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CONTENTS

BEHAVIOR

Burrowing Owls *Athene cunicularia* (Strigidae) respond with increased vigilance to calls of the Curl-crested Jay *Cyanocorax cristatellus* (Corvidae) in the Paraguayan Cerrado

Victoria Austin, Joseph Savary and Paul Smith 1

First records on nests of Pompadour Cotinga (*Xipholena punicea*) in Brazil, with notes on parental behavior

Marcelo Henrique Mello Barreiros 9

ECOLOGY

Diet preference and density of the Greater Rhea (*Rhea americana*) in grasslands of the Flooding Pampa, Argentina

Viviana Comparatore and Cristina Yagueddú 13

Exploitation of *Ceiba pubiflora* flowers by birds

Diego Matiussi Previatto, Daniel Irineu de Souza Dainezi and Sérgio Roberto Posso 21

Foraging techniques of Swallow-tailed Cotinga (*Phibalura flavirostris*) on fruits of *Struthanthus marginatus* (Loranthaceae) in Monte Verde, Camanducaia, state of Minas Gerais, Brazil

Carlos Henrique Luz Nunes-de-Almeida and Verónica del Rosario Avalos 27

A small homage to Maria Sibylla Merian, and new records of spiders (Araneae: Theraphosidae) preying on birds

João Vitor Campos e Silva and Fernanda de Almeida Meirelles 30

SYSTEMATICS, TAXONOMY, AND DISTRIBUTION

A reassessment of the taxonomy of *Crypturellus noctivagus* (Wied, 1820)

Barbara Mizumo Tomotani and Luís Fábio Silveira 34

Olive-sided Flycatcher, *Contopus cooperi*, in the Cerrado biome, and a review of records in Brazil

Karla Dayane de Lima Pereira 46

Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil

Dante Andres Meller and Demétrio Luís Guadagnin 53

A new southern limit for the distribution of the Thrush-Like Wren, *Campylorhynchus turdinus* (Aves: Troglodytidae)

Dilson Vargas-Peixoto and Mariane Bosholn 58

Curlew Sandpipers *Calidris ferruginea* in the western Atlantic: the first, second, and third Brazilian records from Ceará and Maranhão

Lukas J. Musher, Alexander C. Lees, Bruno Jackson M. Almeida, Roberta C. Rodrigues, Carmen E. Fedrizzi, João M. Holderbaum and David Mizrahi 62

First documented record of the Rufous-tailed Attila (Tyrannidae) for Corrientes, Argentina

Natalia C. García, Natalia Trujillo-Arias, Cecilia Kopuchian and Gustavo S. Cabanne 68

Instructions to Authors 73

Revista Brasileira de Ornitologia, 24(1), 1-8
March 2016

ARTICLE

Burrowing Owls *Athene cunicularia* (Strigidae) respond with increased vigilance to calls of the Curl-crested Jay *Cyanocorax cristatellus* (Corvidae) in the Paraguayan Cerrado

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ABSTRACT: Nesting Burrowing Owls (*Athene cunicularia*) in the Cerrado of northeastern Paraguay were observed to show increased vigilance in response to Curl-crested Jay (*Cyanocorax cristatellus*) calls. To test whether this reaction was species specific, a playback experiment was conducted using jay calls, a native passerine and three exotic passerines, and responses of the owls to the recordings were measured. The results indicated that the owls responded with increased vigilance only to calls of the Curl-crested Jay. It is hypothesized that the interaction between the two species may be related to competition for dietary resources initiating a greater aggressive response in the diurnal jay due to its more limited foraging time, compared to the nocturnal and diurnal owls. The vigilant response of the owls may thus be related to avoidance of potentially costly aggressive interactions with jays.

KEY-WORDS: behavior, corvid, interspecies, Laguna Blanca, playback.

INTRODUCTION

Heterospecific species interactions have become an increasingly popular focus of animal behavioral studies in recent years, but their functions remain poorly understood. Interspecies interactions are often energy demanding with evolutionary benefits that are not immediately apparent, making their role difficult to understand. Despite this, they appear to be quite common in nature (Peiman & Robinson 2010). Such interactions vary widely in relation to trophic levels, taxonomy, ecology, time and space (Laiolo 2013) and may be indicative of ecological symbioses or direct competition (Martin & Martin 2001), or simply a result of misdirected interspecies aggression (Murray-Jr. 1971, Martin & Martin 2001).

To date, much of the research in avian interspecies reactions has focused on mixed species flocks (Morse 1970, Krebs 1973, Ragusa-Netto 2002, Harrison & Whitehouse 2011, Sridhar *et al.* 2013, Goodale *et al.* 2015). Studies examining non-flocking species have looked largely at interactions in which the relationship between species is well understood; *i.e.* predators interacting with known prey species or competitive interactions where the dominant species was easily identifiable (Pravosudov & Grubb 1999, Robinette & Crockett 1999). However, more subtle species interactions can also occur but are not as frequently documented, perhaps due to difficulties associated with quantifying them. The ongoing investigation of interspecies interactions, whether overt or subtle, in a variety of species and ecological contexts, remains important in revealing information about species and the environment they inhabit.

In the Cerrado of Reserva Natural Laguna Blanca, San Pedro Department, eastern Paraguay (56°17'W; 23°46'S), previously undocumented direct and indirect heterospecific interactions were observed between the Cerrado endemic Curl-crested Jay *Cyanocorax cristatellus* (Corvidae) and the widespread Burrowing Owl *Athene cunicularia* (Strigidae). The Curl-crested Jay is an intelligent, highly mobile, social corvid (Amaral & Macedo 2003), and a generalist feeder (Amaral & Macedo 2003) which has expanded its range in recent decades (Lopes 2008). The non-melodic call of the Curl-crested Jay is capable of travelling considerable distances across the open terrain that typifies its habitat (Amaral & Macedo 2003), and is easily audible to other species that reside in close proximity. However, the vocal repertoire is poorly understood and differences between calls have yet to be formally identified. The Burrowing Owl is a widespread terrestrial owl distributed throughout the Americas in open habitats from grasslands and deserts to cattle ranches and farmlands (Berardelli *et al.* 2010). This small raptor nests in burrows in the ground which it constructs itself, but will also utilize abandoned burrows of other animals (Crowe & Longshore 2013). In addition to building burrows, Burrowing Owls have been shown to exhibit numerous interesting behaviors including eavesdropping (Bryan & Wunder 2014) and the utilization of dung as a tool to attract insects to their burrows (Levey *et al.* 2004).

During our field studies the two species were observed interacting in four different ways. The most common interaction was Burrowing Owls responding with increased vigilance to Curl-crested Jay calls. This response suggested that the owls were able to recognize the calls of the jays and responded to them as though they indicated a threat. The other interactions we observed, however, made it difficult to deduce exactly why the owls would respond defensively. One interaction that would suggest there is a direct antagonistic relationship between species was a mobbing event. A group of seven jays were observed mobbing an owl away from its nest while two members of the jay's flock occupied the ground directly surrounding the entrance to a burrow. On the other hand, despite frequent observations over three months, this mobbing behavior was only observed once. In the majority of the direct interactions between species, no antagonistic response was elicited from either species, with the jays foraging within 50 m of the owl burrow on multiple occasions without the owls responding. One other indirect interaction was captured by a camera trap set up to watch the entrance of a burrow. The video shows a jay consuming a small unidentified white object taken from the sand at the very entrance of an owl burrow. These observations suggest that the Burrowing Owls and the Curl-crested Jays interact frequently and in a diverse number of ways. The vigilant response of semi-terrestrial owls to the vocalizations of the largely arboreal jays is noteworthy as no obvious link between the ecology of the two species is described in the literature. To test whether the call of the Curl-crested Jay alone was indeed the trigger for the increased vigilance of the Burrowing Owls, we designed an audio playback study. This paper describes the results of this field experiment and suggests possible hypotheses for how the two species may interact.

METHODS

Study Site

The Cerrado is South America's second largest biome (Ab'Saber 1977, Lopes 2008), covering 1.5–1.8 million ha (Cardoso-da-Silva 1995) from central Brazil, west into eastern Bolivia and south to northeastern Paraguay. Studies of the avifauna of the Cerrado are few, and the habitat has been largely overlooked by researchers in Paraguay (Robbins *et al.* 1999) despite the recognized conservation concern of this biodiversity hotspot and the imminent conservation threats that it faces (Cardoso-da-Silva & Bates 2002).

This study was carried out within the Important Bird Area Cerrados of Laguna Blanca (Cartes *et al.* 2008) which is located in San Pedro Department of Paraguay (Figure 1). The area is a large island of Cerrado habitat that was historically bordered on all sides by the Upper Parana Atlantic Forest. The Cerrado of Laguna Blanca is one of only a few places in Paraguay that has been intensively surveyed in terms of its avifauna. It is home to over 319 bird species (Smith *et al.* 2016) 10 of which are of global conservation value (Smith *et al.* 2012). The IBA has recently been classified as an "IBA in danger" as a result of habitat fragmentation due to transformation to agricultural land (BirdLife 2015).

The study site was located across two neighboring properties: Rancho Laguna Blanca, an 1145 ha property home to an eco-tourism business that held private reserve status during the time of the study (the protection elapsed in April 2015); and Agroforestal Rio Verde, a >2000 ha eucalyptus plantation with large tracts of untransformed Cerrado. While neither property currently has formal protection, all the Burrowing Owls observed were found in areas of well-preserved Cerrado habitat alongside internal roads.

Recordings

All recordings were obtained from the XC online data base (www.xeno-canto.org). The recordings fell into one of three categories; 1) target species call; Curl-crested Jay (*Cyanocorax cristatellus*) (Smith 2008, da Silva 2011) 2) familiar local-species call; White-rumped Tanager (*Cypsnagra hirundinacea*) (Velazquez 2008), and 3) exotic species call; Willie-Wagtail (*Rhipidura leucophrys*) (Jacobson 2008), Noisy Myna (*Manorina melanocephala*) (Woodall 2010) or Satin Bowerbird (*Ptilonorhynchus violaceus*) (Deroussen 2011). White-rumped Tanager calls and Curl-crested Jay calls were chosen based on their clarity, and recordings from Paraguay were used to minimize any potential differences in response that may occur due to different unreported vocal dialects in these species. For the category 'exotic species call', we chose three different species' calls to ensure that responses to the unknown calls were not impacted by gradual habituation across the experiment period (Groves & Thompson 1970, Dong & Clayton 2009) and to eliminate pseudo-replication (Catchpole 1989). As all recordings were a maximum of 30 s, they were played placed on a loop so as to run for 60 s during each trial.

FIGURE 1. Location of study site at Reserva Natura Laguna Blanca in San Pedro Department, Paraguay. The study site was located across two neighboring properties: Rancho Laguna Blanca, an 1145 ha property home to an eco-tourism business that held private reserve status during the time of the study and Agroforestal Rio Verde: a >2000 ha eucalyptus plantation with large tracts of untransformed *Cerrado*.

Playback design

For the playback experiment, we utilized a single speaker design (Douglas & Mennill 2010) using an EcoExtreme Speaker (EcoXGear). Nine nest sites were chosen based on accessibility and the site fidelity of the owls. Over the three day study period, we visited each nest three times a day: morning (6 AM–8 AM), mid-day (11 AM–1 PM), and late afternoon (4:30 PM–6:30 PM) (Table 1). The call category remained consistent across each time slot, but the order was changed every day. This was done so that owls were exposed to each call type across the three time frames, eliminating effects of time of day.

Due to the predictable behavior of the owls and their preference to sentinel on bare perches, the researchers were able to approach consistently on the same course for each nest. The owls were easy to locate in all trials except one where the birds were absent from the site. The birds were clearly visible throughout playback trials.

For each trial, nesting areas were approached slowly in a vehicle until the observers reached 60 m from the nearest Burrowing Owl (which were always within 10–20 m of their nests). The use of a vehicle in this experiment as an observation point did not appear to adversely affect behaviors of the owls. As vehicles are used frequently on the properties the birds in this experiment were habituated to their presence prior to the experiment being conducted. Additionally, the distance maintained by observers away from nests appeared sufficient to prevent vigilance responses to the observers themselves. In pilot studies, if researchers exited the vehicle to perform observations, owls showed obvious vigilance behaviors that did not resolve quickly. In this study, conducting observations from a vehicle proved the most efficient unobtrusive means of observing the birds. The angles of nest entries varied for each site, but were either parallel or perpendicular to the vehicle. Due to the terrain, we were limited in the angle we could approach the nests without adversely affecting the owls behavior and thus the results of the experiment.

On arrival, each observer was assigned a single bird to observe and each individual bird was treated as an independent sample. The Burrowing Owls were observed for 120 s to ensure that a vigilant response would not be an artifact of our presence or the presence of some other threat. Playback trials were cancelled if the owls displayed any vigilant response within that 120 s time frame. Trials were also abandoned if some other factor that would cause an external vigilant response (*e.g.* presence of a bird of prey was apparent to observers). The recordings were played from the speaker placed on top of the car directed towards the owls while the observers watched from within the vehicle.

During each trial the same 60 s long recording was played twice at each site. There was a 30 s latent period of silence between each playback. In trials of the familiar local-species call and exotic species call; if the owls remained undisturbed throughout both playbacks, a third recording, that of the target species (the Curl-crested Jay), was played at the end of the trial. This was done to take advantage of the opportunity to test the target call against the two controls in the same time and setting.

Responses of owls were observed using binoculars and behaviors categorized and ranked in order of the intensity of reaction from 0 to 3 (Table 2). Category 0 behaviors showed no obvious response to the playback and birds continued natural behaviors such as preening and sleeping. Category 1 indicated that the playback had been heard, *e.g.* birds would glance in the direction of the playback or cock their head, but no obvious change in behavior or posture indicated an alarmed response. In these cases, owls would often look in the direction of the playback, but then look away almost immediately. A definite increase in vigilance behavior was categorized as a class 2 response and included 360º scan of surroundings, glancing up at the sky, stiffened posture, widened eyes and head bobbing. Finally, category 3 behaviors displayed an active defensive response, *e.g.* taking flight, assuming higher perch or alarm calling. Observers were trained prior to the experiment using videos to ensure that categorization of behaviors remained consistent between observers. The responses were then further categorized as “non-alarmed” (0 or 1) or “alarmed” (2 or 3) for statistical analysis (Table 2). In our analysis, we used a Fisher’s Exact Test to test the significance of responses between playback categories. The data was further analyzed using odds-ratio tests to test for observer bias. We used R software, version 2.11.1 for all statistical analyses.

TABLE 1: Schedule of playback experiments. Observers visited each of the nine nest sites, three times a day: morning (6 AM–8 AM), mid-day (11 AM–1 PM), and late afternoon (4:30 PM–6:30 PM). The time period between trials was approximately 3 h. The time period between repeated trials was at least one day. During each time period, focal animals were exposed to one of three categories of call: target species, exotic species or familiar local species. The call category remained consistent across all nests during each time slot. To eliminate effects of time of day, owls were exposed to each call type once in every time period.

Time Slot	Day 1	Day 2	Day 3
Morning	Target	Exotic	Familiar local
Mid-day	Familiar local	Target	Exotic
Afternoon	Exotic	Familiar local	Target

TABLE 2: Burrowing Owls (*Athene cunicularia*) response levels in reaction to various playback experiments. The playbacks fell into three categories: Target species call – Curl-crested Jay (CCJ) (n = 76); familiar local species call – White-rumped Tanager (WRT) (n = 38); and exotic species call (EXS) (n = 42). Response levels were categorized on an ordinal scale of 0–3; 0 = no reaction, 1= interest or curiosity, *e.g.* staring in the direction of the call or a cocking of the head, 2 = definite reaction with increased vigilance, *e.g.* 360º scan of surroundings, glancing up at the sky, stiffened neck, widened eyes and head bobbing, 3 = active defensive response, *e.g.* taking flight, assuming higher perch or alarm calling. During the playback experiment and then further categorized as either “Non-alarmed Response” or “Alarmed Response” for data analysis.

Call Type	Non-Alarmed Responses			Alarmed Responses		
	No. of 0 Responses	No. of 1 Responses	Total Non-Alarmed Responses	No. of 2 Responses	No. of 3 Responses	Total Alarmed Responses
CCJ	8	13	21	51	4	55
WRT	35	2	37	1	0	1
EXS	16	24	40	2	0	2

RESULTS

Overall, behavioral categories were relatively easy for observers to define as alarmed responses were pronounced. When owls responded with increased vigilance, their gazes were largely directed upward at the sky or in a 360° scan of their surroundings. These scans were repeated during the duration of the playback. Postures also became upright and stiffened. Alarm calls were often accompanied with foot stamping and claw clenching which did not appear to be made in any particular direction. On 3 occasions trials had to be abandoned as owls were showing vigilant behaviors prior to arrival at the sites.

There was a significant difference in the reaction level of the Burrowing Owl to the Curl-crested Jay call when compared to both of the other two categories: familiar species call (Fisher's Exact Test, $p < 0.001$) and exotic species call (Fisher's Exact Test, $p < 0.001$), meaning Burrowing Owls responded with increased vigilance to calls of the Curl-crested Jay more than all other trials (Figure 2). There was no significant difference in reaction levels of the Burrowing Owl between the local species call and the unfamiliar exotic species call (Fisher's Exact Test, $p = 0.538$). Vigilance responses to these calls occurred infrequently. An odds-ratio test showed no significant difference between observers (O-R 1.736, 95% CI: 0.844–3.409).

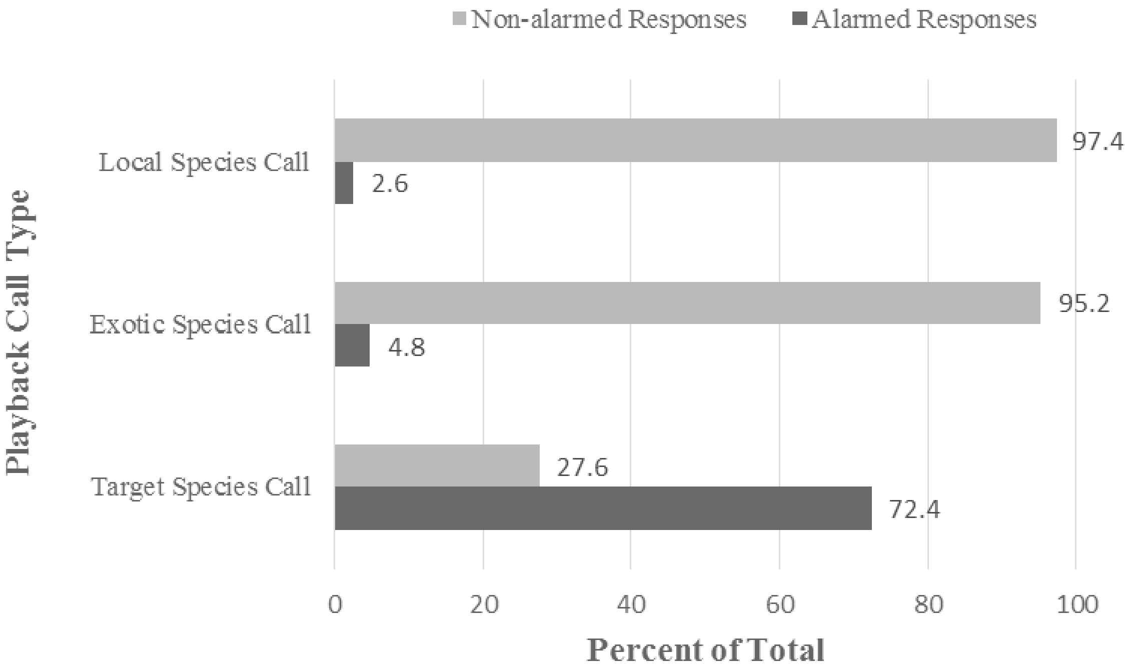

FIGURE 2. Comparison of the percentage of alarmed reactions displayed by burrowing owls in response to different playback experiments. The playbacks fell into three categories: Target species call – Curl-crested Jay (CCJ) (n = 76); local species call – White-rumped Tanager (WRT) (n = 38); and Exotic species call (EXS) (n = 42). Response levels were categorized on an ordinal scale of 0–3 during the playback experiment and then further categorized as either "Non- alarmed Response" or "Alarmed Response" for data analysis.

DISCUSSION

Results confirm that Burrowing Owls of the Paraguayan Cerrado respond to calls of the Curl-crested Jay with increased vigilance. Upon hearing calls of the Curl-crested Jay, Burrowing Owls would scan their entire surroundings, particularly the sky, widen their eyes and straighten their necks, adopting a more upright posture. In many cases a flight or alarm call response was initiated. However, the reason for these vigilant responses and the nature of their interactions remains unclear. Perhaps the simplest explanation is that the owl's response reflects a potential threat posed by the jays. As generalist omnivores it is feasible that jays might predate eggs or small chicks as many corvids do (Andrén 1992, França *et al.* 2009, Němec & Fuchs 2014), although the burrow nests of owls would make these difficult to obtain. However, in order for this to be the most parsimonious explanation, jays would need to be significant predators on owl nests, and such behavior has never been previously reported. It thus seems unlikely that predation by jays on owls is a contributing factor.

Jays, like many corvids, are known to mob species that they see as a potential threat (Yorzinski & Vehrencamp 2009, Marzluff *et al.* 2015) in order to drive them from their immediate vicinity (Krama & Krams 2005, Krams *et al.* 2009). Despite this being an energetically costly practice (Poiani & Yorke 1989, Krama & Krams 2005, Bērziņš *et al.* 2010) "erroneous" mobbing of species that are not actual threats at all does occur (Peiman & Robinson 2010), and it seems that such behavior may have evolved to be directed at a predetermined "search image" of a threat rather than an actual threat (Dawkins 1971). In birds, this "threat image" is particularly associated with members of the families Accipitridae, Falconidae and Strigidae and on two occasions during our field work Curl-crested Jays were observed to mob the falconid American Kestrel (*Falco sparverius*). The largely insectivorous Burrowing Owl (Vieira & Teixeira 2008, Andrade *et al.* 2010) is unlikely to pose any direct threat to adult jays. However, such a mobbing response may be elicited by the fact that other species of owl are potential predators as has been witnessed in another species of corvid, the Western American Crow (*Corvus brachyrhynchos hesperis*) (Caffrey 2000). This would have an interesting side effect in that the vigilant behavior of the owls was elicited in response to a potential aggressive reaction from the jays toward them. Such a reaction by the jays, a non-vulnerable species, would thus be based on a falsely-perceived threat. Though such encounters would involve unnecessary energetic costs in both species, they may have evolved as a byproduct of the eminently useful "search image" of an owl threat to jays.

