on this family in the last two decades has related to captive birds (e.g., de Almeida 1994; Collins 1998; Hallager 2004; Padget 2010).

The objective of this note is to describe basic ecology of *Chunga* and *Cariama*, and determine whether habitat partitioning occurs between these taxa. Such mechanisms of allocation reduce the possibility of competition among species filling similar niches (Brooks *et al*. 2001). Additionally anecdotal biological observations are reported from studying a baited family group of *Chunga*.

METHODS

Study region

The main study site was Estancia Fortín Toledo (hereafter Toledo; 22°33'S; 60°30'W), located in the center of the Paraguayan Chaco (Department Boquerón) 35 km west of the Mennonite town of Filadelfia. This area has been extensively cleared for cattle production, like much of the central Paraguayan Chaco (Benirschke *et al.* 1989). The region is primarily grassland pasture punctuated with man-made ponds (*tajamares*) and some small forest tracts. The primary forest type is Quebracho Woodland (Short 1975) with thorny leguminous bushes (e.g., *Prosopis ruscifolia*) and *Opuntia* cactus (Lopez *et al.* 1987) as the dominant plants, with scattered trees (e.g., *Aspidosperma quebracho, Bulnesia sarmientii*, and *Schinopsis* sp.) up to 13 m in height. Isolated tracts of dense thorn forest are sometimes left remaining when land is cleared for agrarian purposes. Spiny terrestrial plants such as bayonet bromeliads (*Bromelia serra*) and star cactus (*Cleistocactus baumannii*) comprise dominant understory plants (Stabler 1985). Mean annual temperature is 26 C° and annual rainfall is 865 mm (Brooks 1998).

I also made observations on transects in the northern Chaco, a north-south habitat transition from the middle to upper Chaco was noted, with the latter characterized by increased forest stratification and higher canopy, less dense and thorny foliage, and an overall greater abundance of broadleaf species. I identified general habitat occupancy by overlapping a macrohabitat map (Olson *et al.* 2001) with seriema range maps from NatureServe (2014).

Field methods

Field data were collected between September 1989–August 1990, during direct encounters while driving unpaved road transects. Weekly surveys extended 35 km from eastern Toledo to Filadelfia (70 km round-trip), and monthly surveys extended 9.3 km through western Toledo. Other areas were randomly surveyed during various times of the year. Additionally, approximately 2 km were walked daily to collect data on habitat association.

Chunga density was determined using strip transects following Balph *et al.* (1977). The road from Toledo to Filadelfla and back (70 km round-trip) was driven weekly during daylight hours. All seriemas seen 10 m from the center of the road were counted, and the resulting surveyed area comprised a 1.4 km^2 plot.

Daily observations of a familial group of *Chunga* lured to a baited site were made from a blind located 8 m from the bait. Study hours in the blind ranged from 0530–2000 h and averaged 225 min/day. Identification of individuals was possible using a combination of differences in size, feather arrangement, and plumage tint.

Temperature (C°) was recorded using a standard thermometer; rainfall (mm) was recorded using a standard rain gauge; cloud cover (clear = 1, partly cloudy = 3, cloudy = 5, overcast = 7, or rainy = 9); and relative wind velocity (stagnant = 1, occasional light breeze = 3, consistent light wind = 5, or windy = 7) were recorded several times during daylight hours. Monthly means were obtained for temperature, cloud cover, and relative wind velocity; a monthly total was obtained for mm of rainfall. The effects of these individual abiotic parameters on seriema activity (encounters) were measured using Pearson product-moment correlations.

RESULTS

Habitat allotopy

Both species of seriema were observed ≤ 0.5 km from forest tracts at Toledo. Although *Chunga* were frequently observed within these isolated tracts, *Cariama* were not. Moreover *Chunga* were always observed in more xeric areas, whereas *Cariama* were often associated with open, seasonally inundated conditions such as mesic savanna or wetland periphery.

During a survey in the northern part of the Chaco, which contains more forest and is less developed than the central Chaco, *Chunga* were seen on two separate occasions (group sizes = 1 and 2), with tracks at a third locale, and vocalizations just north of the Bolivian border. *Cariama* were not encountered during this survey of forested habitat, reinforcing that these two species are allotopic with regards to habitat selection.

The geographic range of *Chunga* is not entirely sympatric with *Cariama* (Fig. 1), having a more westward distribution in Argentina. Overlapping the geographic ranges of both species (NatureServe 2014) with associated habitats of biomes (Olson *et al.* 2001) corroborates that *Chunga* are restricted to drier forested areas, whereas *Cariama* are adapted to more open often mesic environments.

Additional ecological factors

In transitional patches between xeric forest and open habitats, seriemas were spatially sympatric. For example, an individual *Chunga* was observed ca. 30 m from a family of *Cariama* (an adult pair and two juveniles), suggesting that exclusive territories overlap interspecifically and direct competition may not occur between the two species.

Four abiotic factors (temperature, wind, rainfall, and cloud cover) were each correlated with activity of *Cariama* and baited and non-baited *Chunga* to assess if these environmental parameters influenced seriema activity. The only significant correlation with *Cariama* activity was wind (r = 0.324, P <0.05, n = 48), and no significant correlations were found with non-baited *Chunga*. The only significant correlation with baited *Chunga* was temperature (r = 0.372, P < 0.05, n = 48), reflecting increased activity during warmer periods. Both species would stand in tree shade on excessively hot days. *Chunga* were relatively inactive at temperatures less than 27° C, and none were encountered during surveys with temperatures < 27° C. Although rainfall was not significant, baited *Chunga* left the feeding site during heavy, but not light, rain showers.

Chunga biology

Chunga density ranged 0 - 2.14/km^2 monthly with an annual mean of 0.38/km^2. Mean densities for the Austral spring = 0.35/km^2, summer = 0.29/km^2, fall = 0.80/km^2, and winter = 0.11/km^2.

Each *Chunga* spent an average of 3 min (N = 108 separate visits) at the baited site, with a mode of < 1 min (n = 37, 34% of all observations) in the general viewable area. Non-bait food items consumed included a grass (appeared to be buffel grass *Cenchrus ciliaris*), leguminous shoots from algarrobo trees (*Prosopis alba*), large grasshoppers (Acrididae), green *Ameiva* lizards (*Ameiva ameiva*), small snakes (*Liophis* sp.), and small unidentified passerines. The presence of the baited group at the site diminished during periods of high rainfall likely reflects reduced dependence upon the bait site due to increased activity of reptiles, which appeared to make up the bulk of their natural diet.

An interesting feeding behavior was observed that could be interpreted as a form of tool use. *Chunga* used 'anvils' (i.e., cracking bases) to crack open hard boiled eggs and galletas (hardened pastry). By seizing a food item in the bill and raising it high above the head (head and neck perpendicular to ground), the bird swung down and released the food, smashing it over the anvil. This behavior was observed > 225 times and involved different types of anvils (i.e., salt lick rock, brick, lumber, or hard squash). The smaller pieces were consumed once a food item was broken. If an item was only cracked in two, the smaller piece would be smashed again or the larger piece would be held steady with the foot while the inner portions were consumed. Usually the food item was cracked within the first few throws. Accuracy of hitting the anvil diminished with number of throws. On one occasion a food item was thrown 12 times on four different anvils (hard squash, brick, lumber, and salt rock) before the item was consumed. After a few unsuccessful throws a food item was usually exchanged for another.

The breeding season in *Chunga* is during the Austral summer (December–February) when temperature and wind are fairly constant and high rainfall results in abundant food availability. Sightings of non-baited *Chunga* decreased slightly during this period (see above) due to established territories and nesting behavior commencing. Although typically a single chick is raised, two juveniles were observed with their parents on one occasion. Specific breeding dates and events were observed from the baited pair, as follows:

13 November: Pair arrives together at the feeding site for the first time

1 December: Pair observed unison calling

3 December: Courtship observed

7 December–7 March: Pair absent

8 March: One of the adults returns to the feeding site with a juvenile.

Thus nest building, incubation, hatching, and growth is approximately 13 weeks.