A third hypothesis involves the owls and jays acting as resource competitors. As both species are omnivorous, dietary overlap undoubtedly occurs, and with seasonal resources often limited in the arid Cerrado habitat (Ratter *et al.* 1997, Pinheiro *et al.* 2002) direct competition for food sources is feasible where the species come into close contact with each other. Jays may be attracted to the entrance of owls burrows by potential food resources such as remnant prey items and pellets (Hall *et al.* 2009) discarded by the owls, or seek to capitalize on the Burrowing Owls strategy of placing mammal dung near their nests to attract insect prey (Levey *et al.* 2004). Such "baiting" behavior also occurs in Burrowing Owls of the Cerrado, with dung found frequently near burrows as shown by a video footage showing a Burrowing Owl depositing dung at the entrance of its burrow (authors' unpub. data). It is possible that a kleptoparasitic relationship may have arisen in the Cerrado as has been observed in other corvids, *e.g.* House Crows (*Corvus splendens*) and Ospreys (*Pandion haliaetus*) (Yosef *et al.* 2012). However, if this was negatively affecting owls to the point of distantly calling jays eliciting a vigilant response, it is difficult to understand why the actual presence of jays actively kleptoparasitising their food sources does not result in any defensive reaction by the owls.

The value of a resource correlates positively with the willingness of an individual to engage in energy costly heterospecific interactions to obtain it (Peiman & Robinson 2010). As any such competition would be likely to negatively affect the diurnal jays (with more limited foraging time) more so than the diurnal or nocturnal owls (who can forage jay-free at night), it may be expected to elicit a stronger aggressive response from the jays and a more muted defensive/vigilant/avoidance response from the owls. That this mobbing behavior is resource-based rather than threat-based is circumstantially supported by observations of jays foraging on the ground close to owl burrows with no apparent fear of predation by the occupants. The lack of a defensive response to the jays by the breeding owls may also be understood to imply a lack of fear of nest predation on behalf of the owls. Indeed during three months of camera trap observations on active owl nests, no instances of jays entering owl burrows were recorded. Avoidance of the more aggressive jays as they forage by the more relaxed owls is thus most likely precautionary and aimed at energy conservation rather than through any real direct threat posed by the jays to the owls.

A final and potentially intriguing hypothesis for the consistent vigilant response of the owls to the jay calls, but the lack of a consistent response to the physical proximity of the jays, is that the owls are eavesdropping on jay calls and extracting some other information from them that was not discernible within the boundaries of this experiment (Schmidt *et al.* 2010). Unfortunately, the ability to make conclusions based on this hypothesis requires a better understanding of the vocal repertoire of the Curl-crested Jay. Though the vocabulary of the Curl-crested Jay appears superficially to be limited when compared to some other members of the genus (including the sympatric Plush-crested Jay, *Cyanocorax chrysops*) the complexity of information transfer should not be underestimated.

In order to fully understand interactions between Burrowing Owls and Curl-crested Jays, more research needs to be done into the ecology and general behavior of the understudied Curl-crested Jay. Research into the ecological interactions between animals within the highly threatened Cerrado habitat will greatly enhance current understanding of ecosystem complexity and function and hence contribute to a more effective conservation plan. More investigation of the potential lines of interaction suggested here is likely to be rewarding.

In conclusion, Burrowing Owls of the Paraguayan Cerrado respond with increased vigilance to calls of the Curl-crested Jay and our observations suggest that interactions between the Curl-crested Jay and Burrowing Owl may be more extensive than originally thought. The precise nature of the interaction between these two species cannot be determined without further study, but it may be hypothesized that resource competition is a contributing factor. With more limited foraging time, the diurnal jays place greater value on food resources in the resource poor environment of the Cerrado than do the owls that can forage by both day and night. Further study exploring the feasibility of the hypotheses suggested here is desirable.

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SHORT-COMMUNICATION

First records on nests of Pompadour Cotinga (*Xipholena punicea*) in Brazil, with notes on parental behavior

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ABSTRACT: Nests of cotingas are almost always inconspicuous and very difficult to find, this being especially true for forest species, which remains higher in the canopy. The nests of some Cotingidae species that occurs in Brazil have never been found, or little data on breeding has been recorded. The first two nests of Pompadour Cotinga, *Xipholena punicea* encountered in Brazil are hereby described, found in the northern Manaus, Amazonas, in September 2013 and July 2014. Nests were discovered close to each other, perhaps involving the same female. It was possible to collect some data related to the first nest, such as female feeding her nestling and collecting its feces to discard. Regarding the second nest, the female was only observed carrying materials to construct it.

KEY-WORDS: Amazon, breeding, Cotingidae, nestling.

The genus *Xipholena* (Cotingidae) contains three species of which the male is spectacularly colored in different purple tones, while the female is much paler and duller. Two of these species, *X. punicea* and *X. lammelipennis*, are present in Amazonia, whereas *X. atropurpurea* is an Atlantic Rainforest species (Sick 1997, Snow 2004)). *Xipholena* spp. are canopy-dwelling species most easily seen in brunches of dead trees, and as all other Cotingidae, they are highly frugivorous (Lopes *et al.* 2005) and possibly opportunistic insectivorous as well (Kirwan & Green 2011).

The Pompadour Cotinga *X. punicea* is one of the most beautiful Cotingidae members. The eye of the male is white, the body and head bright reddish-purple, result of a complex of eight carotenoid pigments, six of which are known in no other bird (LaFountain *et al.* 2010). The wing feathers of males are entirely bright white, highly visible during flight; by contrast, the female is mainly grey with pale, dull wings and a pale iris. This is a widespread and common canopy bird (Kirwan & Green 2011), ranging from Guyana through central Amazonia, south to extreme northeastern Bolivia and west to northeastern Peru, mostly in areas with vegetation associated with nutrient-poor soils (Alonso & Whitney 2003, Ridgely & Tudor 2009, Kirwan & Green 2011).

The nest and breeding behavior of the species are little known: the nest was first described by Beebe in 1924 (Snow 1982) from Guyana, while a second, reported by Kirwan & Green (2011), was found in March 2009 in Canaima National Park, southeast Venezuela.

On 03 September 2013, a female *X. punicea* was observed at a nest (Figure 1A) in the canopy, approximately 30 m above ground, at Cuieiras Biological Reserve at *Instituto Nacional de Pesquisas da Amazônia* (INPA), north of Manaus (02°35'20.55''S; 06°60'55.12''W), in Amazonas State, Brazil. During about 100 minutes of observation, the female was seen leaving the nest several times, though never for more than five minutes, twice feeding on unidentified red fruit close to the nesting tree. The nest was sighted in a three-way fork of an unknown tree constructed of small sticks and moss, which was so small and shallow that the female could only keep her belly inside it. In this position, the nest remained almost entirely in the shadow of female's body. This, and the position of the nest in the uppermost canopy, made it impossible to gain precise measurements or more detailed information on its composition. There was only one blue-grayish egg with dark brownish spots and splotches (Figure 1B).

Ten days later, on 13 September, a small chick was observed in the nest. Small and with its first feathers, the chick appeared to have hatched one or two days earlier. The female scarcely left the nest during the 120-minutes observation period, and during this time her only movement was shifting position to protect the chick from the sun. The nest was further visited on the 14, 16, 19 and 27 September. Detailed observations were conducted on the 16 and 19 September, when the nestling and female were observed for a total of 6 h, and their behaviors noted during this time. From the 14 September onwards, the chick increased size remarkably, as well as had the feathers developed and changed in color, from an initial pale white to white splotched with grey, similar to moss and lichens, perhaps to camouflage it from predators.

During the hottest period of the day, it was possible to see the female turning the head of the nestling away from the sun. At other times, the female was seen trying to cover the nestling, evidence that it had difficulty to thermoregulate, as it was seen panting when alone.

FIGURE 1. (A) Female of Pompadour Cotinga, *Xipholena punicea*, at the nest, found in September 2013 near Manaus, Brazil. Photo: Luiz Ribenboim. **(B)** The egg, at the first nest found (2013). Photo: Marcelo Barreiros.

The female left the nest and food for the nestling when returned, having been seen on four occasions feeding the chick with unidentified a small red fruit. Between 06:00 h and 10:00 h, the female always left the nest and returned by the same route, pausing among several large trees nearby before finally landing on the nest. Another common female's behavior was swallowing feces of the chick during several minutes, presumably to keep the nest clean. During the final days of observation, the nestling had grown sufficiently and the female could not remain in the nest along with it, opting instead to perch on a branch nearby.

On 21 July 2014, another nest was found in the same reserve around 30 m distant and nearly 5 m higher than the first one (Figure 2). The female was observed arriving at the nest three times with nest materials similar to those used in the first nest; little sticks on two occasions and on the third an unidentified soft material that she manipulated with her beak. Until the nest was finished, the bird spent some minutes arranging materials, using her beak while sitting inside. Observation of this nest lasted only two hours (07:00 h to 09:00 h). Two differences could be noted between both nests: the fork of the first nest had near-horizontal branches in a three-way fork, whereas in the second nest it had four thick almost vertical branches, allowing it to be deeper than the first one. Furthermore, the first nest was situated far from the center of the tree on which it sat, more exposed to the sun and less protected than nest two. The second nest remained in the center of the tree, in a much shadier position. Unfortunately, four days later, the nest was no longer seen.

FIGURE 2. Female of *Xipholena punicea* at another nest, observed carrying sticks and soft material in July 2014. Photo: Marcelo Barreiros.

The nests here reported were found active in the midst of the local dry season (September), while the other two known nests were both found in March, one with an egg (Guyana) (Kirwan & Green 2011) and the other with a well-grown chick (southern Venezuela) (Kirwan & Green 2011). However, the regions of Guyana and Venezuela in which the nests were found both presents a dry season between January and June, indicating that the regional breeding period is adapted to local seasonality, a feature widely reported over the Amazon basin (Cohn-Haft *et al.* 1997).

There is clearly some variability regarding the location of *X. punicea* nests. While the nest recorded by Kirwan & Green (2011) was found in the canopy, the nest found by Beebe (1924) was slightly lower, 18 m above the floor in the fork of a bamboo clump. Site flexibility may be characteristic of the genus: a nest in a bamboo fork was recorded for *X. atropurpurea* in

Maraú City, Bahia state, northeastern Brazil (Albano 2013), while Sick (1997) mentioned another nest of *X. atropurpurea* in Espírito Santo state, southeastern Brazil, in the basal leaves of an epiphyte ("gravatá": *Bromelia pinguin*, Bromeliaceae), and Teixeira & Almeida (1997) cited two nests of *X. atropurpurea* in the canopy, one in São Miguel dos Campos, Alagoas state, and another one in Camamú, Bahia state.

Regarding the eggs of *X. atropurpurea*, there is little difference between the color of the egg found in this study and the one found by Beebe (1924), in which he cites the egg color as very pale greenish-grey, heavily spotted and blotched within different tones of brown, especially at the large end (Teixeira & Almeida 1997). Regarding structure, the second nest described is most similar to another two nests found in Venezuela, described as "a deep open-cup" (Snow 1982, Kirwan & Green 2011), whereas the first nest was not very deep, perhaps due to the difference of forks used as nest support.

Despite the huge recent advances in our knowledge on tropical birds (Birkhead *et al.* 2013), there are still large gaps in what we know of their natural history. For Cotingidae, there are no data on the breeding biology of many species. Species occurring in Brazil of which no nest seems to have been found, or description data recorded, include *Laniisoma elegans*, *Lipaugus streptophorus*, *Tijuca atra*, *Tijuca condita*, *Xipholena lamellipennis*, *Procnias albus*, *Cotinga maynana*, *Cotinga cotinga*, *Phoenicircus nigricollis* and *Calyptura cristata*. This scarcity of information may be partially explained by the fact that many species are canopy-dwellers (Kirwan & Green 2011), and therefore access to this part of the forest is difficult. This is the case of *Haematoderus militaris*, with only one nest found and no detailed description, due to impossible access (Whittaker 1993).

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Diet preference and density of the Greater Rhea (*Rhea americana*) in grasslands of the Flooding Pampa, Argentina

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ABSTRACT: The Greater Rhea (*Rhea americana*) has been greatly affected by habitat alteration and hunting. Density of rheas was estimated by monthly surveys along transects from June 1996 to November 1997 in 760 ha of coastal grasslands in the Flooding Pampa, Buenos Aires Province, Argentina. Fresh feces and vegetation samples were collected in spring 1996, and in winter and spring 1997 to study diet and resource selection. Feces were macroscopically processed, and the vegetal fraction was prepared for micro histological analysis. Vegetation was sampled in quadrants, separated by species and dried to obtain the percentage of dry weight to estimate availability. Mean density was 0.22 ± 0.04 rheas/ha. Dicots were always preferred in relation to their availability in the grassland, and monocots were not preferred in neither of the two spring seasons studied. Monocots were consumed more frequently than dicots in winter. Legumes were preferred in both spring seasons, with Black Medic (*Medicago lupulina*) the most consumed species. Perennial Ryegrass (*Lolium perenne*) was the most represented monocot, but it was always consumed in proportions similar to its availability. Grasses growing in warm seasons were never preferred. The diet of Greater Rheas in these grasslands was generalist and almost completely herbivorous, showing preference for dicots, mainly legumes. Rheas were more selective in spring, when the availability of the vegetation was higher than in winter.

KEY-WORDS: food habits, herbivory, microanalysis, Ratites.

INTRODUCTION

The Greater Rhea (*Rhea americana*) is a South American ratite endemic to Argentina, Bolivia, Brazil, Paraguay, and Uruguay. In Argentina, this bird is characteristic of the tall grass steppe of the Pampas (Folch 1992). The Pampas occupy the eastern plains of Argentina, between 32°S and 39°S covering an area of over 500,000 km^2, with annual rainfall ranges between 750 and 1100 mm (Bucher & Nores 1988). This area is being heavily modified by land-use practices (Bilenca & Miñarro 2004, Viglizzo *et al.* 2011). Populations of rheas have been greatly affected by grassland destruction, fragmentation of their habitat, and hunting for their skin and meat (BirdLife International 2014). Overgrazing, soil compaction, and fire caused the elimination of tall grasses and their replacement by shorter grass species, giving way before long to agriculture. The economic development of the region produced an increase in the human population and the construction of roads, resulting in a high hunting pressure. Although still locally common, particularly in protected areas and some large ranches, the number of rheas has been greatly reduced, to the point of local extinction in many areas (Bucher & Nores 1988). The Greater Rhea has been categorized as Near Threatened (IUCN 2015), and Threatened in Argentina (López-Lanús *et al.* 2008).

The Greater Rhea lives in open plains generally in mixed groups of males, females and juveniles of five to 50 individuals (Folch 1992). They spend a high proportion of their time foraging in open grasslands (Reboreda & Fernández 1997, Azevedo *et al.* 2010), sometimes together with other wild and domestic herbivores as Pampas Deer *Ozotoceros bezoarticus* (Parera 2002), cattle and sheep, which is advantageous for all to detect threats at a distance (Folch 1992). Rheas also forage in agroecosystems (Comparatore & Yagueddú 2007, Giordano *et al.* 2008). In these agroecosystems, rheas use grasslands and crops as sometimes they cross internal fences (pers. obs.). They are omnivorous, although most of their diet is vegetal including leaves (some thorny species), seeds, fruits, and roots (Folch 1992). They also consume insects and small vertebrates such as birds, snakes, fish and rodents (Raikow 1968, Folch 1992, Martella *et al.* 1996, Silva *et al.* 2001, Azevedo *et al.* 2006, Comparatore & Yagueddú 2007, Masat *et al.* 2011). They are coprophagous, as they were seen feeding on fecal material deposited a few minutes earlier by other rheas (Raikow 1968). Rheas also eat crop weeds (Comparatore & Yagueddú 2007, Bernard 2012) and other plants rejected by cattle, and often eat burr-like seeds, which get tangled in sheep's wool (Folch 1992). As a consequence, the diet overlap with domestic herbivores is low (Martella *et al.* 1996, Vacarezza 2001, Vacarezza *et al.* 2001, Pereira *et al.* 2003). It is worth noting that rheas do not have a crop, but have a very large gizzard and a large cecum which help digestion (Angel 1996). Also, they ingest small stones, which aid the gizzard in grinding (Folch 1992).

Intensive and extensive breeding of rheas has been increasing as an alternative animal production (Maceira *et al.* 2003, Feld *et al.* 2011). The maintenance of rheas through effective management or the breeding of individuals for animal production requires knowledge of their diet requirements. The diet of Greater Rheas in coastal natural grasslands of the Flooding Pampa is unknown. Previous studies at Pila (Yagueddú & Rossi 1985) and Ayacucho (Vacarezza 2001, Vacarezza *et al.* 2001), on diet overlap among rheas and domestic herbivores, were carried out in the inner Flooding Pampa, concluding that the former prefers forbs (legumes and non-legumes), and the latter grasses. So, competition for forage among these species would be low.

The objectives of this study were: a) analyze the dietary habits of the Greater Rhea in coastal grasslands of the Flooding Pampa; and b) estimate rheas' density in the same area. According to the forage abundance hypothesis (MacArthur & Pianka 1966, Schoener 1971), rheas in this area are expected to be more selective in spring, when the availability of the vegetation is higher than in winter. This study complements two others in the region, where the dietary habits in crop fields (Comparatore & Yagueddú 2007) and the habitat use in grasslands (Herrera *et al.* 2004) were described.

METHODS

The study was conducted in the Flooding Pampa (Batista *et al.* 2005), Buenos Aires Province, Argentina, Estancia Medaland (37°22'–37°27'S; 57°12'–57°7'W), considered Valuable Grassland Area (Bilenca & Miñarro 2004). This farm is dominated by natural and modified grasslands with small crop areas, which are rapidly expanding due to changes in land-use. Data were collected over 760 ha of grasslands during the spring 1996, and the winter and spring 1997.

Animal density was estimated from June 1996 to November 1997 with monthly complete surveys (n = 18), walking along ten parallel transects covering the whole area (760 ha) using 10 x 50 binoculars, being careful to count animals only once. The number of animals counted each month was divided by the entire area to obtain 18 density values, which were then averaged to calculate mean density of rheas during the studied period.

Twenty fresh feces were collected in spring 1996, 10 in winter 1997 and 10 in spring 1997, with at least 300 m apart from one another in each season. Then, they were processed in the laboratory to separate pebbles, shells, animal and vegetal material. Plant material was prepared for microanalysis (Sparks & Malecheck 1968) to determine its botanical composition. This vegetal material was dried for 24 h in a forced air oven at 60°C and was then ground over a 1 mm (16 mesh) sieve screen to reduce all plant fragments to a uniform size (Sparks & Malecheck 1968). A representative amount of each fecal sample was soaked in 50% bleach for 30 to 60 s to clear the material, and was then washed to remove the bleach. Each sample was analyzed individually, five slides were prepared from each sample, and 20 microscopic fields were observed from each slide. So, data from 100 microscopic fields were registered for each sample. Species fragment density per field was recorded (Yagueddú *et al.* 1998). Then, the percentage of each item in the diet (species, Class of species, group of species) was calculated as the proportion of the total number of fragments of each item in the 100 observed fields in relation to all counted fragments of the sample. Species were grouped according to their seasonality and digestibility (Mattson 1980). Also, to recognize the species from the fecal fragments, epidermis patterns of all plant species present in the grassland were performed (Dizeo de Strittmatter 1973).

Animal material in the diet involved whole squeezed caterpillars (around 5 cm long) tangled with vegetation. These were counted and then hydrated to facilitate its identification on the basis of their colors and jaws. Their bodies were reduced to their exoskeletons and their cephalic capsules were in good condition, allowing the determination of the species with a key (Pastrana & Hernández 1978/79).

To analyze resource availability, vegetation was clipped at ground level from 50 randomly placed quadrants (2 m x 2 m) in each season. Plants were manually separated by species and dried at 60°C for 2 days to obtain the percentage of dry weight of each vegetal species and the total dry weight/ha (kg DM/ha).

Bonferroni interval (BI) for the observed proportion of use (Neu *et al.* 1974, Byers *et al.* 1984) was calculated (α = 0.05) to analyze the selectivity of species, Class of species (monocots and dicots) and group of species (legumes, other dicots, cool season grasses - C3, warm season grasses - C4, and other monocots). If vegetal availability (expected percentage of use) did not fall within the respective confidence interval for the observed percentage in feces, the difference between diet and availability was regarded as significant. So, if the percentage of the species, Class or group available in the grassland felt below the lower limit of its associated confidence limit, it was considered preferred. If this percentage fell above the upper limit of its associated confidence limit, it was not preferred. Reciprocally, if vegetal availability fell within the respective confidence interval for the observed percentage in feces, the difference between diet and availability was not significant.

RESULTS

The number of individuals in the study area varied between 120 (May 1997) and 215 (November 1996) with a mean density of 0.22 ± 0.04 rheas/ha (n = 18).

Pebbles and seashells were found in all feces, but their composition was mainly vegetal. From the 40 collected feces, only one contained animal material: 67 True Armyworms *Pseudaletia* (=*Mythimna*) *adultera*, (Noctuidae) in spring 1996.