DISCUSSION

The results suggest *Chunga* is associated with more xeric areas, whereas *Cariama* is found in more open, often mesic habitats. This was observed at the main study site, as well as in other parts of the Chaco, and was also confirmed by overlaying range to habitat maps. While these results essentially corroborate the findings of others (cf. Gonzaga 1996), the findings of lack of interspecific territoriality, and the influence of various abiotic components are apparently novel to this study. Specifically, a single *Chunga* was observed near an adult pair of *Cariama* with offspring with no territorial consequence. Additionally wind velocity was significantly correlated with *Cariama* activity, and temperature was correlated with baited *Chunga* activity.

Many of the results for *Chunga* biology are novel, including density (seasonal mean, annual mean, and range) and feeding habits (e.g., reptiles in the diet), and certain aspects of reproduction (cf. Gonzaga 1996). The behavior involving utilizing an anvil to break food items is similar to that described in other species of birds, such as Egyptian Vultures (*Neophron percnopterus*; Van Lawick-Goodall and Van Lawick 1966). This could be considered a form of tool use because the anvil is an inanimate object serving as a functional extension of the animal (McFarland 1987), and the behavior was observed on numerous occasions ($n \geq 225$) upon different anvils.

More detailed autecological studies of habitat association, food habits, behavioral and reproductive ecology would be fertile areas for future research. In particular, the ability to quantify habitat with movements using telemetry equipment would be fruitful, as well as the ability to quantify preferred prey.

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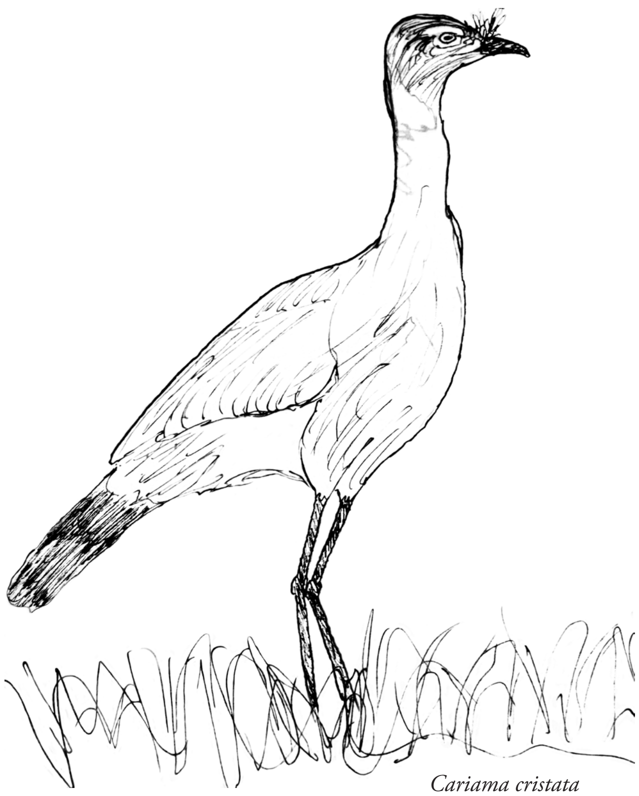

Cariama cristata

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SHORT-COMMUNICATION

Natural history notes and breeding of the Pale Baywing (*Agelaioides fringillarius*) in northern Minas Gerais, Brazil.

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ABSTRACT: In Brazil the Pale Baywing is regarded as an endemic species of the Caatinga biome (Pacheco 2000). We present data on habitat, foraging and breeding of the Pale Baywing (*Agelaioides fringillarius*) obtained between 2001 and 2005 at Francisco Sá, Minas Gerais. We document the occurrence of cooperative breeding, and its host-parasite interactions with Shiny (*M. bonariensis)* and Screaming Cowbirds (*Molothrus rufoaxillaris*), the last a recent invader in this area. Nests (N = 18) were detected from December to February, during the rainy season. Most nests (N =12) were placed within domed twig nests built by three furnariid species, and 5 nests were built within the crowns of palm trees. Six nests containing nestlings had from 4 to 6 attending Pale Baywings that brought food and mobbed or attacked avian predators or nest pirates. Two nests contained feathered Shiny Cowbird (*M. bonariensis*) chicks. Screaming Cowbirds were first seen in Francisco Sá in 1993, but up to 2005 all Screaming Cowbirds chicks were observed in nests of Chopi Blackbirds (*Gnorimopsar chopi*), or were flocking and roosting with this host.

KEY WORDS: Pale Baywing, *Agelaiodes fringillarius*, natural history, nesting, cooperative breeding, brood parasitism, *Molothrus rufoaxillaris*, *M. bonariensis.*

INTRODUCTION

The Pale Baywing was described as *Icterus fringillarius* by Spix in 1824 from Minas Gerais, Brazil. Up to Friedmann´s classical monograph (1929) it was treated as a full species (*Agelaioides fringillarius*). Jaramillo and Burke (1999) suggested that Pale Baywings could deserve specific status. The official Brazilian checklist (CBRO 2011) recognizes this form as a species, which is regarded as an endemic species of the Caatinga biome (Pacheco 2000).

Abundant information on the natural history and nesting behavior is available for the Grayish Baywing (*Agelaioides badius*), an icterid with cooperative breeding and subject to brood parasitism by two parasitic cowbirds (e.g. Friedmann 1929, De Marsico *et al.* 2012, Fraga 1986, 1998, 2011, Lowther 2013, Mason 1980). By contrast, only a minimum of natural history data and nesting information is available for the Pale Baywing. Ihering (1914) provided information on a single Pale Baywing nest, found in Barra, state of Bahia. A summary of the scant nesting information for Pale Baywings (Friedmann 1929, Jaramillo and Burke 1999) indicate the use of abandoned nests of furnariids, absence of cooperative breeding, and rare parasitism by Shiny Cowbirds (*Molothrus bonariensis*).

We present here new information on the natural history and breeding behavior of the Pale Baywing obtained in Minas Gerais, northeastern Brazil. We include data on habitat use, foraging, nesting sites, cooperative breeding and interactions with brood parasites and nest predators. We paid special attention to interactions with Screaming Cowbird (*Molothrus rufoaxillaris*) a parasitic species that invaded this area in 1993 (D'Angelo Neto 2000) and is spreading further north in northeastern Brazil (Fraga 2011). As Grayish Baywings are the main Screaming Cowbird host in Argentina (Friedmann 1929, De Marsico *et al.* 2012, Fraga 1986, 1998, 2011, Lowther 2013, Mason 1980) it was suspected that Pale Baywings could also become hosts of this cowbird (Kirwan *et al.* 2001).

METHODS

The study area was centered in the rural town of Francisco Sá, Minas Gerais state, Brazil (16º29'S, 43º30'W; altitude

630 m). R. Fraga studied the Pale Baywings during two field trips (9 to 19 July 2001, and 28 December 2001 to 6 January 2002). S. D'Angelo Neto studied the species between January 2001 and March 2005.

Pale Baywings were found in an area of 120 km^2 around Francisco Sá at several *fazendas* (rural properties) with altitudes of 600 to 690 m; important information was obtained at Fazenda Baixo da Lasca (16º22'S, 43º33'W). The local climate was classified as "semiarid tropical" (Nimer 1989) with a mean annual temperature of 23º C. Annual rainfall averages 976 mm, with a severe dry season that lasts six months (April to September).

The landscape around Francisco Sá was hilly, and the original vegetation in the more humid lower bottoms was usually replaced with cattle pastures and some irrigated fields, divided by hedges of low native trees and shrubs (e.g. joazeiro *Zyziphus joazeiro*, *Celtis* sp.). Streams and marshes were mostly seasonal. A few remaining forest patches in the *fazendas* included tree species like *Astronium fraxinifolium*, *Myracrodruon urundeuva*, *Anadenanthera colubrina*, *Acacia polyphylla*, *Amburana cearensis* and *Schinopsis brasiliensis*. More xeric deciduous woodland and scrub occurred in rocky hilltops. The town and the larger *fazendas* had introduced trees and orchards of fruit trees like papaya, citrics, goiaba and mango.