In spring 1996, 34 vegetal species were found in feces. Black Medic (*Medicago lupulina*) was the most consumed species, then Perennial Ryegrass (*Lolium perenne*), the Mouse Ear (*Dichondra microcalyx*) and the Salt Water Couch (*Paspalum vaginatum*) (Table 1). In winter 1997, 27 species were found, and the most consumed species were Black Medic and Perennial Ryegrass, then Saltgrass (*Distichlis* spp.) and Chickweed (*Stellaria media*) (Table 1). In spring 1997, 30 species were found: Black Medic was the most consumed species, then thistles (*Carduus acanthoides*, *Cirsium vulgare*, *Cynara cardunculus*, *Onopordon acanthium*), Salt Water Couch and Perennial Ryegrass (Table 1). Black Medic was the most common species in the three studied seasons, and was consumed more than available in both springs (BI 1.4 – 65.4 in 1996; BI 5.0 – 73.7 in 1997). Perennial Ryegrass was the most represented monocot in the diet and was always consumed in the same proportion as available (Tables 1 and 2).

In spring diets, dicots were more consumed than monocots, and during the whole study dicots were always preferred respect to their availability (56.88% ± 16.98; BI 32.6 – 81.1 in spring 1996; 38.67% ± 11.04; BI 4.2 – 73.2 in winter 1997; 65.75% ± 12.63; BI 40.7 – 90.8 in spring 1997). Monocots were not preferred in spring (43.29% ± 16.99; BI 19.6 – 66.7 in 1996; 34.25% ± 12.63; BI 9.2 – 59.3 in 1997), but they were consumed in the same proportion as available in the grassland in winter. Also, monocots were more consumed than dicots in winter (Figure 1).

Legumes were preferred in spring (32.20% ± 14.29; BI 4.6 – 59.8 in 1996; 41.93% ± 24.14; BI 5.2 – 78.6 in 1997), but in winter, although this group was common in the diet of rheas, the difference between consumed (25.68% ± 8.51) and available (4.96% ± 6.62) was not significant. Warm season grasses were not preferred in any season (23.13% ± 13.92; BI -0.02 – 46.3 in spring 1996; 21.93% ± 8.52; BI -0.12 – 55.6 in winter 1997; 19.08% ± 8.81; BI -0.11 – 49.5 in spring 1997, Figure 2A–C). Saltgrass and Smooth Cordgrass (*Spartina* spp.) were not preferred in spring 1996 (BI -8.7 – 14.4 and BI -1.7 – 1.8, respectively), and Buffalo Grass (*Stenothaphrum secundatum*) and Smooth Cordgrass were not preferred in winter 1997 (BI -13.8 – 23.8 and BI -2.1 – 2.2, respectively) (Tables 1 and 2). The remaining plant groups (other dicots, cool season grasses and other monocots) were consumed in the same proportion as available in the grassland.

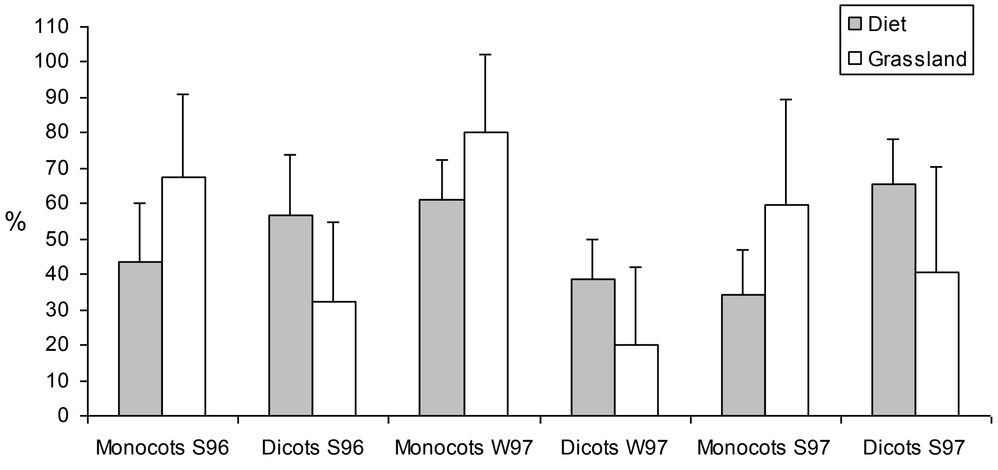

FIGURE 1. Percentage of vegetal Class and standard deviation in the diet of Greater Rhea (*Rhea americana*) and grassland in spring 1996 (S96), winter 1997 (W97), and spring 1997 (S97).

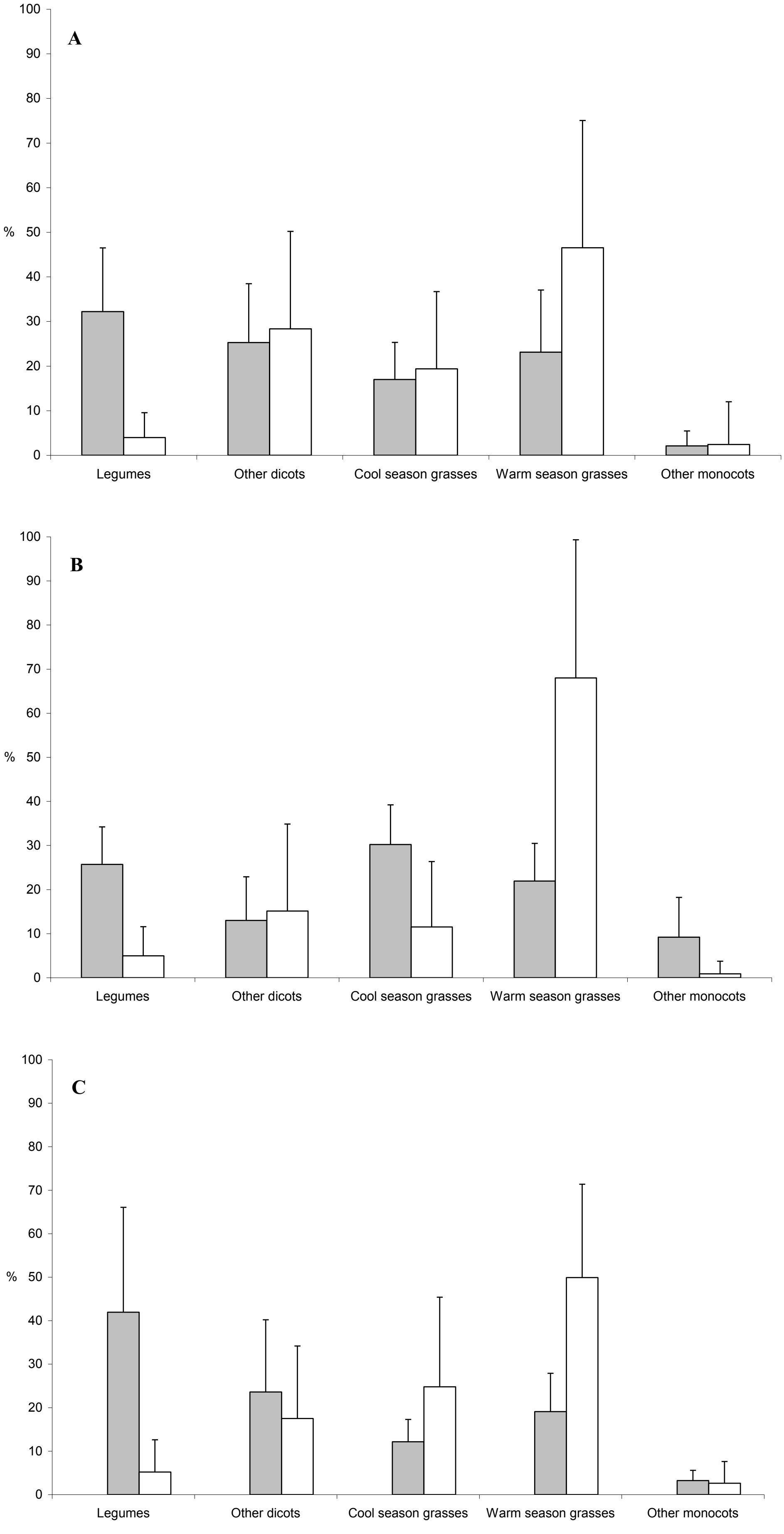

FIGURE 2. Percentage of vegetal groups and standard deviation in the diet of Greater Rhea (*Rhea americana*) and grassland in **(A)** spring 1996, **(B)** winter 1997, and **(C)** spring 1997. Grey = Diet, White = Grassland.

Vegetal availability was 1626.67 ± 1031.65 kg DM/ha in spring 1996, 1208.50 ± 564.81 kg DM/ha in winter 1997, and 3341.30 ± 1531.86 kg DM/ha in spring 1997. Grassland species, either native or adventive, were adapted to low wet soils, typical of the Flooding Pampa (Cabrera & Zardini 1993). Vegetal availability in spring 1997 was twice the one in spring 1996, and 50% of the diet of rheas consisted of Black Medic and thistles. Alternatively, in spring 1996, 50% of the diet was composed of Black Medic, Perennial Ryegrass and Mouse Ear. In winter 1997, with the lowest availability, 50% of the diet of rheas was composed of Black Medic and Perennial Ryegrass (Table 1).

Among the species that appeared in the grassland, but not in the diet, the Saltwort (*Sarcocornia ambigua*) stands out. In spring 1996, vegetation samples had an important proportion (9.00% ± 21.33), but it was not found in feces. Other species that did not appear in the diet and had low representation in the grassland (<1%) were *Galium aparine*, *Conium maculatum* and *Bupleurum teniusimum.*

TABLE 1: Botanical composition in percentage of the number of fragments of each species over the total number of fragments (Mean ± SD) in the diet of the Greater Rhea (*Rhea americana*) in Argentinean grasslands. N: native, A: adventive, C: cultivable, W: weed (Cabrera & Zardini 1993). *Statistically significant differences between consumption and availability.

Species in diet		Spring 1996 n = 20	Winter 1997 n = 10	Spring 1997 n = 10
Legumes				
Medicago lupulina (Black Medic)	A	30.42 ± 13.81*	22.60 ± 10.29	39.39 ± 25.86*
Trifolium repens (White Clover)	AC	1.02 ± 2.06	0.16 ± 0.39	2.38 ± 2.60
Adesmia incana	N	0.75 ± 1.12	2.89 ± 8.42	0
Medicago arabica (Spotted Medic)	A	0	0	0.18 ± 0.49
Other dicots				
Malvella leprosa (Alkali Mallow)	N	0.66 ± 1.03	0.07 ± 0.12	1.31 ± 1.13
Phyla canescens (Hairy Fogfruit)	N	3.63 ± 2.79	0	2.99 ± 3.95
Stellaria media (Chickweed)	A	3.59 ± 3.27	9.81 ± 9.63	4.76 ± 4.16
Ambrosia tenuifolia (Lacy Ragweed)	N	3.72 ± 3.58	0.83 ± 1.49	0.65 ± 1.02
Dichondra microcalyx (Mouse Ear)	N	9.05 ± 9.17	0.95 ± 1.76	1.51 ± 3.31
Mentha pulegium (Pennyroyal)	A	1.19 ± 2.33	0	0.67 ± 1.48
Plantago spp. (Plantain)	N	3.01 ± 4.81	1.33 ± 2.30	1.01 ± 2.49
Leontodon taraxacoides (Lesser Hawkbit)	A	0.24 ± 0.45	0	0
Thistles	AW	0	0	10.00 ± 9.49
Centaurea spp. (Star Thistles)	AW	0	0	0.25 ± 0.69
Rapistrum rugosum (Annual Bastardcabbage)	AW	0	0	0.47 ± 1.00
Eryngium spp. (Sea Holly)	N	0.09 ± 0.22	0	0
Cool season grasses				
Lolium perenne (Perennial Ryegrass)	AC	9.06 ± 7.60	22.58 ± 11.53	8.32 ± 4.44
Poa spp. (Meadow Grass)	N	1.20 ± 1.36	0.37 ± 0.74	1.44 ± 1.70
Bromus unioloides (Rescue Grass)	NC	1.75 ± 4.11	5.58 ± 6.03	0.41 ± 1.05
Hordeum bonariense (Barley)	N	1.94 ± 2.95	0.09 ± 0.27	0.28 ± 0.56
Festuca arundinacea (Tall Fescue)	AC	0.57 ± 1.16	0.15 ± 0.25	0
Stipa neesiana (Needle Grass)	N	1.55 ± 2.45	1.37 ± 1.39	0.49 ± 0.96
Avena sativa (Common Oat)	AC	0.18 ± 0.37	0	1.21 ± 1.71
Chaetotropis elongata	N	0.74 ± 1.38	0.09 ± 0.29	0
Warm season grasses				
Stenothaphrum secundatum (Buffalo Grass)	N	3.89 ± 5.96	4.95 ± 5.75*	5.18 ± 5.39
Leersia hexandra (Rice Grass)	N	2.54 ± 2.30	0.12 ± 0.29	1.38 ± 1.86
Thinopyrum ponticum (Tall Wheat Grass)	AC	2.67 ± 2.73	1.22 ± 2.00	0
Paspalum vaginatum (Saltwater Couch)	N	8.76 ± 7.36	3.10 ± 4.39	9.15 ± 3.04
Distichlis spp. (Salt Grass)	N	2.86 ± 1.83*	10.06 ± 7.11	1.27 ± 2.00
Setaria geniculata (Bristle Grass)	N	0.62 ± 1.40	0.25 ± 0.67	0
Sporobolus indicus (Smut Grass)	N	1.57 ± 2.82	2.11 ± 2.27	0.22 ± 0.42
Cynodon dactylon (Bermuda Grass)	AW	0.15 ± 0.28	0.06 ± 0.20	0
Bothriochloa laguroides (Silver Bluestem)	N	0.02 ± 0.08	0	1.72 ± 2.35
Spartina spp. (Smooth Cordgrass)	N	0.05 ± 0.19*	0.05 ± 0.16*	0
Other monocots				
Carex bonariensis	N	1.39 ± 3.55	4.06 ± 4.44	0.84 ± 1.66
Eleocharis flavescens (Yellow Spikerush)	N	0	0	0.96 ± 2.71
Cyperus rotundus (Nut Grass)	A	0	0	0.31 ± 0.88
Scirpus sp. (Sedges)	N	0.40 ± 0.55	0	0.91 ± 1.06
Sisyrinchium platense (Blue-eyed Grass)	N	0.03 ± 0.09	0.03 ± 0.09	0
Juncus imbricatus (Folded Rush)	N	0.27 ± 0.80	5.10 ± 6.78	0.21 ± 0.59

TABLE 2: Grassland botanical composition in percentage of dry weight (Mean ± SD) of the most common species in the diet of Greater Rheas (a, b, c, d, e) and less represented species in relation to their availability (f, g, h).

Species in grassland	Spring 1996 n = 50	Winter 1997 n = 50	Spring 1997 n = 50
a *Medicago lupulina* (Black Medic)	1.29 ± 2.85	0.78 ± 2.66	4.40 ± 7.55
b *Lolium perenne* (Perennial Ryegrass)	7.67 ± 8.43	5.57 ± 9.85	11.80 ± 14.27
c *Dichondra microcalyx* (Mouse Ear)	0.76 ± 2.59	0	1.20 ± 2.90
d *Bromus unioloides* (Rescue Grass)	0.52 ± 2.40	0.57 ± 2.71	0.40 ± 1.26
e *Paspalum vaginatum* (Saltwater Couch)	3.67 ± 9.49	0.43 ± 2.09	8.50 ± 14.93
f *Stenothaphrum secundatum* (Buffalo Grass)	13.19 ± 18.17	24.22 ± 27.79	10.00 ± 15.61
g *Distichlis* spp. (Salt Grass)	14.52 ± 27.25	14.65 ± 28.80	6.00 ± 11.94
h *Spartina* spp. (Smooth Cordgrass)	14.62 ± 29.42	26.09 ± 42.60	9.10 ± 18.81

DISCUSSION

Diet of Greater Rheas in coastal natural grasslands of Argentina was generalist and predominantly herbivorous. These animals consumed a large number of vegetal species, but preferred dicots, mainly the legume *M. lupulina.* On the other hand, monocots were not preferred in neither of the two springs and were consumed in the proportion as similar to their availability in the grassland in winter. Martella *et al.* (1996) also found that the Greater Rhea preferred wild short-lived forbs and Alfalfa (*Medicago sativa*), but showed no preference for grasses, while Paoletti & Puig (2007) and Puig *et al.* (2013), found that the Lesser Rhea (*Pterocnemia pennata*) showed preference for forbs and shrubs with dominant grasses not selected. Even though rheas feed selectively, the Greater Rhea in this study showed a higher selectivity with increasing resources (forage abundance hypothesis), while the diet selectivity of the Lesser Rhea decreased with increasing resources (selective quality hypothesis) as it is predicted for arid environments (Puig *et al.* 2013).

Although Greater Rhea did not prefer monocots in any of the two spring seasons, the high proportion of cool season grasses in the diet in winter, principally *L. perenne*, could be due to their lower fiber content and to the low availability of dicots at that time of the year. It is in this season when diet of rhea and cattle can overlap (Pereira & Quintana 2009). Legumes preference in both springs could be related to their high nitrogen (N) content (Mattson 1980). In general, short-lived, fast-growing species require and therefore contain more N than long-lived, slower-growing species (Mattson 1980). The non-preference for warm season grasses (C4) in all studied seasons could be due to their lower N content and higher fiber content in comparison to cool season grasses (C3) (Mattson 1980). Similar results were found by Madanes *et al.* (2010) for Greater Rhea in the lower Paraná River Basin.

Despite the low availability of the most consumed species, rheas seek them and use their bill to select these plants when they are small. Besides, they ate native and adventive species, therefore, what they eat would depend on their preferences based on species quality, availability, and phenological stage of the plants. In the study site, rheas preferred sites near streams in all seasons (Herrera *et al.* 2004), probably due to the presence of riparian communities dominated by dicots as well as available water for drinking. Also, domestic animals like cattle, sheep and horses, used these areas near water sources. These large groups of wild and domestic herbivores gain the benefit of protection from predators and hunters (Farias & Canepuccia 2001, Carro & Fernández 2009, Barri *et al.* 2012). Moreover, in grasslands of the Flooding Pampa, these domestic herbivores prefer grasses, so their diet overlap with rheas would be low (Vacarezza 2001, Vacarezza *et al.* 2001).

Mean density of rheas was greater in neighboring crops (0.43 rheas/ha in the wheat area in spring 1996, and 0.40 rheas/ha in the oat area in spring 1997, Comparatore & Yagueddú 2007) than in the natural grasslands sampled in the present study (0.22 rheas/ha) in the same property and in the same counting period. This could be related to the fact that rheas ate weeds and animal plagues of these crops (Comparatore & Yagueddú 2007). The large number of True Armyworms found in one feces in the grassland in spring 1996, shows that rheas can cross fences to the neighboring wheat crop attacked by these caterpillars that move all together. True Armyworms were present in many feces collected in the neighboring wheat crop in the same season (Comparatore & Yagueddú 2007). The absence of caterpillars in feces collected in spring 1997 could be a consequence of a different neighbor crop (*i.e.* oat instead of wheat, pers. obs.). Oat is not a preferred crop for True Armyworms (SENASA 2016). Incorporating a high-protein item to the diet when it appears shows an opportunistic behavior. A food selection study in captivity supports the above. When minced meat was offered to rheas, the animals spent between 12 and 29% of the time of the experiment eating it (Comparatore & Herrera 1998). This opportunistic behavior was also found for the Greater Rhea in a wetland region of Argentina (Pereira & Quintana 2009). Birds tend to be opportunistic foragers and often make ready use of superabundant food resources (Szaro *et al.* 1990). Furthermore, Southwood (1977) sustains that in disturbed environments, such as the one where this study was conducted, individuals, populations, and species should feed more flexibly.

Rheas can endure in agroecosystems that include grasslands, pastures and crops (Comparatore & Yagueddú 2007, Bernard 2012). Conservation problems for rheas may occur with the rapid increase of the area used for grain production and consequently low habitat diversity (Giordano *et al.* 2008, 2010, Codesido *et al.* 2012). This emphasizes the importance of coordinating actions to conserve grassland bird areas as exposed by Di Giacomo & Krapovickas (2005).

In conclusion, in the studied grasslands, rheas were more selective in spring, when the availability of the vegetation was high, and they preferred dicots (mainly legumes) and rejected monocots. In winter, when the availability of vegetation was low, they consumed legumes and monocots in the same proportion as available in grassland. Also, rheas showed an opportunistic behavior consuming caterpillars when they appeared.

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Exploitation of *Ceiba pubiflora* flowers by birds

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ABSTRACT: This paper provides the first description of the exploitation of floral resources of *Ceiba pubiflora* by birds in the Neotropical region. We sampled five different specimens of *C. pubiflora,* focusing on plant-bird and bird intra/interspecific aggressive interactions. We recorded thirteen species of birds exploiting its floral resources. Only hummingbirds are potential pollinators by feeding effectively on the flower corolla. *Hylocharis chrysura* and *Heliomaster furcifer* were considered the best potential pollinators and dominated the agonistic interactions. On the other hand, *Icterus cayanensis* and tanagers pierced the flower at the base of the corolla, drinking the nectar directly, without contacting the pollen. Psittacidae (*Aratinga nenday*, *Brotogeris chiriri* and *Amazona aestiva*) and *Saltator coerulescens* destroyed the flowers by feeding on petals. Although they are ineffective pollinators, the nectar and petals are valuable food resources for these birds, when fruits are scarce during the dry season.

KEY-WORDS: floral resources, florivorous birds, flower exploitation, nectarivorous birds, potential pollinators.

INTRODUCTION

Birds play an important role in the reproductive success of tropical plants (Snow 1981) by pollinating Neotropical angiosperms (Gilbert 1989, Marzluff *et al.* 2001, Mendonça & Anjos 2003), aiding in seed dispersal (Howe 1977, Wunderle-Jr 1997, Muller-Landau *et al.* 2008), or negatively interfering by consuming and destroying the flowers (Galetti 1993, Ragusa-Netto 2002, Sazima & Sazima 2007).

Flowers and nectar are valuable food resources for frugivorous and omnivorous birds in highly seasonal habitats, when resources such as fruits are seasonally scarce (Pettet 1977, Terborgh 1986). Birds, especially hummingbirds, defend these floral resources by vocalizing and attacking other birds in intraspecific and interspecific agonistic behavior (Previatto *et al.* 2013).