Study areas for Grayish Baywings in Argentina (1977-1979) are described in Fraga (1986, 1998).

Field observations were carried with 8 x 10 binoculars. Bird behavior and vocalizations were monitored with a Sony Walkman Professional cassette recorder with an AKG C568 shotgun microphone. Nests in the "nestling stage" are those that contained nestlings (seen or heard) or those where we saw adult Pale Baywings carrying food. Observation times for nests ranged from 1 to 6 h, in most successful nests observation times were spread along three days.

RESULTS

Habitat use, roosting, foraging, and group sizes

Pale Baywings were mostly found in human-modified environments. They were abundant and even nested in Francisco Sá, using *praças*, street trees, orchards and gardens. In the *fazendas* they were one of the most common passerines.

Pale Baywings roosted only in trees. During the study we counted from 14 to 64 individuals roosting in street trees at Francisco Sá, often in company of House Sparrows (*Passer domesticus*) and less frequently Shiny Cowbirds (*Molothrus bonariensis*), Screaming Cowbirds, and Picui (*Columbina picui*) and Ruddy Ground Doves (*C. talpacoti*). Contrasting with roosting Grayish Baywings, group singing was rare in Pale Baywings, with a maximum of 2-3 individuals producing brief songs. Around dawn, groups of Pale Baywings commuted to open fields elsewhere.

The largest group size of foraging Pale Baywings consisted of about 70 individuals, feeding in an empty corral. Elsewhere foraging groups ranged from two to 43 individuals. Most foraging was done on the ground, in weedy fields, pastures or stubble. In the non-breeding season Pale Baywings were largelly comensal with rural people, feeding on spilled seeds and domestic refuse around houses, barns, poultry yards and corrals. We saw Pale Baywings feeding on cultivated seeds (maize, sorghum) or chicken food, rarely picking arthropods. A small group fed on exudates of Homoptera, and other tried to capture a small *Tropidurus* lizard. Pale Baywings did not follow grazing livestock. In the dry season the more abundant Chestnut-capped Blackbird (*Chrysomus ruficapillus*) frequently associated with foraging Pale Baywings in the *fazendas*. Shiny Cowbirds were less common associates. In fewer cases we saw the ground doves, Saffron Finches (*Sicalis flaveola*), Red-cowled Cardinals (*Paroaria dominicana*), Screaming Cowbirds and Chopi Blackbirds (*Gnorimopsar chopi*) near Pale Baywing groups.

Breeding

We detected nests (N = 18) from December to February, during the rainy season. J. Minns (pers. comm.) observed a case of nest building during the early rainy season (2 October 2002) at Januaria, Minas Gerais. Most nests (N =12) were placed within domed nests of twigs built by three species of furnariids: Rufous-fronted Thornbird (*Phacellodomus rufifrons*), Caatinga Cacholote (*Pseudoseisura cristata)* and Chotoy Spinetail (*Schoeniophylax phryganophila*). One nest was found within a nest of Great Kiskadees (*Pitangus sulphuratus*) in the main *praça* of Francisco Sá. Five nests were built within the crowns of the palm trees *Cocos nucifera* (N =4) and *Roystonea regia*, this last one in the town of Francisco Sá. We did not observe Pale Baywings using the mud nests of Rufous Horneros (*Furnarius rufus*), although some were available.

Domed twig nests of furnariids were abundant in the study area, in the case of the thornbird up to five nests could be find in a single tree. All Pale Baywing nests were solitary, more than 200 m from each other. Nest heights ranged from 3.5 to 11 m, and only two could be inspected. Pale Baywing nests in palms were built at the base of fronds, the one in *Roystonea* partially hidden by a flowering spathe.