Most *Ceiba* species (Malvaceae) have nocturnal anthesis and are mainly pollinated by bats, moths, and butterflies (Gribel *et al.* 1999, Gibbs & Semir 2003). There are several records of hummingbirds visiting flowers of *Ceiba jasminodora*, *C. schottii* and *C. speciosa*, but these birds are considered ineffective pollinators, because they do not touch the anthers/stigma (Gibbs & Semir 2003). In the Amazon rainforest, *Ceiba pentandra* was visited by seven hummingbird species and 26 other bird species (Toledo 1977), but only two species of bats acted as pollinators (Gribel *et al.* 1999).

Ceiba pubiflora is one of the most common tree species in the Corumbá region in Mato Grosso do Sul, western Brazil (Lima *et al.* 2010) occurring mainly in semi-deciduous woodlands, and particularly in calcareous soils (Gibbs & Semir 2003). Flowering occurs during the dry season, with a massive bloom that lasts several weeks and anthesis is diurnal (Gibbs & Semir 2003). These characteristics make *C. pubiflora* a tree with high feeding potential for birds. Besides, there is no study on the interactions between this plant and birds.

In this study, we observed birds that exploit floral resources of *C. pubiflora* to find out how birds use flowers as food resources. We focused on: 1) how often these birds exploit such resources; 2) how the nectar and floral parts are exploited by birds; 3) what are the intra and interspecific agonistic behaviors among birds that visit this plant.

METHODS

The study was conducted near the riparian forest of the Paraguay river, in Corumbá city, southern part of the Pantanal in western Brazil (19°00'00.8''S; 57°37'47.5''W, 135 m.a.s.l.). The climate is tropical of altitude, Awa type according to Köppen, with dry winters and rainy summers. The average temperature is around 25°C, with a minimum close to 0°C and the maximum around 40°C (Soriano 1997).

We sampled five specimens of *C. pubiflora* during their flowering period in June 2013. The observations were carried out during the daytime as follows: 1) morning (from 6:00 to 9:00 h); 2) afternoon (from 14:00 to 17:00 h). We performed 126 h of observation, 63 in the morning and 63 in the afternoon. The time of sampling was divided equally between the five plants studied. We defined the term event for each observation period, either in the morning or afternoon, totaling 42 events (21 in the morning and 21 in the afternoon).

We first identified the bird species and the frequency of occurrence of each species. We then checked how the flower resources were exploited (Figure 1), according to Machado (2009): a) legitimate visit: characterized by the insertion of the bird's beak in the corolla of the flower, possibly contacting the reproductive organs of the plant and taking pollen adhered to its beak, head or neck; b) illegitimate visit: the bird pierces the flower at the base of the corolla, taking the nectar directly without contact with the reproductive organs of the plant. We also used c) flower damaging: bird eats part of the flower, such as petals, sepals, anthers and stigma, most of the time damaging it in such a way that makes the flower unable to receive new pollinators or developing into a fruit. Lastly, we observed whether there were intraspecific and interspecific agonistic interactions, considering interactions only attacks or persecution, as proposed by Machado (2009).

To compare the proportion of bird visits in the morning and in the afternoon, as well as intraspecific and interspecific bird conflicts we used a χ^2 test. Plant species was identified according to Lorenzi (1998). Bird field guides (Erize *et al.* 2006, Gwynne *et al.* 2010) were used to identify bird species. Classification and taxonomy of bird species follows the list of the CBRO (Piacentini *et al.* 2015).

RESULTS

We recorded 13 bird species from four families exploiting the floral resources of *C. pubiflora* (Table 1). Birds were more frequent in the afternoon (χ^2 test = 4.94, p = 0.03, df = 1), but some species presented similar frequencies at both periods. None showed higher frequency in the morning, except *Polytmus guainumbi* recorded only during this period. We observed *Hylocharis chrysura* with the highest frequency of occurrence, exploiting the nectar of *C. pubiflora* in all samples. *Heliomaster furcifer* and *Tangara sayaca* also had high frequencies, both sampled at 40 events (95.24% of all events sampled).

Only six species, all of them hummingbirds (*Chlorostilbon lucidus*, *Eupetomena macroura*, *H. furcifer*,

TABLE 1. Frequency of occurrence of birds visiting *Ceiba pubiflora* according to the period of visits (events) and feeding behavior. Birds are arranged in decreasing order of occurrence . LV: legitimate visit; IV: illegitimate visit; FD: flower damage. Total of morning events: n = 21. Total of afternoon events: n = 21. Total of events: n = 42.

Species	Morning (%)	Afternoon (%)	Total of Events	Feeding behavior
Hylocharis chrysura	100	100	42	LV
Heliomaster furcifer	90.48	100	40	LV
Tangara sayaca	95.24	95.24	40	IV
Brotogeris chiriri	66.67	100	35	FD
Chlorostilbon lucidus	57.14	76.19	28	LV
Eupetomena macroura	19.05	71.43	19	LV
Tangara palmarum	9.52	42.86	11	IV
Icterus cayanensis	23.81	23.81	10	IV
Thalurania furcata	9.52	9.52	4	LV
Amazona aestiva	-	9.52	2	FD
Aratinga nenday	-	4.76	1	FD
Polytmus guainumbi	4.76	-	1	LV
Saltator coerulescens	-	4.76	1	FD

H. chrysura, *P. guainumbi* and *Thalurania furcata*), made legitimate visits. All other species made illegitimate visits (*Icterus cayanensis*, *Tangara palmarum* and *T. sayaca*) or destroyed the flowers (*Amazona aestiva*, *Aratinga nenday*, *Brotogeris chiriri* and *Saltator coerulescens*) (Table 1).

All hummingbirds hovered in front of flowers to feed and then inserted the head in the corolla of the flower to reach the nectar. In this process, parts of their body made contact with the anthers and stigma, possibly promoting pollination. Occasionally, some hummingbirds such as *H. chrysura* and *H. furcifer*, landed on the petals and inserted their beaks into the flowers to get the nectar. *Heliomaster furcifer* sometimes inserted its beaks underneath the anthers and stigma, never touching them.

Damage to the flower and illegitimate visits were recorded for parrots and passerines (Table 1), especially for *B. chiriri* and *T. sayaca* (Figure 1), both species common in our samples (83.33% and 95.24%, respectively, of all events sampled). Occasionally, *E. macroura* made illegitimate visits. *Brotogeris chiriri* visited the *C. pubiflora* trees in flocks of up to 30 individuals, and some quarreled with up to four *B. chiriri* engaged. The flocks of *B. chiriri* consumed pollen and petals, often tearing and consuming hundreds of flower buds. Similar behavior was recorded for *S. coerulescens*, but at a smaller scale. *Tangara sayaca* was less destructive, piercing the flowers at the base of the corolla, leaving the flower almost intact, except when the flower was old when it usually fell down.

FIGURE 1. *Ceiba pubiflora* flower exploited by birds **A)** Legitimate visit: Insertion of the bird's beak in the corolla of the flower; **B)** Illegitimate visit: the bird pierces the flower at the base of the corolla, taking the nectar directly without contact with reproductive parts. **C)** and **D)** Damage to the flower: Birds eat parts of the flower, such as petals, sepals, anthers and stigma, likely damaging it in such a way that makes it unable to develop a fruit. **A)** *Heliomaster furcifer*; **B)** *Tangara sayaca*; **C)** *Brotogeris chiriri*; **D)** *Amazona aestiva.* Photos: Daniel Dainezi.

There was a difference between intra and interspecific agonistic interactions ($\chi^2 = 13.26$, $p < 0.001$, df = 1). Interspecific agonistic interactions were more frequent (57.53%) than intraspecific interactions (42.46%). *Hylocharis chrysura* was the most frequent in territorial disputes and also the most aggressive species, present in 53% of all events. The second species was *H. furcifer*, present in 36.64% of all interactions. The other species accounted for 4% of agonistic interactions or less (Table 2).

Hylocharis chrysura showed high territorial behavior, fighting against individuals of the same species. However, its efficiency in chase away other birds was partial, as its assaults were occasionally unsuccessful in warding off the intruder. When *H. chrysura* attacked *H. furcifer* males, it was sometimes ignored or suppressed, so that *H. chrysura* succeeded in expelling only *H. furcifer* females and juveniles. All the attacks that *H. chrysura* made towards *E. macroura* were ignored or retaliated by the latter.

TABLE 2. Frequency of intra/interspecific agonistic interactions among birds visiting *Ceiba pubiflora* trees.

Species	Total of Interactions	Intraspecific	Interspecific
Hylocharis chrysura	310	164	146
Heliomaster furcifer	214	72	142
Chlorostilbon lucidus	26	3	23
Eupetomena macroura	20	-	23
Brotogeris chiriri	8	8	-
Tangara sayaca	3	1	2
Thalurania furcata	3	-	3

Heliomaster furcifer was the second species present in territorial disputes. Unlike *H. chrysura*, *H. furcifer* was more aggressive towards individuals of other species (66%). Males were dominant, while females and young were subordinate to other species such as *H. chrysura* and *E. macroura*.

DISCUSSION

There was a clear predominance (present in most samples) of *H. chrysura*, *H. furcifer*, *T. sayaca* and *B. chiriri*. *Hylocharis chrysura* was recorded in all samples and is a generalist that often feeds on nectar from plants with no ornithophilous syndrome (Snow & Snow 1986, Araujo & Sazima 2003). This bird was also one of the most common hummingbirds recorded in other studies taking the nectar of a variety of plants (Mendonça & Anjos 2005, Parrini & Raposo 2010, Polatto *et al.* 2012).

In this study, the three most common species of birds at *C. pubiflora* (*H. chrysura*, *H. furcifer* and *T. sayaca*) were recorded in both periods of the day and in almost all samples. These species consumed the nectar of the flowers without damaging flowers. In the afternoon, birds were recorded consuming petals and pollen.

Only hummingbirds made legitimate visits to *C. pubiflora* flowers in our study. In fact, these birds are responsible for 15% of the pollination in the Neotropical plants (Feinsinger 1983). In addition to making almost exclusively legitimate visits, they were also present in most or all sampling events (100% *H. chrysura* and 95.24% *H. furcifer*) and they showed a high potential for *C. pubiflora* pollination. *Heliomaster furcifer* has a long beak and it does not need to insert it deep into the flower to feed, and sometimes does not touch the anthers. Thus, it may be a less effective pollinator than other hummingbirds.

Parrots interfered negatively in the reproduction of *C. pubiflora* by damaging the flowers and consuming hundreds of flowers buds. The flower-damaging behavior of *B. chiriri* was already recorded by Marques (2012). Besides this, Stiles (1981) argues that birds, except hummingbirds, are often considered “floral parasites” exploiting floral resources in the Neotropical region and acting only as pollinator in moderate to low levels. Ragusa-Netto (2007) also observed the floral parasite behavior of large flocks of *A. nenday* exploiting the nectar of various plants in dry seasons in the Pantanal region.

According to McDade & Kinsman (1980), floral parasitism causes serious damage, due to the flowers exploited in such a way that they have fewer pollinators and lower potential for nectar recovery when compared to those exploited by effective pollinators. Moreover, due to the reduction of nectar in flowers, potential pollinators may partially or totally avoid plants that have their nectar stolen by parasites. Thus, they directly influence the ecology and evolution of the pollination system of the plants (McDade & Kinsman 1980, Hargreaves *et al.* 2009).

The potential for damaging *C. pubiflora* flowers by *B. chiriri* is here emphasized. Although these psittacids were less frequent than other three bird species, they were often present in flocks of over ten individuals, feeding on flowers for hours over a single tree. Similar flocks of *B. chiriri* were observed by Parrini & Raposo (2010), who recorded these birds exploiting the flowers of *Erythrina fusca* in the Pantanal dry season in the state of Mato Grosso, western Brazil. Ragusa-Netto (2004) also noted a remarkable abundance of *B. chiriri* using nectar as their main food source and damaging flowers, claiming this feeding behavior was due to the scarcity of fruit during the dry season in the Pantanal.

Tangara sayaca was one of the most frequently observed species exploiting *C. pubiflora* flowers and nectar. Thraupidae birds have a generalist diet, with nectar as an important component in their diets (Feinsinger *et al.* 1979, Sazima *et al.* 1993). Our study shows that *C. pubiflora* can be an important food source for *T. sayaca*, as well as for other Thraupidae species. These birds can be considered parasites of *C. pubiflora*, due to thieving nectar from flowers.

Hylocharis chrysura was the most aggressive species, but its efficiency in scaring away birds of other species was low. On the other hand, *H. furcifer* was more aggressive with individuals of other species than *H. chrysura*. Males of *H. furcifer* showed dominance, winning almost all disputes with *H. chrysura*, while females and young birds were easily driven off by other species. The territorial behavior of *H. chrysura* was also observed by Faria & Araújo (2010), who recorded these birds defending territories around *Lophostachys floribunda* and *Ruellia angustiflora*. *Eupetomena macroura* is usually strongly territorial, with dominance over other birds (Mendonça & Anjos 2005, Toledo & Moreira 2008, Previatto *et al.* 2013). However, we did not observed territorial defense in this species, as it showed some aggressiveness only in cases in which it was attacked by other birds, always winning disputes.

Only *B. chiriri* showed exclusively intraspecific interactions. According to Marques (2012) *B. chiriri* interacted with at least 11 species of birds, but no hummingbirds. *Brotogeris chiriri* possibly did not attack other species while on *C. pubiflora* trees because hummingbirds, passerines and others psittacids did not pose a threat to this species of parakeet.

The exuberant flowering of *C. pubiflora* provided plentiful resources for at least 13 species of birds, which compete for flower resources and fed both on nectar and flower parts. All flower parts are consumed by Psittacidae (*A. nenday*, *B. chiriri* and *A. aestiva*). Hummingbirds, especially *H. chrysura*, are possibly the most effective pollinators of this tree, as they consume nectar without damaging flowers.

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SHORT-COMMUNICATION

Foraging techniques of Swallow-tailed Cotinga (*Phibalura flavirostris*) on fruits of *Struthanthus marginatus* (Loranthaceae) in Monte Verde, Camanducaia, state of Minas Gerais, Brazil

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ABSTRACT: We record a new observation of a group of 22 individuals of *Phibalura flavirostris* (Cotingidae) from field observations and photographs, in the district of Monte Verde, municipality of Camanducaia, in the southern state of Minas Gerais, Brazil. We also report the same individuals foraging on fruits of the Loranthaceae *Struthanthus marginatus* using the techniques "perch-gleaning" and "sally-strike". The later technique was not previously recorded for this species.

KEY-WORDS: altitudinal migrant, Cotingidae, mistletoe, perch-gleaning, sally-strike.

The Swallow-tailed Cotinga (*Phibalura flavirostris*) is an endemic bird from South America and currently considered "Near Threatened" (IUCN 2016). In Brazil, the Swallow-tailed Cotinga (*Phibalura f. flavirostris*) apparently prefers forest borders and partially or lightly wooded areas (Snow 2004). This species feeds mainly on fruits and insects (Snow 2004), consuming fruits of various species of Loranthaceae in Brazil (Snow 2004). This species is an altitudinal migrant, except in the breeding season, during which it forages in groups of 15–20 individuals due to a high abundance of food (Sick 1997). However, little is known about the gregarious habits and foraging behavior of the Swallow-tailed Cotinga in Brazil (Moura 2014), and there are no recent reports of aggregation or partial migration (Sick 1997). Herein, we report a group of Swallow-tailed Cotinga foraging in a species of Loranthaceae not previously recorded as a food source.

We observed 22 individuals foraging together on Mistletoe (*Struthanthus marginatus* (Desr.) Blume) (Loranthaceae) at Monte Verde district, municipality of Camanducaia, Minas Gerais state (22°51'52.88"S; 46°1'22.79"W; 1,600 m.a.s.l.) on 28 April 2013, from 08:45 to 09:15 a.m. Birds were observed with 8 x 42 binoculars and photographed using a DSLR camera with a 100–400 mm lens. The study area is urban and composed of lodges and summer homes (Figure 1A). The predominant vegetation is high montane forest (França & Stehmann 2004). Climate is temperate, the average annual temperature is 14.7°C and the annual rainfall average is 1,723 mm/year (Climatempo 2016).

The 22 adult birds were perching on top of a dead tree with a height of about 30 m (Figure 1B). Birds later flew off this tree (Figure 1C) to lower trees colonized by mistletoe, an aerial hemiparasitic plant (Mathiasen *et al.* 2008). These plants were at a height of about 15 m and filled with ripe fruits (Figure 1D). The majority of birds, about 17, were catching fruits in flight using the "sally-strike" technique and then returned to the dead tree to complete consumption of the fruits (Figure 1E). Some individuals also flew from the dead tree directly to the branch with mistletoe, perched briefly (about 20 s), picked the fruit from the branch using the technique "perch-gleaning" (Figure 1F) and then swallowed the fruit. In this period of observation we also observed individuals of White-crested Tyrannulet (*Serpophaga subcristata*) and Yellow-bellied Elaenia (*Elaenia flavogaster*) feeding on the fruits of the same Loranthaceae.

The observation of this species is a new record for the district of Monte Verde, Minas Gerais state, Brazil.

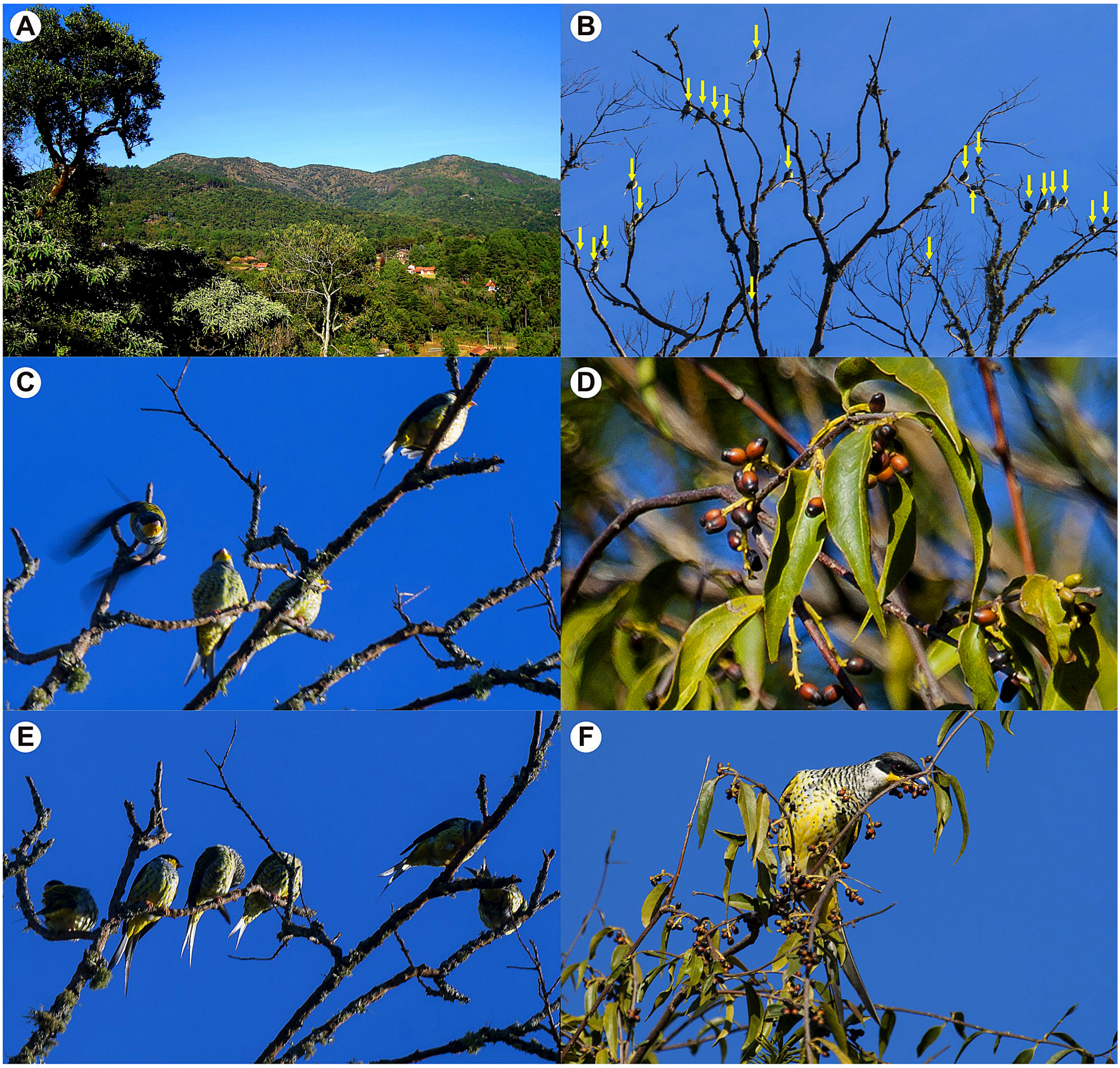

FIGURE 1. A) Study area in Camanducaia, south of the state of Minas Gerais; **B)** 22 individuals of Swallow-tailed Cotinga (arrows) resting on a dead tree used as a starting point for feeding flights; **C)** A male flying to the tree with Mistletoes; **D)** Branch with ripe fruits of mistletoe; **E)** A group of six individuals of Swallow-tailed Cotinga, one cleaning the beak (right) after swallowing the fruit and others sunning; **F)** A male Swallow-tailed Cotinga picking the fruit of mistletoe using the "perch gleaning" technique. Photo: Viviane Pigatto de Almeida.

These Swallow-tailed Cotingas are usually observed in pairs or small groups of three to five individuals (Nunes-de-Almeida pers. obs.). The group observed in late April, during the dry season, indicates that this behavior could be associated with the abundance or availability of mistletoe, which sets fruit in autumn/winter (Greta Dettke pers. comm.). This tree could be an important source of nutrients, especially during this season (Faustino & Machado 2006, Sick 1997).