We have data on numbers of visiting Pale Baywing adults only for nine nests, including six that reached the nestling stage. One baywing nest in a low thornbird nest was found before egg-laying and contained an empty, loose cup of grasses. Only two adults visited this site and scolded during our inspections. On a next visit this nest had no eggs and appeared abandoned. Three adults visited an inaccessible cacholote nest. Incubation had started in a second inaccessible cacholote nest, with one individual remaining inside for up to 45 min. It was visited by up to four individuals. All nests that reached the nestling stage were visited by 4 to 6 adults that brought food, carried fecal sacs and defended the nests. Six individuals provisioned 15 food items to a 9 m high thornbird nest in *Schinopsis* observed during 4 h on 28 December 2001. Identifiable items brought to nestlings were mostly insects and spiders, and rarely pieces of small lizards or amphibians. On 4 January 2002, three nestlings were leaving this nest and 8 Pale Baywing adults were noisily vocalizing within 5 m of it.

Pale Baywing nesting groups were seen noisily attacking and mobbing five bird species. Once a Harris Hawk (*Parabuteo unicinctus*) successfully carried feathered nestlings although it was attacked and pursued by five Pale Batwings. Guira Cuckoos (*Guira guira*) were successfully evicted around nests four times, and Cattle Tyrants (*Machetornis rixosus*) twice. The most striking and successful case of nest defense occurred on 28 December 2012 in a thornbird nest at Baixo da Lasca twice attacked in 4 h by a pair of Campo Troupials (*Icterus jamacaii*). Four of the six Pale Baywings chased and mobbed the troupials while two perched blocking the nest entrance. In a similar case two Catinga Cacholotes that perched within 10 m of one Pale Baywing nest were mobbed and chased while other individuals remained as sentinels near the nest. All the attacked species were nest predators, nest pirates or nest competitors (Pinto 1967, Remsen 2003).

In December-February we saw Pale Baywing groups of 2-8 adults plus food-dependent fledglings. Some of those post-nesting groups foraged in the thorny woodlands on the rocky hilltops, which were seldom visited during the dry season. In two *fazendas* juveniles with pinkish mouths were following adults as late as 10-12 July, but their gaping behavior and begging calls did not elicit feeding. However, Roadside Hawks (*Buteo magnirostris*) that perched within 20 m from two juveniles were mobbed and chased by 3-4 adults.

Brood parasitism by cowbirds

The two nests within the town of Francisco Sá contained single feathered Shiny Cowbird chicks, both with dusky black plumage, plus host chicks. Female and juvenile plumages are similar in Shiny Cowbird populations (Fraga 2011) and most Shiny Cowbird females seen in the study area belonged to this dusky black *melanogyna* morph. One Shiny Cowbird chick fledged from the *Pitangus* nest on 5 January 2002. The next day we also observed two recently fledged host chicks at the same site. Many adults brought food to the host chicks during 3 h of observation, but the parasite chick was ignored. The fate of the Shiny Cowbird chick in the *Rostoynea* nest remains unknown, as the nest was deserted in our next visit.

No visits of Screaming Cowbirds to Pale Baywing nests were observed during the 2001-2004 breeding seasons. Only once we saw an interaction between breeding Pale Baywings and Screaming Cowbirds. On 29 December 2005, two Pale Baywings chased a Screaming Cowbird pair near a thornbird nest, while two more baywings perched at the nest entrance. We did not observe in our post-breeding Pale Baywing groups the diagnostic black-blotched plumage of molting Screaming Cowbird fledglings.

Breeding Chopi Blackbirds around Francisco Sá used palm crowns and nests of thornbirds and horneros, thus partially overlapping in site use with Pale Baywings. The first case of Screaming Cowbird parasitism at Francisco Sá was observed on 23 December 1993 when a Chopi Blackbird nest in a tree hole 4 m high contained two parasite chicks plus one host nestling. In 2001-2005 we observed adults, juveniles and fledglings of Screaming Cowbirds mostly at Fazenda Baixo de Lasca. Adults occurred in groups of one to four pairs or (once) a single displaying and singing male. Screaming Cowbirds flocked with Chopi Blackbirds at this *fazenda* and shared roost sites with them. Around those roosts we saw five Screaming Cowbird fledglings (some molting into black plumage) being fed and guarded by adult Chopi Blackbirds.

DISCUSSION

Pale Baywings resembled Grayish Baywings in using mostly human-modified habitats and in consuming an opportunistic mixture of seeds and animal food. Rarer plant foods in the diet of Grayish Baywings (fruits and nectar, Fraga 2011) could be used by Pale Baywings as well. Gregarious roosting, foraging behavior and group sizes are comparable in both forms. The breeding season of Pale Baywings at Francisco Sá presumably extends to the end of the rainy season in March.