In their molecular phylogenetic work, Ohlson *et al.* (2013) found that systematic interrelationships among Pipridae, Cotingidae and Tyrannoidea are very close and difficult to tease apart, despite increasing amounts of data. Morphological aspects of these birds are strongly correlated with the ways they feed and select their fruits (Estrada & Fleming 2012). Birds use different foraging techniques depending on habitat type and food (Avalos 2009). The "sally-strike," the main foraging technique used to pick fruit observed in this group of Swallow-tailed Cotinga has not been previously recorded. Fitzpatrick (1980) observed the same technique in flycatchers (Tyrannidae). This record is different from that described in the Bolivian Swallow-tailed Cotinga (*P. f. boliviana*) which generally uses "reach" and "glean" techniques to pick fruit (Avalos 2009). Like Quetzal (*Pharomachrus mocinno*) when in sally, the Swallow-tailed Cotinga usually takes only one fruit per flight (Nunes-de-Almeida pers. obs.) (Santana & Milligan 1984). Moreover, flying for fruits is a high-energy expenditure (Avalos 2009, Estrada & Fleming 2012). Thus, the costs of sallying for a single fruit must be compensated by the energy gained from the food item (Santana & Milligan 1984).

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SHORT-COMMUNICATION

A small homage to Maria Sibylla Merian, and new records of spiders (Araneae: Theraphosidae) preying on birds

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ABSTRACT: Spiders have a great potential to prey on small vertebrates. However, detailed events are sparse in the literature. In the current work, two detailed records of Tarantula predation in the Brazilian Amazon are documented. Preying begins by bird's eyes, which eases the inoculation and spread of the digestive enzymes. Maria Sibylla Merian described the predation of a bird by a Tarantula in a scientific illustration, though her descriptions were labeled as fanciful. The current work makes a small homage to this 17th Century naturalist that challenged the prejudice of her time with her artistic and scientific production.

KEY-WORDS: Bird predated, Tarantula

Reports involving the predation of vertebrates by invertebrates have been known for a long time in the scientific literature. Spiders are the main predators, while crustaceans, centipedes and insects have also been recorded as predators of small vertebrates (Teixeira *et al.* 1991). In the case of birds and spiders, predation has been a strong link between the two groups: spiders are eaten in great quantity by insectivore birds (Sick 1997, Gunnarsson 2007) and, less frequently, birds become a part of the diet of some species of spider (Teixeira *et al.* 1991, Peloso & Souza 2007). Humingbirds, such as *Phaetornis petrei* (Lesson & Delattre, 1839), *Phaetornis ruber* (Linnaeus, 1758) and *Cloristibon* sp., and even some passerine birds such as *Sporophila caerulescens* (Vieillot, 1823), *Polioptila plumbea* (Gmelin, 1788) and *Todirostrum cinereum* (Linnaeus, 1766) have been captured by the effective webs woven by spiders of the genus *Nephila*. However, in most cases the spider does not attack and actually recoils until the bird can free itself (Teixeira *et al.* 1991, Duca & Modesto 2007, Peloso & Sousa 2007), because the web is a low selection trap that ends up trapping undesired prey (Ludy 2007).

It is also important to notice that in some cases the birds inspect the webs in search for food or material for nest construction, and occasionally get stuck (Waide & Hailman 1977). There are few reports that confirm the predation of birds by *Nephila* spiders (Peloso & Sousa 2007), though some of these vertebrates may perish later due to web stuck on their bodies (Duca & Modesto 2007).

Most cases involving spiders preying on birds are from spiders of the family Theraphosidae (Gallon 2000), commonly known as "caranguejeiras" in Brazil, babbon spiders in South Africa and tarantulas in North America. Although these reports have been present in the scientific literature for centuries, the descriptions are problematic, since they lack reliable examples and do not detail the predation event (Bates 1864). This theme has sparked a peculiar case in the academic world, led by Maria Sibylla Merian, a Frankfurt-born naturalist in 1647. Merian was a scientific illustrator and drew more than a hundred species of animals and plants, contributing significantly to the area of systematics, especially insects (Etheridge 2010). Between the years 1699 and 1701, Merian went on an expedition to Surinam, then a Dutch colony. In the year 1705 she published her best known work *Metamorphosis Insectorum Surinamesium* and, among 60 plates, she recorded the moment in which a tarantula consumed a hummingbird (Figure 1). That record in particular was fiercely criticized by scientists, including Langsdorf, whom in 1812 returned from an expedition to the Brazilian Amazon. Langsdorf argued that it was unlikely that a spider with nocturnal habits would attack a diurnal bird and criticized Merian's records as fanciful and nothing more than "childhood fear" reproductions from the author (Smith 2000).

FIGURE 1. Detail from plate 18 of the book *Metamorphosis Insectorum Surinamensium, in qua Erucae ac Vermes Surinamenses, cum omnibus suis transformationibus* by Maria Sibylla Merian (Amsterdam 1705).

Here we describe two records of theraphosid spiders preying on birds in the Brazilian Amazon, thus making our small homage to Maria Sybilla Merian. This is the first detailed description of this kind of predation.

The first event occurred at 08:00 h of 13 August 2009 during a bird sampling in one of the areas of the *Projeto Dinâmica Biológica de Fragmentos Florestais* (PDBFF) (2°23'16.84"S; 59°54'7.83"W) located 70 km from Manaus, Amazonas state, Brazil. The second event occurred in the Sumaúma State Park (3°2'5.79"S; 59°58'55.25"W), in the city of Manaus, Amazonas state, Brazil.

In the first event a bird from the specie *Gymnopithys rufigula* (Boddaert, 1783) was stuck in a mist net, used to catch birds in ornithological studies. The bird was at about 30 cm from the ground and was preyed upon by a *Theraphosa blondi* (Latreille, 1804) (Figure 2). The spider pierced the eye of the bird with its fangs, which caused the death of the bird in a few seconds. Afterwards, with no human interference, the spider cut the net and took the bird to the entrance of its burrow, located at 1.5 m from the net. At 11:30 h, the bird had its head and a small portion of its body digested. The species *G. rufigula* has around 13.5 cm and mass between 26–32 g, lives in the understory of white-water floodplain and "terra firme" forests of the Amazon rainforest, and it is a mandatory follower of army ants, feeding on the arthropods and insects that are scared away by the ants (Sick 1997).

The second event occurred in the morning of 15 April 2011. Around 10:00 h, an individual of *Troglodytes musculus* Naumann, 1823 was preyed upon by an *Avicularia avicularia variegata* (Fukushima, 2011) tarantula, inside a plant nursery of 10 x 6 m (Figure 3). As in the previous record, this species of spider introduced its fangs into the bird's eye and, after the action of the digestive enzymes, proceeded to feed on the head of the bird. At 15:00 h, about half the prey was digested. *Troglodytes musculus* has around 12 cm and body mass between 9.7–11.8 g, lives in several types of forest and is a common sight around houses and gardens while feeding on insects (Sick 1997).

Both events were carried out by Theraphosidae spiders, which include 940 species. The species of spiders recorded in this study were identified with the help of researchers from the University of São Paulo and the Butantan Institute. In tropical forests, species of these tarantulas build their burrows in rocky soils, natural cavities and even in the canopy (Gallon 2000, Yáñez & Floater 2000). *Caranguejeiras* are the largest spiders of

FIGURE 2. *Gymnopithys rufigula* being preyed upon by a *Theraphosa blondii* in one of the areas of the Biological Dynamics of Forest Fragments Project, Amazonas state, Brazil.

FIGURE 3. *Troglodytes musculus* preyed upon by *Avicularia avicularia variegatus* in Sumaúma State Park. Amazonas, Brazil.

the New World, usually solitary, territorial and generalist predators (Edwards & Hibbard 1999, Gallon 2000). They have two large fangs that inject the venom stored in the chelicerae (Gallon 2000). It is noteworthy that, although these spider species are nocturnal foragers (Gallon 2000), our records are from the morning period. Thus, although the peak activity of these tarantulas is during the night, their diurnal foraging activities should not be underestimated.

It is known that spiders have a substantial ecological impact on the populations of other invertebrates (Nyffeler 2000). However, there are no known studies that cover this effect over vertebrate populations. We emphasize that both events described were opportunistic, but environments occupied by these spiders are also inhabited by a wide range of bird species that build their nests and look for shelter in cavities in the forest ground (Sick 1997). Because in many localities the density of some of these theraphosid spiders is high (Shaw *et al.* 2011), this type of predation may have an impact over the bird population, especially the ones that live close to the forest ground.

An interesting and novel fact of the current study is that the predation events started by the eye of preyed bird. Eyes have softer tissues that may ease the venom injection and the spread of digestive enzymes, as it is a highly vascularized area (Curtis 1975). Furthermore, the first area to be digested would be the brain. Birds have large and well developed brains in comparison to the rest of their bodies, varying between 2–9% of the whole body mass, and are lipid-rich tissues (Curtis 1975). It is a highly nutritious organ, which justifies it being consumed first than other body parts. Moreover, with the attack starting with the eyes the prey dies quickly.

Documenting aspects of the natural history of organisms is paramount for the understanding of the ecological and evolutionary biology of the studied species. It is important that future studies cover the ecological impact of spiders preying on bird species as potential prey.

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A reassessment of the taxonomy of *Crypturellus noctivagus* (Wied, 1820)

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ABSTRACT: *Crypturellus noctivagus noctivagus* (Wied, 1820) and *C. noctivagus zabele* (Spix, 1825) are endemic Brazilian tinamous restricted to Atlantic Forest and Caatinga, respectively. We used plumage, morphometric, vocal and oological characters to examine the validity of these taxa. Presence of sexual dimorphism in plumage only in birds occurring in Caatinga, and diagnostic differences in plumage pattern, tarsus color and egg color and shape allow us to recognize these two forms as distinct lineages, being considered here as *Crypturellus noctivagus* and *Crypturellus zabele*. We also provide updated diagnoses, descriptions, and geographic distributions for these two taxa.

KEY-WORDS: coloration, *Crypturellus zabele,* morphometrics, plumage, vocalizations.

INTRODUCTION

The genus *Crypturellus* Brabourne & Chubb comprises the majority of the South American tinamous (Sick 1997). Although several taxonomic revisions have been conducted (Hellmayr & Conover 1942, and references therein), much uncertainty persists in the taxonomy of this genus, in which considerable inter- and intraspecific variation is known to exist (Amaral & Silveira 2004). For example, at least 10 taxa have been considered subspecies of *Crypturellus noctivagus* (Wied, 1820), including *C. n. erythropus*, *C. n. atrocapillus*, *C. n. garleppi*, and *C. n. duidae* (Hellmayr & Conover 1942, Phelps & Phelps Jr. 1958, Blake 1977, Schwartz 1984). Many of these forms are currently considered species, such as *C. duidae*, *C. atrocapillus*, and *C. erythropus*, the latter two polytypic and likely requiring further taxonomic revision. Although most species in the genus *Crypturellus* are found in Amazonian and Andean forests, the two taxa presently allocated to *C. noctivagus* are endemic to eastern Brazil: *C. noctivagus noctivagus* (Wied, 1820), from the Atlantic Forest and *C. noctivagus zabele* (Spix, 1825), from the Caatinga.

Tinamus noctivagus Wied, 1820 (= *C. n. noctivagus*) and *Pezus zabelé* Spix, 1825 (= *C. n. zabele*) were described as separate species, but were later considered synonyms (Salvadori 1895, Hellmayr 1906, Ihering & Ihering 1907, Peters 1931, Pinto 1938). With more material available, Hellmayr & Conover (1942) recognized two subspecies, reviving the name *zabele* for the Caatinga birds and distinguishing them from nominal *C. noctivagus* by an overall paler color, a well-defined superciliary stripe, and broader bars in the wing-coverts and remiges. They also noticed possible sexual dimorphism in *C. n. zabele,* correcting the observations of Salvadori (1895), who described sexual dimorphism in *C. n. noctivagus* by using a female of *C. n. zabele* and a male of *C. n. noctivagus* in his analysis. Subsequent authors (Pinto 1964, Blake 1977, Pinto 1978, Mayr & Cottrell 1979, Cabot 1992, Sick 1997, Davies 2002, Grantsau 2010) followed the taxonomy proposed by Hellmayr & Conover (1942).

A proper investigation of the taxonomic status of these two forms requires the examination of a large and geographically diverse series of specimens, with a careful analysis of plumage variation and the inclusion of additional data of taxonomic interest, such as vocalizations, morphometrics, color of tarsus and eggs, and egg shape. Here we present a taxonomic revision of the *C. noctivagus* complex and provide updated diagnoses, descriptions, and geographic distributions.

METHODS

We analyzed 67 skins of adult *Crypturellus noctivagus* (38 males, 18 females and 11 unsexed), including the holotypes of both taxa (*i.e.*, the nominal *noctivagus* and *zabele*), and 12 eggs (from four clutches), housed at the following institutions: American Museum of Natural History (AMNH), New York, USA; Field Museum of Natural History (FMNH), Chicago, USA; Zoologische Staatssammlung München (ZSM), Munich, Germany; Museu de História Natural Capão da Imbuia (MHNCI), Curitiba, Brazil; Museu Nacional (MNRJ), Rio de Janeiro, Brazil; and Museu de Zoologia da Universidade de São Paulo (MZUSP), São Paulo, Brazil. Juveniles, identified by distinct plumage and by smaller structural size (wing, bill and tarsus) which did not overlapped with the adults, were excluded from morphometric or plumage analyses and only considered for distribution analysis.

Characters analyzed included color and patterns of plumage, egg size, shape, and color, and tarsus color, as well as morphometric characters. All measurements and color data were taken by a single observer (B.M.T.). We analyzed the color of the supercilium, crown, nape, throat, breast, abdomen, and back, as well as the light barring in the tail and in the wing coverts, and the color of eggs and tarsus. We also analyzed the width of the light barring in the wings, supercilium length, and the presence of barring in the breast. Plumage colors were classified following Munsell (1994), comparing the specimens' colors to the reference colors provided by the charts, and then grouped in eight color categories (Table 1) to allow more straightforward comparisons. Tarsus color, although not preserved in the museum skins, could be analyzed through high-quality photos from birds in the wild (www.wikiaves.com.br) and also from information present on the specimens' labels. We also analyzed high quality photos of eggs when available (www.wikiaves.com.br). Morphometric analysis included wing and tarsus length, bill size (length, height and width) and egg size and shape (length, width and "roundness index", *i.e.*, length/width). All measurements were taken using calipers. To measure the wing bars, three bars from the middle coverts were selected, measured and the mean value was calculated. Student *t*-tests were conducted in PAST software v.2.15 (Hammer *et al.* 2001) and multivariate analysis (Principal Component Analysis) was carried out in SPSS 13.0. To avoid bias in the analyses, we did not consider *a priori* the provenance and previous identification of each specimen.

TABLE 1. Color categories and the original Munsell (1994) color codes from which they derived.

Color categories	Munsell (1994)
Black	5YR 2.5/1; 7.5YR 2.5/1; 10YR 2/1
Dark grayish brown	2.5YR 2.5/1; 2.5YR 3/1; 5YR 3/1; 7.5YR 3/2; 10YR 3/1; 10YR 3/2; 10YR 4/1
Grayish brown	5YR 4/2; 7.5YR 4/2; 10YR 4/2; 10YR 4/3; 10YR 5/2
Dark reddish brown	2.5YR 3/6; 5YR 2.5/2; 5YR 3/2; 5YR 3/3; 5YR 3/4; 7.5YR 2.5/2; 7.5YR 3/4; 10YR 2/2
Reddish brown	2.5YR 4/4; 2.5YR 4/6; 2.5YR 5/6; 2.5YR 5/8; 5YR 4/4; 5YR 4/6; 5YR 5/4; 5YR 5/6; 5YR 5/8; 5YR 6/8; 5YR 7/8; 7.5YR 4/6; 7.5YR 5/6; 7.5YR 5/8
Yellowish brown	7.5YR 6/6; 7.5YR 6/8; 10YR 5/4; 10YR 5/6; 10YR 5/8; 10YR 6/4; 10YR 6/6; 10YR 6/8
Yellow	7.5YR 7/6; 7.5YR 7/8; 7.5YR 8/6; 10YR 7/6; 10YR 7/8; 10YR 8/6
Pale	2.5YR 8/1; 7.5YR 7/4; 10YR 7/3; 10YR 7/4; 10YR 8/2; 10YR 8/3; 10YR 8/4

Vocal samples were obtained at the Arquivo Sonoro da Seção de Aves do MZUSP, on internet databases (www.wikiaves.com; www.xenocanto.com), and from colleagues. Sonograms were created and analyzed using the software Raven Pro 1.4 (Bioacoustics Research Program 2011). We only used recordings that produced clear and precise sonograms, with low or no background noise (sample size: n = 10 for *C. n. noctivagus*, n = 5 for *C. n. zabele*). The choice of vocal characters for the analysis was based on Isler *et al.* (1998) and Bertelli & Tubaro (2002), namely: the number of notes (a note being defined as an unbroken trace in the spectrogram), total duration of vocalization, maximum frequency, minimum frequency, bandwidth (max. freq. minus min. freq.), peak frequency (frequency at the point of highest amplitude), peak time (point in time of highest amplitude), and duration of each note and internote. Not all sonograms allowed precise note distinction; therefore, sample size varied for the analyses of note and internote duration. To minimize possible intra-individual differences, we followed Isler *et al.* (1998) and used a mean value when we had more than one vocalization for a single individual. The locality of each specimen was taken from their respective labels and from gazetteers (Paynter & Traylor 1991; Vanzolini 1992) and geographic data websites (*e.g.* http://www.fallingrain.com and http://www.bngb.ibge.gov.br/bngb.php), and mapped using the QuantumGis software.

RESULTS

Consistent differences in plumage color and pattern, morphometric characters, color of tarsus, egg color and egg shape were found. A very distinctive feature that stands out is the tarsus color. Tarsi are olivaceous in birds from the Atlantic Forest (currently *C. n. noctivagus*) and pure-

FIGURE 1. Ventral (above), lateral (center) and dorsal (below) views of *C. n. noctivagus* (from left to right MZUSP 43761, MZUSP 56384, MZUSP 48335 and MZUSP 49333) and *C. n. zabele* (male MZUSP 7603; female MZUSP 8496).

yellow in those from the Brazilian Caatinga (currently *C. n. zabele*). Another important difference between the two forms appears when we compare females. The upper breast of both males and females of *C. n. noctivagus* is solid gray, whereas the upper breast is solid gray only in males of *C. n. zabele*. The upper breast of females of *C. n. zabele* is barred rather than solid-gray (Figure 1). Therefore, breast color is a diagnostic difference between females of the two forms. As a consequence, *C. n. zabele* shows sexual dimorphism in plumage, which was not noticed in *C. n. noctivagus.* Although males of *C. n. noctivagus* tend to be more reddish than females, this is not a consistent difference (Table 2).

We found in almost every plumage character analyzed that *Crypturellus n. zabele* are paler than *C. n. noctivagus.* This is much more prominent in the wing bars and tail, and in the overall color of the throat, upper breast, and abdomen, which are darker and/or redder in *C. n. noctivagus* (Table 2). There is overlap in some of the characters analyzed; however, the color of the wing bars and tail coverts are distinct (Figure 1; Table 2). Even with a minor overlap in the color of the wing bars, the differences between the wings of the two forms become evident when we consider the larger bars in *C. n. zabele* wings (Table 3) combined with its overall paler colors. The color of the light bars in the tail coverts is particularly interesting: most *C. n. zabele* specimens showed a clear difference between the color of bars in rump (reddish brown) and tail coverts (pale), not observed in any *C. n. noctivagus*, which had darker tail covert bars. We also noted that the superciliary stripes tend to be not only paler in *C. n. zabele* (Table 2), but also broader and longer than in *C. n. noctivagus*, which usually had short, thin or even fragmented stripes (in *C. n. zabele* the stripes were evidently marked).

When sexual dimorphism for morphometric characters was analyzed, Student's *t*-test indicated that females of *C. n. noctivagus* are borderline significantly smaller than males for wing (t_{44} = 1.96, p = 0.05) and tarsus length (t_{44} = 2.06, p = 0.04). Males and females of *C. n. zabele* were indistinguishable when the same characters are compared ($p > 0.05$ in all cases). When comparing the same characters between males and females of each form, the tarsus length and wing bars of males of *C. n. noctivagus* significantly differed from males of *C. n. zabele* (t_{33} = 2.22, p = 0.03 and t_{27}= -3.96, $p < 0.01$, respectively), with males of the latter having smaller tarsi and broader wing bars than males of *C. n. noctivagus*. When females were compared, differences were only found in wing bars size, broader in *C. n. zabele* (t_{15} = -2.51, p = 0.03). It is important to notice that, except for the wing bars, these morphometric differences were very subtle (Table 3). When all birds were analyzed in the Principal Component Analysis (Figure 2), two factors explained 66.8% of the total variance between the two taxa. The taxa cluster with small overlap (Figure 2) suggesting the existence of morphometric differences between *C. n. noctivagus* and *C. n. zabele*, the latter with a tendency to have shorter tarsi and broader wing bars.

We also found differences between the two taxa in egg color and shape: eggs of *C. n. noctivagus* are greenish, while those of *C. n. zabele* are bluish; moreover, eggs of *C. n. zabele* are more elongated (greater length/width index; Table 3). However, owing to the small number of available clutches, these differences should be treated as tentative rather than definitive.

TABLE 2. Proportion (%) of specimens of *C. n. noctivagus* and *C. n. zabele* in relation to color characters analyzed. First line shows summed data of all specimens considered. The second line shows data of males and females separately.