Furnariids provided most nest sites for Pale Baywings, as with most reports for Grayish Baywings from Argentina (e.g. Hoy and Ottow 1968, Di Giacomo 2005). In another study from Argentina (Fraga 1988) Grayish Baywing nest sites were more diversified, including holes in trees and clumps of epiphytic bromeliads, not observed in our small Pale Baywing sample. Most studies of Grayish Baywings from Argentina do not mention nests in palm trees (e. g. Hoy and Ottow 1968, Di Giacomo 2005) and only 4 of 161 nests in Fraga (1988) were built in the base of palm fronds. Pale Baywings seem to nest in palm trees more frequently than Grayish Baywings in Argentina. Nests built within the crowns of palm trees are reported for a small number of Neotropical icterids, particularly Chopi Blackbirds, Cuban Blackbirds (*Dives atroviolacea*) and the Puerto Rican Yellow-shouldered Blackbird (*Agelaius xanthomus*) (Fraga 2011).

Our data shows that Pale Baywings are cooperative breeders, with more than two individuals sharing parental duties at every nest that reached the nestling stage, sometimes even before. We saw higher numbers of helpers per nest than in Argentinian Grayish Baywings (Fraga 1991). More information is needed on the age, sex and degree of kinship of the helpers.

We confirmed parasitism of Pale Baywings by Shiny Cowbirds. On the other hand, twelve years after the arrival of Screaming Cowbirds in Francisco Sá we could not find solid evidence that they were effectively parasitizing Pale Baywings. We cannot predict if a host-parasite interaction will evolve in the future. Although Screaming Cowbird nestlings resemble those of Pale Baywings in plumage and calls, aggressive and coordinated nest guarding by Pale Baywing groups may be a deterrent to this newly arrived brood parasite. Our data shows that Chopi Blackbirds played a main role during the remarkable range expansion of Screaming Cowbirds in northeastern Brazil.

ACKNOWLEDGEMENTS

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SHORT-COMMUNICATION

Record of the White-throated Woodcreeper *Xiphocolaptes albicollis* using a millipede for anting in Argentina

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ABSTRACT: We describe the second record of the White-throated Woodcreeper *Xiphocolaptes albicollis* anting with a millipede in South America, and the first such record for Argentina. The woodcreeper rubbed the millipede against its wings while perched at the base of a tree and on the ground. The anting seemed to not seriously injure the millipede, identified as a species of the Rhinocricidae (Spirobolida).

KEY-WORDS: White-throated Woodcreeper; *Xiphocolaptes albicollis*; anting; millipede; preening; Argentina.

The term anting is used for a behavior of birds in which they use arthropods, mostly ants, to rub on their plumage as part of the birds' preening process (Chisholm 1959; Potter 1970). Several hypotheses have been proposed for anting, including deterring of ectoparasites (Clark & Clark 1990; Sick 1997). Another hypothesis is that ant secretions soothe skin that has been irritated when new feathers emerge (Southern 1963; Potter 1970). At present, about 200 bird species (Clayton & Vernon 1993) and mammals have been reported to perform anting (Valderrama *et al.* 2000; Weldon *et al.* 2003). Among wild birds, anting is performed quickly and can be overlooked or mistaken for foraging or simply as sun/dust-bathing with anting taking place passively (Chisholm 1959; Potter 1970; Wenny 1998). Besides ants and other noxious arthropods, birds are known to use millipedes while anting (Chisholm 1959). Here we report on the White-throated Woodcreeper *Xiphocolaptes albicollis* anting with a millipede, the first record of this behavior for Argentina.

We observed a White-throated Woodcreeper handling a millipede around noon, on 19 November 2011 at Cruce Caballero Provincial Park, Misiones, Argentina (26º31'S, 54º00'E; 550-600 m elevation). During our observations, the woodcreeper rubbed the millipede against its wings mostly while perched at the base of a tree about 50-100 cm above ground, and once on the ground. On one occasion the bird flew a few meters away, leaving the millipede on the ground. While photographing the dropped millipede we noted that it was not severely injured, and afterwards we moved away to proceed with our observations. The woodcreeper returned in less than one minute, picked up the millipede, and proceeded anting. After 10 min the bird retreated into the forest, thus ending our observations. The millipede was identified as a species of the Rhinocricidae (Order Spirobolida).

Our observations of woodcreeper anting were similar to those described by Sazima (2009) for the same bird species, except that the bird he observed ingested the millipede at the end of the anting session. As we were unable to record the end of the anting process, we cannot say whether the bird was trying to lessen the effects of ingesting a toxic or distasteful prey as suggested by Sazima (2009). The woodcreeper we observed could have been biting the millipede to enhance its secretions by accessing the internal reservoirs of glandular fluids, as suggested for monkeys biting millipedes (Valderrama *et al.* 2000; Weldon *et al.* 2003). Careful observation of additional bird species' behavior during dust/sunbathing or even during regular preening may yield a better understanding of the use of odorous/noxious substances from arthropods as part of their preening process.

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We dedicate this article to Juan Mazar Barnett, cornerstone of modern ornithology in South America and an inspiring naturalist who sought to unravel the mysteries of the natural world. We thank A. Bodrati and K. Cockle for inviting us to collaborate on the Pino Paraná Forest Project, and A. G. Zubarán, S. Rowland, and L. A. Pereira for identifying the millipede. We also thank Y. Oniki for her comments on anting and K. McFarland, I. Sazima, P. Vickery, and K. Roesler for critical suggestions on the first draft of this manuscript.

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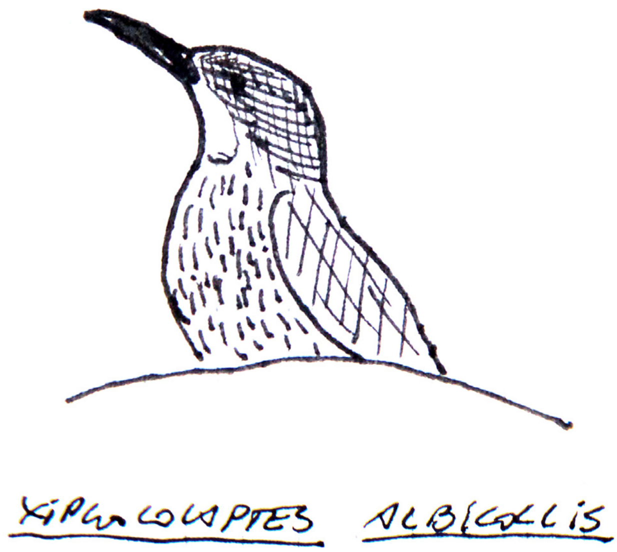

ERRATUM

As shown in figure 1a and b, the owl identified as a Crested Owl *Lophostrix cristata* (Daudin, 1800) in Rocha & López-Baucells (2014) is indeed a Mottled Owl *Strix virgata* (Cassin, 1849). Therefore, all results and conclusions in the paper pertaining to *L. cristata* refer in fact to *S. virgata*. Both the authors and the Editor in Chief of *Revista Brasileira de Ornitologia* thank readers for noticing this inconsistency and apologize for this misidentification error.

REFERENCE

Rocha, R. & López-Baucells, A. 2014. Opportunistic predation of the Crested Owl *Lophostrix cristata* upon Seba's short-tailed bat *Carollia perspicillata. Revista Brasileira de Ornitologia,* 22: 35-37.

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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.

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Sick, H. 1985. *Ornitologia brasileira, uma introdução,* v. 1. Brasília: Editora Universidade de Brasília.

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Remsen, J. V. & Robinson, S. K. 1990. A classification scheme for foraging behavior of birds in terrestrial habitats, p. 144-160. In: Morrison, M. L.; Ralph, C. J.; Verner, J. & Jehl Jr., J. R. (eds.). Avian foraging: theory, methodology, and applications. Lawrence: Cooper Ornithological Society (Studies in Avian Biology 13).

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

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