Character	Taxa	Dark reddish brown	Reddish brown	Yellow/ Yellowish brown	Pale
Supercilium	*C. n. noctivagus*	4.35 (♂67.41 ♀0)	34.78 (♂37.04 ♀16.67)	41.3 (♂40.74 ♀50)	19.57 (♂14.81 ♀33.33)
	C. n. zabele		10 (♂25 ♀0)	30 (♂25 ♀0)	60 (♂50 ♀100)
Wing barring	*C. n. noctivagus*		2.13 (♂3.85 ♀0)	93.62 (♂92.31 ♀93.33)	4.26 (♂3.85 ♀6.67)
	C. n. zabele			10 (non sexed)	90 (♂100 ♀100)
Tail coverts bars	*C. n. noctivagus*	10.91 (♂9.68 ♀6.67)	89.09 (♂90.32 ♀93.33)		
	C. n. zabele		10 (non sexed)	50 (♂50 ♀66.67)	40 (♂50 ♀33.37)
Throat	*C. n. noctivagus*	9.26 (non sexed)	40.74 (♂16.13 ♀0)	29.63 (♂64.52 ♀66.67)	20.37 (♂19.35 ♀33.33)
	C. n. zabele			20 (♂25 ♀0)	80 (♂75 ♀100)
Abdomen	*C. n. noctivagus*		10.91 (♂12.90 ♀6.67)	69.09 (♂64.62 ♀73.33)	20 (♂22.58 ♀20)
	C. n. zabele			10 (♂0 ♀33.37)	90 (♂100 ♀66.67)

TABLE 3. Mean, maximum and minimum values of each morphometric character analyzed; all values are in centimeters. *p*-values of Student *t*-test were obtained from the comparison of males and females of each taxon separately. Asterisks indicate significant values at $p < 0.05$

Character	Gender	Sample size	*Crypturellus n. noctivagus*			Sample size	*Crypturellus n. zabele*			*p*-value
			Mean (SD)	Max	Min		Mean (SD)	Max	Min	
Wing length	♂	31	18.66 (0.63)	19.60	16.80	4	18.98 (0.59)	19.30	18.10	0.36
	♀	15	18.27 (0.67)	19.50	17.00	3	19.10 (0.36)	19.50	18.80	0.06
Tarsus length	♂	31	54.25 (2.26)	58.05	47.75	4	51.65 (1.50)	53.14	49.86	0.03*
	♀	15	52.72 (2.54)	56.25	46.30	3	51.24 (1.93)	53.31	49.50	0.36
Culmen	♂	31	30.20 (1.97)	34.50	25.15	4	30.29 (1.35)	31.65	28.43	0.93
	♀	15	30.10 (1.78)	33.20	26.65	3	30.26 (1.27)	31.71	29.37	0.89
Beak height	♂	28	6.34 (0.69)	8.80	5.40	3	6.48 (0.27)	6.73	6.20	0.74
	♀	15	6.03 (0.51)	7.10	5.00	2	6.70 (1.07)	7.45	5.94	0.14
Beak width	♂	31	6.71 (0.46)	7.65	5.60	4	6.49 (0.26)	6.81	6.20	0.35
	♀	15	6.52 (0.56)	7.70	5.90	3	6.77 (0.31)	7.10	6.49	0.47
Wing streaks	♂	26	1.70 (0.21)	2.17	1.35	4	2.19 (0.30)	2.60	1.91	<0.01*
	♀	14	1.79 (0.29)	2.42	1.40	3	2.27 (0.32)	2.63	2.05	0.02*
Egg length (L)		8	53.12 (1.74)	56.70	50.69	4	51.68 (1.68)	54.13	50.40	0.20
Egg width (W)		8	43.85 (0.59)	44.80	43.00	4	40.34 (0.78)	41.50	39.84	<0.01*
Egg (L/W ratio)		8	1.21 (0.04)	1.30	1.168	4	1.28 (0.02)	1.30	1.26	0.01*

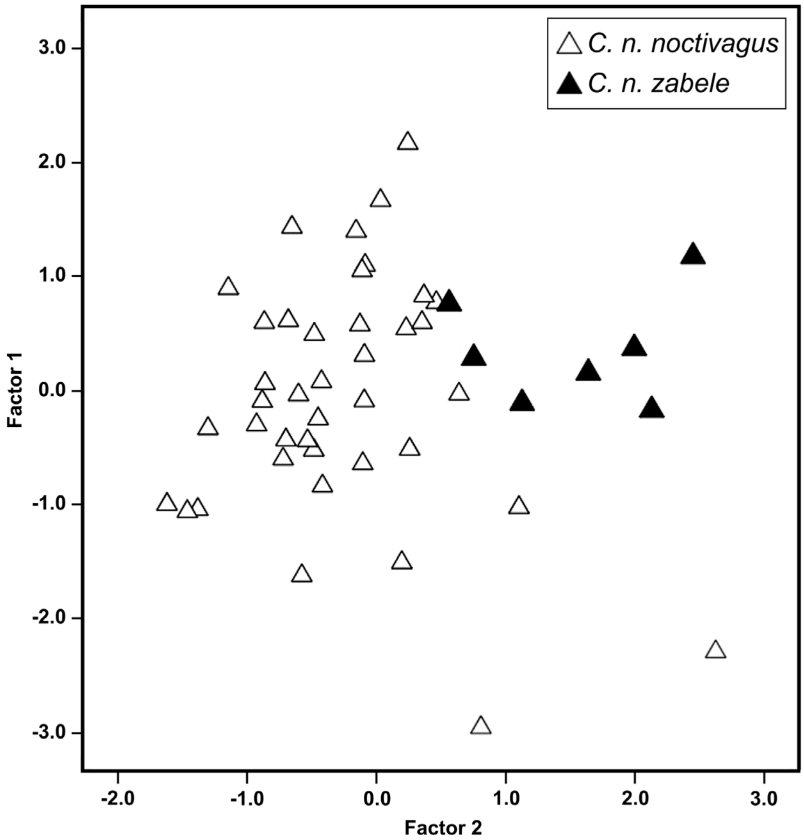

FIGURE 2. Results of the Principal Component Analysis (Eigenvalue: 66.8%), based on morphometrics (wing, tarsus, beak, wing streaks) of *Cryputrellus n. noctivagus* and *C. n. zabele* with each taxa represented by a different symbol.

Spectographic (sonogram) analysis did not show significant differences in the vocal characters analyzed (Table 4). Songs of both *C. n. noctivagus* and *C. n. zabele* consist of three to four notes with equally variable note and internote duration, as well as varied frequency and amplitude time (peak time) (Figure 3). The point of highest amplitude (peak time) can happen on the first or second note, and both patterns appeared in vocalizations of a single individual. Therefore, we analyzed peak time considering the mean of each individual, as was done for

TABLE 4. Mean, maximum and minimum values of each vocal character analyzed with p-values of Student *t*-test comparing the two taxa. Bandwidth is the maximum frequency minus minimum frequency, peak frequency is the frequency at the point of higher amplitude, and peak time is the point in time of highest amplitude (represented as a percentage of the total vocalization). Peak time was calculated for the mean of each specimen vocalizations and for grouped vocalizations in which the highest amplitude was in the first or second note. Not all sonograms allowed precise note distinction; therefore sample size varied for the analysis of note and internote duration.

Vocal character	Sample size	*Crypturellus n. noctivagus*			Sample size	*Crypturellus n. zabele*			*p*-value
		Mean (SD)	Max	Min		Mean (SD)	Max	Min	
Max Freq (Hz)	10	1112.79 (102.22)	1311.45	966	5	1003.38 (135.6)	1106.53	819.10	0.11
Min Freq (Hz)	10	429.78 (101.64)	592.5	291.45	5	413.04 (92.7)	550.98	298.40	0.70
Bandwidth (Hz)	10	683.01 (194.97)	1020	400.7	5	590.34 (211.32)	792.60	346.08	0.41
Peak Freq (Hz)	10	752.24 (72.6)	861.3	689.1	5	684.04 (52.47)	750	602.9	0.08
Total length (s)	10	1.46 (0.12)	1.65	1.34	5	1.44 (0.12)	1.56	1.28	0.67
1st note duration (s)	7	0.56 (0.06)	0.66	0.48	5	0.54 (0.14)	0.75	0.4	0.75
1st space duration (s)	7	0.13 (0.09)	0.26	0.02	5	0.21 (0.03)	0.25	0.18	0.06
2nd note duration (s)	7	0.24 (0.04)	0.29	0.19	5	0.25 (0.04)	0.30	0.19	0.56
2nd space duration (s)	7	0.07 (0.07)	0.21	0.02	5	0.03 (0.03)	0.07	0.00	0.23
3rd note duration (s)	7	0.29 (0.08)	0.4	0.16	5	0.21 (0.06)	0.28	0.15	0.09
3rd space duration (s)	5	0.04 (0.02)	0.07	0.01	4	0.06 (0.05)	0.11	0.01	0.43
4th note duration (s)	5	0.2 (0.08)	0.29	0.09	4	0.19 (0.04)	0.23	0.14	0.83
Peak time - mean (%)	10	27.63 (12.44)	51.33	11.91	5	38.46 (21.87)	61.59	12.82	0.23
Peak time - 1st note (%)	16	20.63 (7.2)	34.1	11.63	7	15.9 (6.78)	31.05	11.25	0.15
Peak time - 2nd note (%)	3	53.62 (12.1)	66.7	42.83	3	61.42 (0.38)	61.67	60.99	0.32

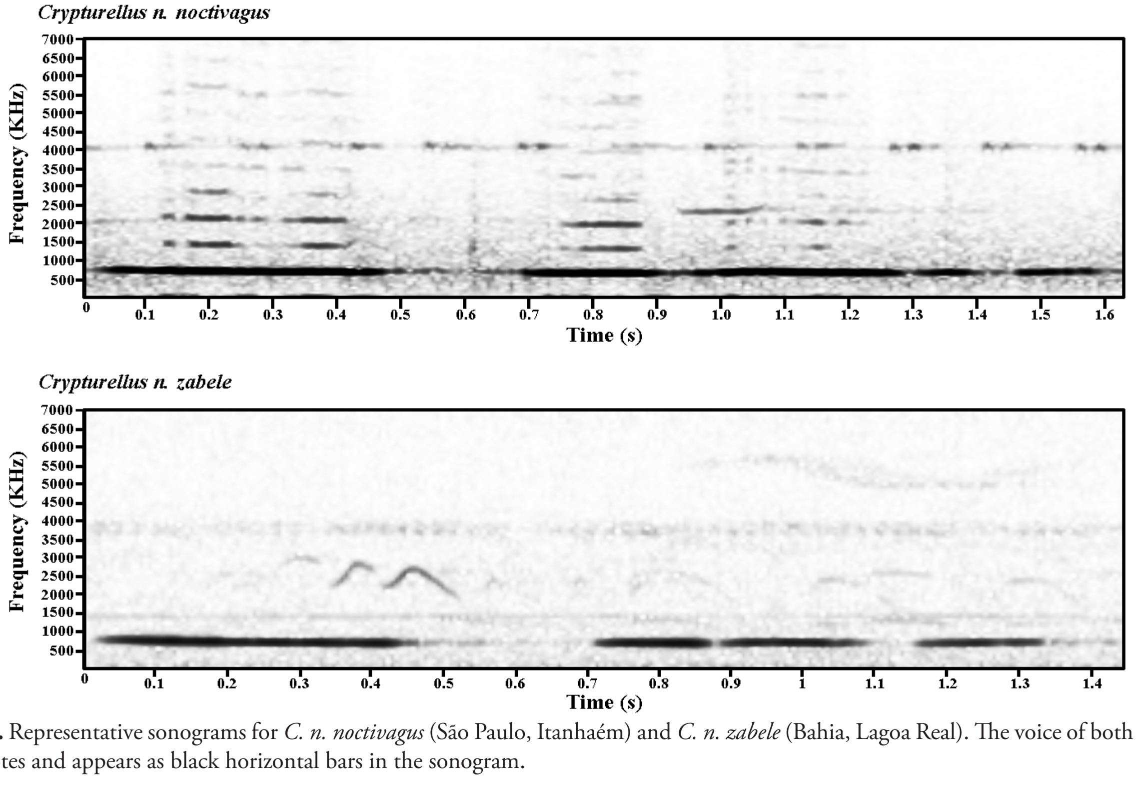

FIGURE 3. Representative sonograms for *C. n. noctivagus* (São Paulo, Itanhaém) and *C. n. zabele* (Bahia, Lagoa Real). The voice of both taxa consists in 3 to 4 notes and appears as black horizontal bars in the sonogram.

other characters, but we also measured it considering each vocalization, grouping vocalizations with the peak time in the first and second note, but significant differences were not found. However, *C. n. zabele* peak time seemed to occur slightly later than the peak time of *C. n. noctivagus*. The voice of *C. n. zabele* also seemed to have a slightly lower frequency than that found in *C. n. noctivagus*, but there was a great overlap between the two taxa.

Regarding distributions, the two taxa do not overlap. *Crypturellus n. zabele* is endemic to the Caatinga, also marginally inhabiting the Cerrado (Figure 4), and occurs in northeastern Brazil from Piauí to northwest Minas Gerais states, whereas *C. n. noctivagus* is endemic to the Atlantic Forest, occurring from Bahia to Rio Grande do Sul states (Figure 4). However, in the present, due to the severe deforestation of the Atlantic Forest, which resulted in its replacement by open, drier vegetation similar to the Caatinga, *C. n. zabele* distribution can be extended closer to the western limits of the nominate form in Espírito Santo and southern Bahia states.

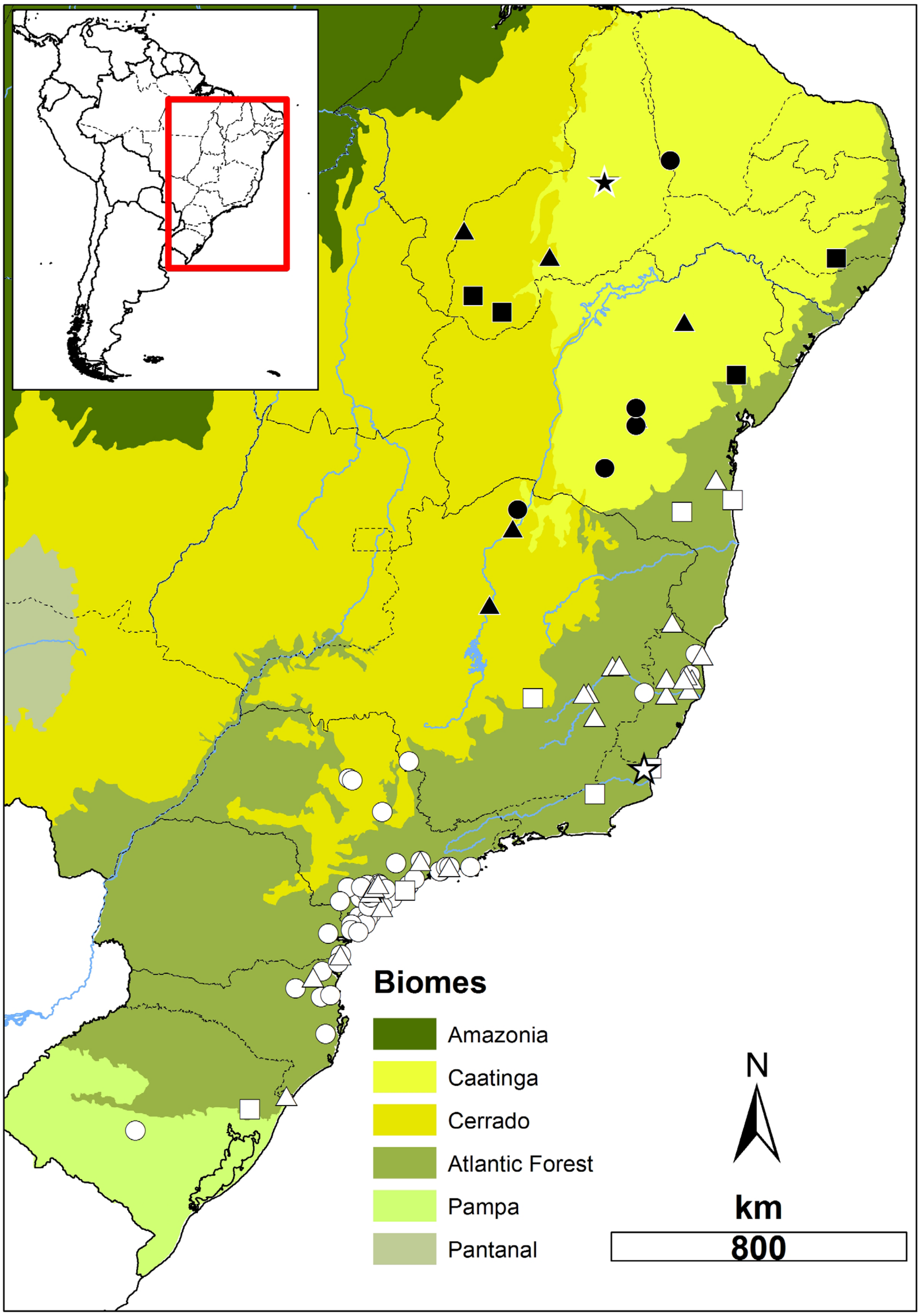

FIGURE 4. Distribution of *C. n. noctivagus* (open symbols), and *C. n. zabele* (closed symbols). **Triangles:** museum specimens (skins); **stars:** Type-localities; **circles:** recent records (literature, photos or vocal records); **squares:** historical records. Biomes according to IBGE & MMA (2004).

DISCUSSION

The overall plumage of *C. n. zabele* is paler than in *C. n. noctivagus* and they also differ in morphometric characters and egg shape and color. However the most striking differences appear when we compare the tarsus coloration and the females' breast plumage. These diagnostic characters are critical to the recognition of these taxa as two distinct, independent lineages, which must be considered as separated species under the Phylogenetic Species Concept.

The first description of a specimen from the *Crypturellus noctivagus* complex was provided by Wied (1820), who described *Tinamus noctivagus* (= *Crypturellus n. noctivagus*) based on a type specimen from Muribeca Farm, Itabapuana River, Espírito Santo state. It was characterized as possessing dark gray-reddish brown upper parts, reddish rust-brown lower back and rump, ashy gray lower neck and rusty-yellow bright brownish breast. The author did not mention tarsus color, and no plate accompanies his description. Five years later, Spix described *Pezus zabelé* (= *Crypturellus n. zabele*) based on a specimen from Oeiras, Piauí state. A plate accompanied the description, where the yellowish wing and tail bars, as well as the yellow legs, can be clearly seen (although the superciliary stripe is absent).

Several authors attempted to analyze these taxa such as Salvadori (1895) and Miranda-Ribeiro (1938), but Hellmayr & Conover (1942) provided the most accurate description to date, with the recognition of two forms: *C. n. noctivagus* and *C. n. zabele*. They noticed that while females of *C. n. zabele* had barred breasts, males of the same subspecies did not, so they recognized the existence of a sexually dimorphic character in this form. Hellmayr & Conover (1942) were unsure about their female analysis, having a single adult female, but our analysis with more specimens allow us to recognize the bars in female breasts as a diagnostic character of *C. n. zabele*. Hellmayr & Conover (1942) also pointed that *C. n. zabele* would be distinguishable from *C. n. noctivagus* due to several paler characters, wings more broadly barred with pinkish buff and distinctive superciliary stripes. We could recognize all these characters in our analysis, but most of them had a small degree of overlap with *C. n. noctivagus*.

Salvadori (1895) treated these two taxa as synonyms under the name *Crypturus noctivagus* and proposed that the species is sexually dimorphic: females were suggested to show more distinct wing barring than males, yellow buff and more barred rump and tail coverts, with the black bars wider and better defined than the chestnut ones, paler yellowish buff or rufescent upper tail covert bars, and more heavily barred flanks, with the brown-black bars extending from the flanks to the sides of the breast. However, Salvadori's description of the male corresponds to *C. n. noctivagus* while the female corresponds to *C. n. zabele* (Hellmayr & Conover 1942). Our data support the conclusions of Hellmayr & Conover (1942).

Miranda-Ribeiro (1938:739, 754) did not consider *C. n. zabele* as valid, but instead reported sexual dimorphism in *C. noctivagus*. He had at hand a very small series (five specimens), and his description of *Orthocrypturus noctivagus* includes characters found in both taxa. Miranda-Ribeiro (1938) indicated that females have a more ochre and distinct superciliary stripe, as well as a more ferruginous neck and upper breast than males. In *C. n. zabele*, the more ferruginous and barred upper breast does occur in females, instead of having the solid gray upper breast observed in females of *C. n. noctivagus*.

Further studies after Hellmayr & Conover (1942) did not expand or deepen the discussion over the taxonomic status of these tinamous. Pinto (1964), however, suggested possible sexual dimorphism in *C. n. noctivagus* based on the presence of black bars on the entire back, rump and tail coverts in females (in males, present mainly in the tail coverts). Nevertheless, according to our analysis, barred back and rump are found in both males and females. Pinto (1964) also mentioned a specimen (MZUSP 14031) as an intermediate form, here classified as a typical *C. n. noctivagus*.

A different explanation for the plumage differences of the two forms would be the Gloger's Rule. It indicates that darker plumage is associated with more humid habitats, and one can also argue that differences in habitat lighting condition can cause different plumage coloration in birds, such as red or orange in closed habitats (McNaught & Owens 2002). Indeed, the humid forest inhabitant *C. n. noctivagus* is darker in plumage than *C. n. zabele*, which inhabits the open, sunny Caatinga.

However, we noticed consistent diagnostic characters such as the tarsus color and the breast plumage of females, along with a distinct, non-overlapping distribution, and habitat preferences. Therefore, these taxa can be recognized as distinct species under the Phylogenetic Species Concept, and hereafter would be treated as such. The recognition of the two forms under the Biological Species Concept (BSC) is less evident. However, the presence of sexual dimorphism only in *C. zabele,* differences in eggs' color and shape, and absence of hybrids even in areas where the distribution of two taxa approaches suggests that these two closely related forms could be reproductively isolated and that could be also recognized as a full species under the BSC.

This revised taxonomic status may be important for future conservation efforts, including captive breeding and reintroductions. *Crypturellus noctivagus* is considered threatened in Brazil and also São Paulo, Paraná and Rio Grande do Sul states (Straube *et al.* 2004, Tomotani

2010, Corrêa *et al.* 2010, MMA 2014) and is probably extinct in Rio de Janeiro (Pacheco *et al.* 1996), with hunting and deforestation being the main causes for the population decrease. *Crypturellus zabele,* although still quite common in some national parks such as Serra das Confusões (Silveira & Santos 2012), is also threatened at national level (MMA 2014). We also speculate that the destruction of the Atlantic Forest in eastern Brazil, where it is being replaced by more open, secondary vegetation, could contribute for a south/eastward expansion of *C. zabele* in areas originally dominated by Atlantic Forest (and thus previously inhabited by *C. noctivagus*).

TAXONOMY

This section summarizes our taxonomic recommendation and provides revised diagnoses for the taxa involved.

Crypturellus noctivagus (Wied, 1820)

Tinamus noctivagus Wied 1820: 158 (footnote).

Crypturus noctivagus: Tschudi 1844: 307 (n. 277); Burmeister 1856: 320; Reinhardt 1870: 47; Salvadori 1895: 539.

Nothocercus noctivagus: Bonaparte 1856: 881.

Crypturellus noctivagus noctivagus: Peters 1931: 22; Pinto 1938: 8; Hellmayr & Conover 1942: 59; Pinto 1964: 09; Grantsau 2010: 15 (pl. 2).

Orthocrypturus noctivagus: Miranda-Ribeiro 1938: 754.

Holotype: AMNH 6740 (♂, Muribeca, Espírito Santo state; examined).

Common name

Portuguese (Brazil): *jaó-do-sul*. English: Yellow-legged Tinamou. *C. noctivagus* and *C. zabele* share the popular “Yellow-legged Tinamou” name, but only the latter show such coloration; *C. noctivagus* has olivaceous legs and the English name should be adjusted for this species.

Diagnosis

Distinguished from *C. zabele* by solid gray upper breast in females and olivaceous tarsus. Also generally darker and/or more reddish overall coloration than *C. zabele*, especially in the wing and tail covert bars, but also commonly seen in the abdomen and throat. Usually thinner wing covert light bars. Superciliary stripe usually smaller, thinner and less marked. Eggs more rounded and greenish than in *C. zabele*.

Re-description

Crown and nape until back black, dark reddish brown or dark grayish brown. Superciliary stripe variable in width and length, usually small; reddish brown, yellowish brown or pale colored. Throat color from pale to reddish brown. Upper portion of breast dark grayish brown, grayish brown or dark reddish brown. Lower portion of breast reddish brown or yellowish brown. Abdomen from reddish brown to yellowish brown or pale. Wing pattern: alternating black or dark reddish brown bars and reddish brown, yellowish brown or pale bars (pattern may uncommonly consist of non-distinguishable black or dark reddish brown and yellowish brown irregular markings and spots instead of defined bars). Tail coverts pattern: alternated black or dark reddish brown bars and reddish brown bars (same color as lower portion of rump). Males usually redder. Tarsus olivaceous. Eggs greenish.

Distribution

Atlantic Forest, from southern Bahia (coastal lowlands), Espírito Santo and eastern Minas Gerais to Rio Grande do Sul states. No specimen from Rio de Janeiro state was found in collections, but Pacheco *et al.* (1996) list the species for this state. The species is considered threatened in São Paulo and Paraná (Straube *et al.* 2004, Tomotani 2010), probably extinct in Rio de Janeiro (Pacheco *et al.* 1996) and was considered extinct in Rio Grande do Sul (Bencke *et al.* 2003), until the recent record in a gallery forest (Corrêa *et al.* 2010).

Examined material (n = 67)

Bahia: Gongogi River (MZUSP 14031 ♂). **Minas Gerais:** Mairinque (MZUSP 7792 ♀); Doce River, Governador Valadares (MNRJ 22340 ♂); Doce River, Baixo Suaçuí (MZUSP 24470 juvenile ♂, 24471 ♂, 24796 ♂, 24797 ♂, 24798 nd, 24799 nd, 24804 ♂); Doce River (right margin), Baixo Piracicaba (MZUSP 24466 ♀, 24467 ♂, 24468 ♂, 24469 ♀); Doce River (right margin) (MZUSP 24462 ♀, 24463 ♀, 24464 nd, 24465 ♂, 24800 ♂, 24801 ♀, 24802 ♂, 24803 ♂); Raul Soares (MNRJ 25489 ♂, 25490 ♂). **Espírito Santo:** Muribeca (AMNH 6740 ♂, holotype); Fazenda Boa Lembrança, Itaúnas River, Conceição da Barra (MNRJ 39739 ♂); Cupido, Linhares (MNRJ 26798 ♀, 26799 ♀); Córrego Cupido, Barra Seca River, Sooretama (MNRJ 39586 ♂); São José River (MZUSP 28054 ♂, 28055 ♀); São Domingos (MNRJ 19404 ♂); Linhares (MNRJ 26264 ♂); Rancho Fundo, Colatina (MNRJ 19402 ♀, 19405 juvenile ♀), not specified (AMNH 317184 ♂; MNRJ 19401 nd, 19403 ♂, 19406 nd). **São Paulo:** Varjão do Guaratuba (right margin) (MZUSP 43761 ♂); Ipiranga (MZUSP 49335 ♂); Iguape (AMNH 469092 ♂, 469093 nd; MZUSP 245 - 2 eggs); Barra das Corujas River (MZUSP 56384 ♀); Rocha, Ribeirão Fundo (MZUSP 49332 ♂, 49333 ♀, 49334 ♀, 2257 - 5 eggs); Ipiranga River, Tamanduá, Juquiá (MZUSP 47486 nd, 47487 nd); Primeiro Morro (MZUSP 49331 ♀); Fazenda Poço Grande, Juquiá River (MZUSP 24374 ♂, 24375 juvenile nd, 24376 juvenile nd, 24377 ♂, 24378 ♂). **Paraná:** Limeira, Serra da Prata, Guaratuba (MHNCI 4387 ♀). **Santa Catarina:** Colônia Hansa (MZUSP 1906 nd). **Rio Grande do Sul:** Lagoa do Morro do Forno, Dom Pedro de Alcântara (AMNH 313713 ♂, 313714 ♂); not specified (MZUSP 1955 – 1 egg).

Crypturellus zabele (Spix, 1825)

Tinamus noctivagus: Wied 1821: 111 (*non* Wied, 1820).

Pezus Zabelé Spix, 1825: 62 (pl. 77).

Crypturus noctivagus: Wagler 1827: 19, sp. 6; Tschudi 1844: 307 (n. 277); Burmeister 1856: 320; Forbes 1881: 360; Salvadori 1895: 539; Hellmayr 1906: 701.

Nothocercus noctivagus: Bonaparte 1856: 881.

Crypturornis noctivagus noctivagus: Hellmayr 1929: 477.

Crypturellus noctivagus noctivagus: Peters 1931: 22; Pinto 1935: 54; Pinto 1938: 8.

Orthocrypturus noctivagus: Miranda-Ribeiro 1938: 754.

Crypturellus noctivagus zabele: Hellmayr & Conover 1942: 60; Pinto 1964: 09; Grantsau 2010: 15 (pl. 2).

Holotype: ZSM unnumbered (♂, Oeiras, Piauí; examined). The original (Spix, 1825) reads "in limite sylvarum campestrium (Catingha)". Hellmayr & Conover (1942) suggested the type locality Oeiras.

Common name

Portuguese (Brazil): *zabelê*. English: Yellow-legged Tinamou.

Diagnosis

Distinguished from *C. noctivagus* by grayish barring on upper breast of females and by pure yellow tarsus. Also generally paler coloration than *C. noctivagus*, never so red; light bars on wing coverts broad; and more marked difference between color of tail covert bars (pale) and rump covert bars (reddish brown). Superciliary stripe usually broader, longer and more marked. Eggs bluish, apparently more elongated than in *C. noctivagus*.

Re-description

Crown and nape until back black, dark reddish brown or dark grayish brown. Superciliary stripe large and broad, yellowish brown or pale. Throat pale or yellowish brown. Upper portion of breast dark grayish brown or grayish brown in males; grayish bars in a reddish brown or yellowish brown background in females. Lower portion of breast reddish brown or yellowish brown. Abdomen yellowish brown or pale. Wing pattern: alternating black or dark reddish brown bars and large pale bars. Tail coverts pattern: alternating black or dark reddish brown and pale or yellowish brown bars (gradually darken and/or become redder until rump). Tarsus yellow. Eggs bluish.

Distribution

Mainly in Caatinga, from Piauí to northern Minas Gerais states, does not occur on coastal lowlands. Records from the literature indicate that the species was also found in Pernambuco state (Forbes 1881), however no specimen from this region was found in museum's collections.

Examined material (n = 17)

Piauí: Oeiras (ZSM no number ♂ holotype); Correntes (AMNH 240962 ♂, 240963 ♂, 240964 ♀); P.N. Serra das Confusões (MZUSP 77621 nd). **Bahia:** Vila Nova (MZUSP 7603 ♂, 7604 ♂, 7606 juvenile ♂, 183 - 4 eggs); Macaco Seco, Andaraí (FMNH 47486 ♂); not specified (AMNH 469094 ♀, 469095 nd). **Minas Gerais:** Gruta do Tatu - São Francisco (MNRJ 4510 nd); Rio São Francisco, Pirapora (MZUSP 8496 ♀).

Additional examined material

Without locality (n = 4): AMNH 185893; MNRJ 4509, 4511, 4512.

Captivity (n = 3): MHNCI 2024 nd; MNRJ 33187 juvenile nd, 39740 nd.

Vocalization (voc), photography (pho) and historical record (hr) examined for vocal analysis (^{v}) and/ or map confection (^{m}) with respective number of recording, author, year and source.

***Crypturellus noctivagus* (n = 24): Minas Gerais:** Rio Doce State Park (XC1223 voc^{vm}, Jones D. 1997, Xenocanto; XC85039 voc^{vm}, Minns J. 1997, Xenocanto); Lagoa dos Patos (hr^{m}, Salvadori 1895). **Rio de Janeiro:** Cantagallo (hr^{m}, Euler 1867 *apud* Hellmayr & Conover

1942). **São Paulo:** Bertioga (vocalization^{vm} from 2008 provided by Cavarzere V.); Cananéia (WA329285 voc^{m}, Souza M.J. 2010, Wikiaves); Carlos Botelho State Park (XC4902 voc^{m}, Planqué C. 2005, Xenocanto); Curucutu, Itanhaém (vocalization^{vm} from 2007 provided by Schunck F.); Eldorado (WA251118 voc^{m}, Kaseker E.P. 2010, Wikiaves) Ibiúna (WA504913 voc^{m}, Mervinskas M. 2011, Wikiaves); Guaratuba (WA105021 voc^{vm}, Kaseker E.P. 2010, Wikiaves); Pariquera-Açu (WA585083 pho^{m}, Souza M.J. 2012, Wikiaves) Peruíbe (WA551282 voc^{m}, Faitarone A. 2012, Wikiaves); Registro (WA482781 voc^{vm}, Sanches D. 2011, Wikiaves); São Sebastião (WA519772 voc^{vm}, Lopes B.J. 2011, Wikiaves); Sítio do Cervo, Miracatu (XC18996 voc^{vm}, Hirsch T. 2008, Xenocanto). **Paraná:** Guaraqueçaba (WA480308 voc^{vm}, Deconto L.R. 2011, Wikiaves); Guaratuba (WA576531 voc^{m}, Gussoni C. 2012, Wikiaves); Mãe Catira (XC92171 voc^{m}, Luijendijk T. 2011, Xenocanto) **Santa Catarina:** Blumenau (WA221952 voc^{m}, Legal E. 2009, Wikiaves); Ilhota (WA484960 voc^{m}, Encarnação J. 2011, Wikiaves); Reserva Volta Velha, Itapoá (XC28292 voc^{vm}, Patrial E. 2008, Xenocanto). **Rio Grande do Sul:** Arroio Grande, near Taquara (hr^{m}, Berlepsch & Ihrering, 1885 *apud* Hellmayr & Conover, 1942); São Sepé (WA533224 pho^{m}, Corrêa L.L.C. 2011, Wikiaves); Taquara do Mundo Novo (hr^{m}, Berlepsch & Ihrering, 1885 *apud* Hellmayr & Conover, 1942).

Crypturellus zabele **(n = 11):** Piauí: Gibués (hr^{m}, Hellmayr & Conover 1942) Parnaguá (hr^{m}, Hellmayr & Conover 1942). Ceará: RPPN Olho D'água do Urucu, Parambu (XC13536 voc^{vm}, Albano C. 2007, Xenocanto). Pernambuco: Garanhuns (hr^{m}, Forbes 1881). Bahia: Boqueirão, Rio Pardo (hr^{m}, Wied 1821); Lagoa Real (XC40027 voc^{vm}, Albano C. 2009, Xenocanto); Lamarão (hr^{m}, Hellmayr & Conover 1942) Lençóis (XC15592 voc^{m}, Athanas N. 2007, Xenocanto); Mucugê (XC82085 voc^{vm}, Santos S.S. 2003, Xenocanto). Minas Gerais: Cavernas do Peruaçu National Park (XC11923 voc^{vm}, Beadle D. 2002, Xenocanto; XC85041 voc^{vm}, Minns J. 2002, Xenocanto).

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ARTICLE

Olive-sided Flycatcher, *Contopus cooperi*, in the Cerrado biome, and a review of records in Brazil

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ABSTRACT: The Olive-sided Flycatcher, *Contopus cooperi* (Nuttall, 1831), is a long distance migrant bird from North America. This Tyrannidae bird has wintering areas in Central and South America, and such as other long distance migrants, has decreased their populations, probably due to the use of pesticides, which in turn decrease the abundance of aerial insects, their main food supply. Little is known about the wintering distribution range of the species, mainly in South America. In Brazil its known distribution includes 11 states and 36 municipalities at the Amazon and Atlantic Foresst, occurring between October and April. This study reviews the distribution area of this species in Brazil, reporting for the first time, its occurrence in the Goiás state and the Cerrado biome.

KEY-WORDS: geographical distribution, migratory bird, North American migrant, occurrence.

The Olive-sided Flycatcher, *Contopus cooperi* (Nuttall, 1831), is a passerine bird, seasonal visitor originated from the northern hemisphere (Piacentini *et al.* 2015). It is known for long migration and wide distribution, with breeding grounds located in the boreal forests of Canada and Alaska mountains, moving southward to Central America and Mexico toward South America (Kotliar 2007). During the boreal winter this species holds its wintering territories in Central and South America (NatureServe 2015).

In Brazil the best-known seasonal occurrence is during the austral summer, between October and March (Sick 1997). Recent records report their presence after the austral summer, during April, in the states of Rio de Janeiro, São Paulo and Pará (Antunes & Pereira 2014, Coquetti 2014, Joel & Girotto 2014, Junqueira 2016). Among Brazilian records, one was on transitional environments between Amazon and Cerrado (Santos 2012). Table 1 summarizes all records found during the review and Figure 1 shows their respective locations.

The oldest record of *C. cooperi* in Brazil was provided by Pinto (1944) in the summer of 1937 at Amazon. The Amazon region contains the highest number of records of this species in the country, reported in 22 cities and 6 states. Otherwise, in the Atlantic Forest the oldest record of this species was in São Paulo state in 1983 (Willis *et al.* 1993). In this biome its occurrence covers 14 municipalities and 5 states.

During the present study, on 12 March 2012, at 7:44 h, a *C. cooperi* specimen was observed in rural areas in the municipality of Barro Alto, on the border with the municipality of Santa Rita do Novo Destino, Goiás state (15°3'54.94"S; 49°0'47.63"O; 1,141 m.a.s.l., Figure 1). The specimen was alone, roosted on an exposed branch in the forest canopy edge in vegetation mosaic composed of gallery forest with large waterfall and slope areas of hills, *cerradão* and grasslands. The identification of the specimen in the field was based especially in contrasting white plumage on the flanks, less evident in other congeneric species, and the solitary habit of landing upright on branches exposed on top of tall trees, edge of forests and half open fields, in order to facilitate their foraging strategy of preying insects in flight (COSEWIC 2007, Gwynne *et al.* 2010, Robertson 2012, Sigrist 2013). The photographic records performed *in situ* were listed in the Image Bank Acquis FaunaCO program in the Laboratory of Biogeography, Universidade Federal de Goiás, UFG-GO (Figure 2). Based on published studies, no previous record had been documented for the Goiás state. Thus, this is probably the first record of *C. cooperi* for the Goiás state and the Cerrado biome.

TABLE 1. Records of occurrence of *Contopus cooperi* in Brazil.

Brazilian Biomes	State	City	Place of occurrence	Date	Reference
Amazon	Roraima	Mucajaí	Colonia Apiau	30 Sep to 10 Oct 1987	Stotz *et al*. 1992
		Pacaraima	uninformed	18 Nov 2012	Laranjeiras *et al*. 2012
Amazon	Amapá	Oiapoque	Cabo Orange National Park	between Dec 1995 and Sep 2006	Souza *et al*. 2008
Amazon	Amazonas	Itacoatiara	uninformed	31 Mar 1937	Pinto 1944
		Presidente Figueiredo	Balbina Dam	26 Oct to 19 Mar, between 1979 and 1991	Stotz *et al*. 1992
			Biological Dynamics of Forest Fragments Project (BDFFP), INPA, 41 Km.	25 Jan 2011	Leite 2011
		Rio Preto da Eva	uninformed	21 Jan 1993	Pacheco 1993
		Autazes	uninformed	24 Oct 2013	Malacco 2013
		Manaus	Fazendas Dimona, Porto Alegre, and Esteio. Biological Dynamics of Forest Fragments Project (BDFFP) of INPA.	between 1979 and 1994	Cohn-Haft *et al*. 1997
			uninformed	10 Jan and 12 Dec 2010	Daffonseca 2010
			Tropical Silviculture Experimental Station of INPA, ZF-2, 45 km, BR-174	12 Jan 2011	Deconto 2011
			uninformed	27 Dec 2013	Cohn-Haft 2013
			uninformed	18 Jan 2014	Daffonseca & Pinheiro 2014
			uninformed	20 Nov 2014	Trondle 2014
			uninformed	10 Oct 2015	Czaban & Souza 2015
			uninformed	26 Dec 2015	Cordasso & Czaban 2015
Amazon	Acre	Rio Branco	Reserva Extrativista Chico Mendes	between 2005 and 2008	Mestre *et al*. 2010
		Mâncio Lima	uninformed	6 Dec 2012	Guilherme 2012
Amazon	Pará	Parauapebas	uninformed	between 1991 and 2006	Pacheco *et al*. 2007
			uninformed	9 Dec 2008	Malacco & Alteff 2008

Brazilian Biomes	State	City	Place of occurrence	Date	Reference
			uninformed	10 Nov 2010	Endrigo 2010
			uninformed	10 Dec 2012	Aguiar 2012
			uninformed	10 Apr 2014	Joel & Girotto 2014
			uninformed	3 Nov 2014	Filho 2014
			uninformed	10 Oct 2015	Fonseca 2015
		Novo Progresso	uninformed	16 Nov 2008	Davis 2008
		Goianésia do Pará	uninformed	20 Nov 2013	Moura 2013
		Anapu	uninformed	4 Feb 2015	Junqueira & Lara 2015
			uninformed	10 Apr 2016	Junqueira 2016
		Vitória do Xingu	uninformed	5 Mar 2016	Castilho 2016
Amazon	Mato Grosso	Alta Floresta	uninformed	30 Oct 1989	Willis *et al.* 1993
			Cristalino Jungle Lodge	2 and 3 Nov 2015	Coelho *et al.* 2015
			Cristalino Jungle Lodge	21 Nov 2015	Figueiredo & Borges 2015
		Cotriguaçu	uninformed	28 and 29 Jan 2012	Rennó 2012
Amazon and Cerrado		Comodoro	uninformed	12 Feb 2012	Santos 2012
Amazon		Marcelândia	uninformed	08 Nov 2012	Hobus 2012
		Apiacás	Fazenda Boca da Onça	17 Nov 2013	Ferreira & Guglielmino 2013
			Fazenda Boca da Onça	20 Nov 2013	Martins *et al.* 2013
		Paranaíta	uninformed	2 Feb 2013	Oliveira 2013
			uninformed	4 Feb 2013	Fernandes 2013
			uninformed	21 Mar 2014	Castro 2014
			uninformed	2 Feb 2016	Cristina 2016
		Aripuanã	uninformed	27 Dec 2015	Veronese & Cena 2015

Brazilian Biomes	State	City	Place of occurrence	Date	Reference
Atlantic Forest	São Paulo	Salesópolis	Boractia Biological Station, Serra do Mar State Park	27 Nov 1983	Willis *et al.* 1993
		Guapiara	Intervales State Park, Serra do Paranapiacaba	14 Feb; 3 and 4 Mar 1987	Willis *et al.* 1993
		Ubatuba	Agricultural Experiment Station and Fazenda Capricomio	16 and 18 Mar 1990	Willis *et al.* 1993
		São Sebastião	Alcatrazes Archipelago	1 Nov 1992	Muscat *et al.* 2014
		Tapiraí	Serra do Paranapiacaba	8 and 9 Dec 2014	Fernandes & Bucci 2014
		Pindamonhangaba	uninformed	6 Apr 2014	Coquetti 2014
			uninformed	17 Jan 2015	Bucci *et al.* 2015
			uninformed	25 Jan 2015	Oberhuber *et al.* 2015
			uninformed	1 Feb 2015	Silveira 2015
Atlantic Forest	Rio de Janeiro	Itatiaia	Itatiaia National Park, Serra da Mantiqueira	30 Nov; 2 Dec 1986	Parker-III & Goerck 1997
		Sapucaia	uninformed	20 Mar 1988	Pacheco *et al.* 1996
		Paraty	uninformed	10 Nov 1990; 10 Mar 1994; 3 Feb 2001	Pacheco *et al.* 1997; Browne 2005
		Angra dos Reis	uninformed	27 Dec 2011	Camacho & Serpa 2011
		Nova Friburgo	uninformed	19 and 20 Apr 2014	Antunes & Pereira 2014
Atlantic Forest	Bahia	Camacan	uninformed	7 Dec 2012	Albano 2012
Atlantic Forest	Espírito Santo	Vargem Alta	uninformed	15 Jan 2016	Magnago 2016
Atlantic Forest	Paraná	Fernandes Pinheiro	uninformed	23 Nov 2014	Klosovski 2014

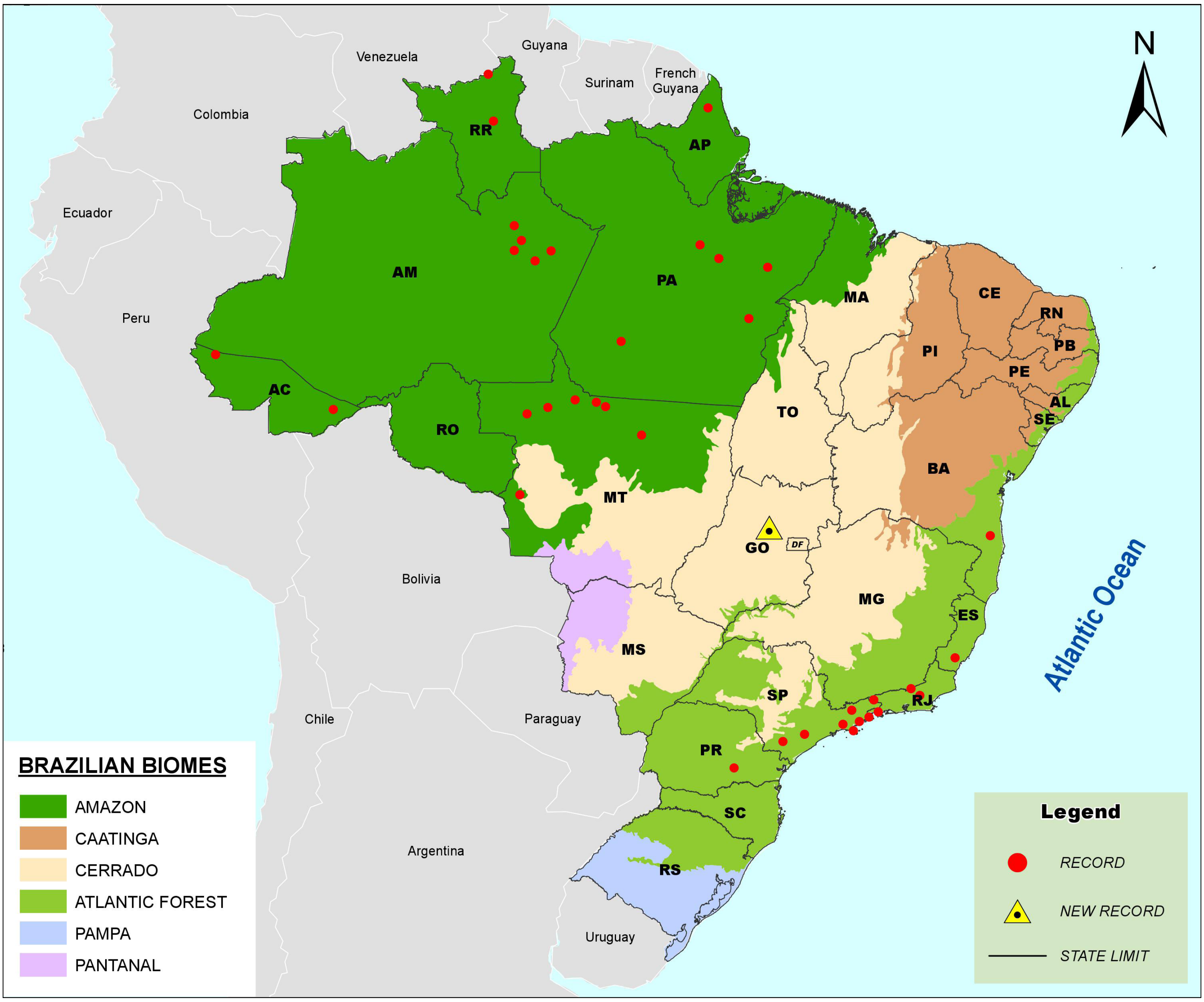

FIGURE 1. Localities of occurrence of *Contopus cooperi* in Brazil. Red circles: localities of occurrence reviewed for the present study (Table 1). Yellow triangle: new record obtained during the study.

FIGURE 2. **(A)** *Contopus cooperi* photographed at a distance on 12 March 2012, between the cities of Santa Rita do Novo Destino and Barro Alto, Goiás state, Brazil; **(B)** alert behavior due to approaching of the observer; **(C)** close up photo of the individual, after approaching. Photos: Karla Pereira.

This is a species of concern and international interest for conservation, currently classified as "near threatened" by extinction (Altman & Sallabanks 2012, IUCN 2015). Its population decline may be associated with loss or degradation of its wintering habitats. However, the causes of these declines have not been clearly established, as the species has been recorded in disturbed habitats (Altman & Sallabanks 2012). Another possible cause of the decline may be food dependency of this species on flying insects. North American aerial insectivorous birds and long distance migrants are showing declining populations, probably associated with pesticide use (Nebel *et al.* 2010, Altman & Sallabanks 2012, NatureServe 2015). In particular, organochlorine pesticides are still widely used in Central and South America (Nebel *et al.* 2010). This may have a direct effect on mortality of this specific group of birds, as the pesticides directly affect their food supply (Nebel *et al.* 2010, Altman & Sallabanks 2012).

The current record in Central Brazil could be due to the expansion of wintering areas of *C. cooperi* in Brazil, or a resting place during migration to the northern hemisphere. In this sense, the record of this individual in the Goiás state contributes to increase knowledge about the migration of this species in Brazil. With this new record, the distribution area of *C. cooperi* in Brazil now includes 12 states and 37 municipalities in the Amazon biome, the Cerrado and Atlantic Forest.

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SHORT-COMMUNICATION

Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil

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ABSTRACT: This paper describes three records evidencing the presence of Harpy Eagle (*Harpia harpyja*) in Turvo State Park, Rio Grande do Sul, Brazil. Besides an historical record showing a picture of a young Harpy Eagle shot in the 1970's in the surroundings of Turvo State Park, we also describe two recent records made inside the park. One of them was visual, made at the Yucumã Waterfalls in 2011 by the Argentinean park ranger V. Matuchaka. The other one, documented by a picture, was made by D.A.M. in March 2015 next to a remote valley of the park. These records proof the Harpy Eagle still occurs in Rio Grande do Sul state and highlights the project of Panambi's Hydroelectric should be redesigned to minimize impacts on the area of Turvo State Park.

KEY-WORDS: Atlantic Forest, Panambi Hydroeletric, raptors, Turvo State Park, Yucumã Waterfalls.

From physical aspect the Harpy Eagle, *Harpia harpyja* (Linnaeus, 1758) is the most formidable raptor in the world (Brown & Amadon 1968). It is highlighted as the most powerful aerial hunter in tropical forests of new world, hunting arboreal mammals as big as capuchins (*Cebus*) and howlers (*Alouatta*) monkeys (Peres 1990, del Hoyo *et al.* 1994). The species inhabits lowland forests, ranging from southern Mexico south to eastern Bolivia, southern Brazil, and extreme northern Argentina (Brown & Amadon 1968). Besides its wide distribution, the Harpy Eagle has disappeared from large parts of its former range; in Brazil, it is reasonably common only in Amazonia, being very rare or even extinct elsewhere (del Hoyo *et al.* 1994, Sick 1997, Soares *et al.* 2006).

Recent records (after 1980) of Harpy Eagle in the Brazilian Atlantic Forest are scarce and now restricted to the large remaining forests, which are also scarce. Most of these records are from the states of Bahia and Espírito Santo (Galetti *et al.* 1997, Pacheco *et al.* 2003, Silveira *et al.* 2005, Srbek-Araujo & Chiarello 2006, Vargas *et al.* 2006, Sánchez-Lalinde *et al.* 2011, Aguiar-Silva *et al.* 2012, Novaes *et al.* 2010), but there are also records for the states of Minas Gerais, Rio de Janeiro and São Paulo (Galetti *et al.* 1997, Marigo 2002, Pacheco *et al.* 2003, Vargas *et al.* 2006). In southern Brazil there are a few recent records, and they are restricted to the states of Paraná and Santa Catarina (Albuquerque 1995, Scherer-Neto & Ribas 2004), without any recent confirmed observation for Rio Grande do Sul. Most recent records for southern Atlantic Forest comes from Misiones, Argentina, where there are also observations of nests (Anfuso *et al.* 2008, Chebez 2008).

In Rio Grande do Sul (RS) there are six historic records of Harpy Eagle known in the literature. They consist of six specimens which were shot in the state before 1940, which are now deposited in different museums of RS and Santa Catarina (Bencke *et al.* 2003, Favretto 2008). The actual occurrence of Harpy Eagle in RS was speculated both by Belton (1994) and Bencke *et al.* (2003), who suggested the mostly appropriated area for encounters would be the Turvo State Park ("Parque Estadual do Turvo" - PET), in Derrubadas municipality. These assumptions were mostly based on Misiones records, where there are records in areas next to PET (Chebez 2008). Moreover, there are some doubtful observations in PET as well (Guadagnin & Menegheti 1994, Bencke *et al.* 2003). However, the lack of confirmed records makes the Harpy Eagle to be regarded as extinct for long time in RS.

We have reported three records of Harpy Eagle in PET, one historical and two recent[1], confirming its actual occurrence in RS. The first one comes from an event occurred in the surroundings of PET, where a young Harpy Eagle was shot by dwellers in the locality of Desimigrados, in Derrubadas municipality (27°15'S; 53°54'W) in the 1970's (Figure 1). This fact is well known by the elders living in Derrubadas, once a note was published in a local journal named "Jornal da Terra", in Tenente Portela municipality (N. Martens, pers. comm.). We gathered the details of this record and the photo, but we could not find the original note. The second record was made on 31 January 2011 in PET, when a Harpy Eagle was perched by the morning in an *Apuleia leiocarpa* aside the Yucumã Waterfalls, in the Brazilian side of the Uruguay River (27°8'S; 53°53'W). This record was based only on visual observations, made by an Argentinean park ranger with experience on the local avifauna, who described the bird as a probable female, due to its huge size (V. Matuchaka, *in litt.*). The third record was made by D.A.M. in 23 March 2015, when an adult Harpy Eagle, probably a male, was observed and photographed also at an *Apuleia leiocarpa* (Figure 2). The bird was perched aside the road that takes to Salto do Yucumã Waterfalls, inside PET (27°12'S; 53°51'W). It was observed for a few minutes before it flew off into the direction of a valley in one of the most remote areas of PET.

The Harpy Eagle is the largest raptor in the forests of South America. Nonetheless, its presence is hard to be detected, due to its secretive behavior (Thiollay 1989, Seipke & Cabanne 2002, Soares *et al.* 2006). Different from other raptors, the Harpy Eagle rarely soars, flying mostly below the canopy (Brown & Amadon 1968, Ferguson-Lees & Christie 2001). This is why traditional methods of surveying birds of prey do not work with Harpy Eagles, and could explain its absence in raptors surveys made in PET by Meller (2011). Although the Harpy Eagle can be hard to find, it is occasionally conspicuous while sunbathing on exposed perches in early morning (Thiollay 1989, del Hoyo *et al.* 1994). The record from 2011 could be made at this condition, but the observer also related that there was a great abundance of birds in the bed of the Uruguay River, because the level of the water was decreasing fast in response to hydroelectric operation (V. Matuchaka, *in litt.*). Thus, the Harpy Eagle could be still-hunting from the tree. This still-hunting behavior was already observed by D.A.M. for the Ornate Hawk-Eagle (*Spizaetus ornatus*) in the area of Yucumã Waterfalls at similar conditions (D. A. M., pers. obs.). The 2015 record was made just before

FIGURE 1. A young *Harpia harpyja* shot in the 1970's in the surroundings of Turvo State Park, Derrubadas, Rio Grande do Sul state, Brazil. Image provided by A. Biguelini.

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[1] After the paper was issued, the Harpy Eagle was seen again in Turvo State Park in 26 June 2016 by D.A.M. and Ataiz C. de Siqueira. The eagle - probable a male - was flying slowly over the canopy forest and then perched on a tree aside the road that leads to Salto do Yucumã Waterfalls, in a place known as "Cascalho" (27°11'26"S; 53°50'39"W). At the time the eagle perched, some Black-horned Capuchins started to produce aggressive sounds. Soon the eagle flew off and was not seen anymore. This is the fourth confirmed record of the Harpy Eagle inside the Turvo State Park.

FIGURE 2. An adult *Harpia harpyja* photographed on 23 March 2015 at Turvo State Park, Derrubadas, Rio Grande do Sul state, Brazil. Photo: D. A. Meller.

sunset, and the eagle apparently was still-hunting Azara's Agouties (*Dasyprocta azarae*), which were noising on the forest ground. In Misiones, Argentina, Opossums (*Didelphis* spp.), Tayras (*Eira barbara*) and Hairy Dwarf Porcupines (*Coendou spinosus*) are known prey of the Harpy Eagle (del Hoyo *et al.* 1994). Also Black-horned Capuchins (*Sapajus nigritus*) have been reported (Anfuso *et al.* 2008). All these mammals are found in PET, and some of them are quite common (Kasper *et al.* 2007, D.A.M., pers. obs.). Nevertheless, hunting pressure that occurs in PET may affect prey populations on which the Harpy Eagle bases its diet (Thiollay 1989, del Hoyo *et al.* 1994, Bencke *et al.* 2003, Silva *et al.* 2005).

Even though the presence of the Harpy Eagle in PET was long expected, these are the first confirmed records ever made. However, two doubtful records in literature could also be of Harpy Eagle. One was made by E. Albuquerque, who reported an observation in 1982, in the Yucumã Waterfalls (Guadagnin & Menegheti 1994, E. Albuquerque, *in litt.*). This record could be questioned because it describes two Harpy Eagles flying at high altitude (see Guadagnin & Menegheti 1994). Other records that describe similar behavior were those reported by Albuquerque (1995) at Serra do Tabuleiro, in Santa Catarina. Although unusual, and even questionable, this could be a behavior presented by the species in rare occasions. In the interactive website dedicated to the Brazilian community of birdwatchers (www.wikiaves.com.br) there is at least one picture showing high soaring behavior. The record made in Bodoquena, Mato Grosso do Sul, by M. Martins (catalogue number 1369622) shows an adult Harpy Eagle apparently soaring at fairly high altitude (Martins 2014). The other doubtful record made in PET is from a nest in a remote place inside the park, observed by the park ranger I. dos Santos in the 1980's (Guadagnin & Menegheti 1994, Bencke *et al.* 2003, I. dos Santos, pers. comm.). There are at least four other reports made by local people, which we treated as uncertain and do not present here, understanding that anyone without the proper knowledge and equipment (binoculars) may not recognize the different forest eagles that occur in the area.

According to Soares *et al.* (2006), and now including PET, the Harpy Eagle has recent records in 18 areas in the Brazilian Atlantic Forest. In addition, these authors also consider the possibility of being found in Iguaçu National Park, Paraná. Bierregaard-Jr. (1995) observes that the Harpy Eagle could have some local populations in decline, and the main reasons are hunting and deforestation (del Hoyo *et al.* 1994). This probably explains the critical situation that Harpy Eagle faces in Atlantic Forest nowadays. The species became so rare that the only recent documented records are from Espírito Santo, Bahia and Misiones, Argentina (Anfuso *et al.* 2008, Chebez 2008, Sánchez-Lalinde *et al.* 2011, Aguiar-Silva *et al.* 2012). In this context, the picture made in 2015 in PET is unprecedented for southern Brazil. The first two records reported by us were given to the process of revision of threatened fauna in RS, which converted the status of Harpy Eagle from "probably extinct" to "critically endangered" (FZB 2013). The Harpy Eagle shot in the 1970's reminds other historical records of Harpy and Crested Eagle *Morphnus guianensis* (Daudin, 1800) in RS (Bencke *et al.* 2003), where young and inexperienced birds were close to proprieties, probably trying to hunt domestic animals. This could be a threat for the species in the future, especially if it is nesting in the area. The supposed Harpy Eagle nest found in the 1980's was at a different place, but in the same valley in which the bird recorded in 2015 flew into. Not far from this place, there are some slopes with the same characteristics of the known nests of Harpy Eagles in Misiones, Argentina, and also similar to the one found in PET in the 1980's. In general, the nests in Misiones were at the lower slopes of deep valleys facing southward (E. Krauczuk, *in litt.*). Therefore, if the species is really nesting in PET, it could be expected that immature birds wandering in search of territories could reach the edge of the park. Educational programs should be conducted in the region to prevent Harpy Eagles to be killed by dwellers.

The presence of Harpy Eagle indicates once more the relevance that PET has in conserving biodiversity in RS, as the species can only be found in well preserved areas. The species is considered to be even more demanding than jaguars (Chebez 2008), which are also present in the area (Kasper *et al.* 2007). The probably reason to the Harpy Eagle still be found in PET is the connection that this park has with the large forests of Misiones, Argentina. Together with Misiones and Iguaçu National Park, PET is included in an area which has about one million ha of well-preserved forests (Bencke *et al.* 2006). Aside to PET is the Yabotí Biosphere Reserve, which in spite of being a large continuous forest, much of its area are private proprieties, allowing selective logging (Bodrati *et al.* 2005, Anfuso *et al.* 2008). This kind of exploitation tends to scarce emergent trees, which include the ones used by Harpy Eagles for nesting. Most nests studied in Misiones were built in trees of the species *Enterolobium contortisiliquum*, and one was in a *Tabebuia heptaphylla* (Chebez 2008). The tree of the supposed Harpy Eagle nest in PET was a *Cordia trichotoma* (I. dos Santos, pers. comm.). Some of these emergent trees not only are used for nesting, but also characterize the kind of canopy that Harpy Eagles requires. Because PET is not under logging since 1948 (Silva *et al.* 2005), the habitat could be more appropriated for the species that some areas of Yabotí Reserve (E. Krauczuk, *in litt.*). This is why the species could occupy temporarily or even be resident at PET.

The project of Panambi's Hydroelectric continues to be a threat for PET (Bencke *et al.* 2006). At the quota of 130 m the project assumes to flood important areas of the park and disconnect its forests from those of Misiones. Because it will cause loss of habitat and isolation of PET from Yabotí Biosphere Reserve, we consider this the most imminent threat to the survival of Harpy Eagle in RS. Impacts would affect not only the Harpy Eagle itself, but also its prey. Thus, the project must be redesign in a quota that Panambi's Hydroeletric does not reach PET, other way its implementation could account for the extinction of the Harpy Eagle in RS.

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SHORT-COMMUNICATION

A new southern limit for the distribution of the Thrush-Like Wren, *Campylorhynchus turdinus* (Aves: Troglodytidae)

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ABSTRACT: We report the first record of the Thrush-like Wren *Campylorhynchus turdinus* (Wied, 1831) in the Rio Grande do Sul state, at the city of Santa Maria, Brazil. The record, in which the individual vocalized and changed its perch constantly, was held on April 2015. We extend the known distribution range of the *C. turdinus*, and establish a new southern limit for its geographic distribution, approximately 460 km from the previous record in Paraná. For the state of Rio Grande do Sul, Helmut Sick reported the presence of the *C. turdinus* in 1972. However, the occurrence was considered hypothetical because did not agree with its distribution pattern. Therefore, our record of *C. turdinus* for the state of Rio Grande do Sul update the list for this state.

KEY-WORDS: Brazil, occurrence, record, Rio Grande do Sul.

The Thrush-like Wren, *Campylorhynchus turdinus* (Wied, 1831), is a polytypic species of Troglodytidae distributed across Argentina, Bolivia, Colombia, Ecuador, Peru, Paraguay and Brazil (Ridgely & Tudor 1994, review in Sick 1997, Narosky & Yzurieta 2003, Sigrist 2009). In Brazil, the Thrush-like Wren occurs at higher altitudes in humid forests throughout western Amazonia as well as in a strip of Atlantic coastal forest in Brazil (Ridgely & Tudor 1994, review in Sick 1997, Sigrist 2009). The only record in southern Brazil was in the state of Paraná (Bencke *et al.* 2008). However, after observing one individual in the wild, we confirm the presence of this species in Rio Grande do Sul, the southernmost state in Brazil. Therefore, we extend the known distribution range of the *C. turdinus*, and establish a new southern limit for its geographic distribution, approximately 460 km from the record in Paraná.

The current *C. turdinus* record occurred on 26 April 2015, in the urban area of Santa Maria city (29°40'25"S; 53°47'52"W). Santa Maria is located in an ecotone area, surrounded southwards by the Pampa Biome and northwards by the Atlantic Forest Biome (Marchiori 2009, IBGE 2016). The region where the bird was photographed is located in the northeastern urban zone of the city, bordering hills of part of the slope of the Plateau of Rio Grande do Sul. It belongs to the hydrological basin of the Jacuí River, and is mainly covered by secondary Semidecidual Seasonal Forest (Marchiori 2009).

The observed individual (Figure 1) vocalized and changed its perch constantly. It was observed together with an individual of Southern House Wren, *Troglodytes musculus* (Naumann, 1823), both moving through tree branches. It was also sighted under attack by a House Sparrow, *Passer domesticus* (Linnaeus, 1758).

For the state of Rio Grande do Sul, Helmut Sick recorded the presence of the *C. turdinus* (in Belton 1994). However, Bencke *et al.* (2010) mentioned the occurrence of the *C. turdinus* in Rio Grande do Sul as hypothetical, given that it was based on unreliable information, and noted that its occurrence did not agree with its distribution pattern (Bencke *et al.* 2010). In 2008, individuals of the *C. turdinus* were observed in the state of Paraná (Bencke *et al.* 2008). According to Bencke *et al.* (2008), sighting at western Paraná was not unexpected, given that Rey & Zurita (2004) recorded specimens in the province of Misiones, Argentina, which borders the state of Paraná. We hypothesize that the distribution of *C. turdinus* varies in its southern region, as attested by reports of the species from western Paraná. However, it was expected that the first current records of the Thrush-like Wren would occur in northwestern Rio Grande do Sul, *e.g.* at the Turvo State Park. This Park, whose forest is connected to that

FIGURE 1. Thrush-Like Wren, *Campylorhynchus turdinus*, photographed at Santa Maria, Rio Grande do Sul state, on 26 April 2015.

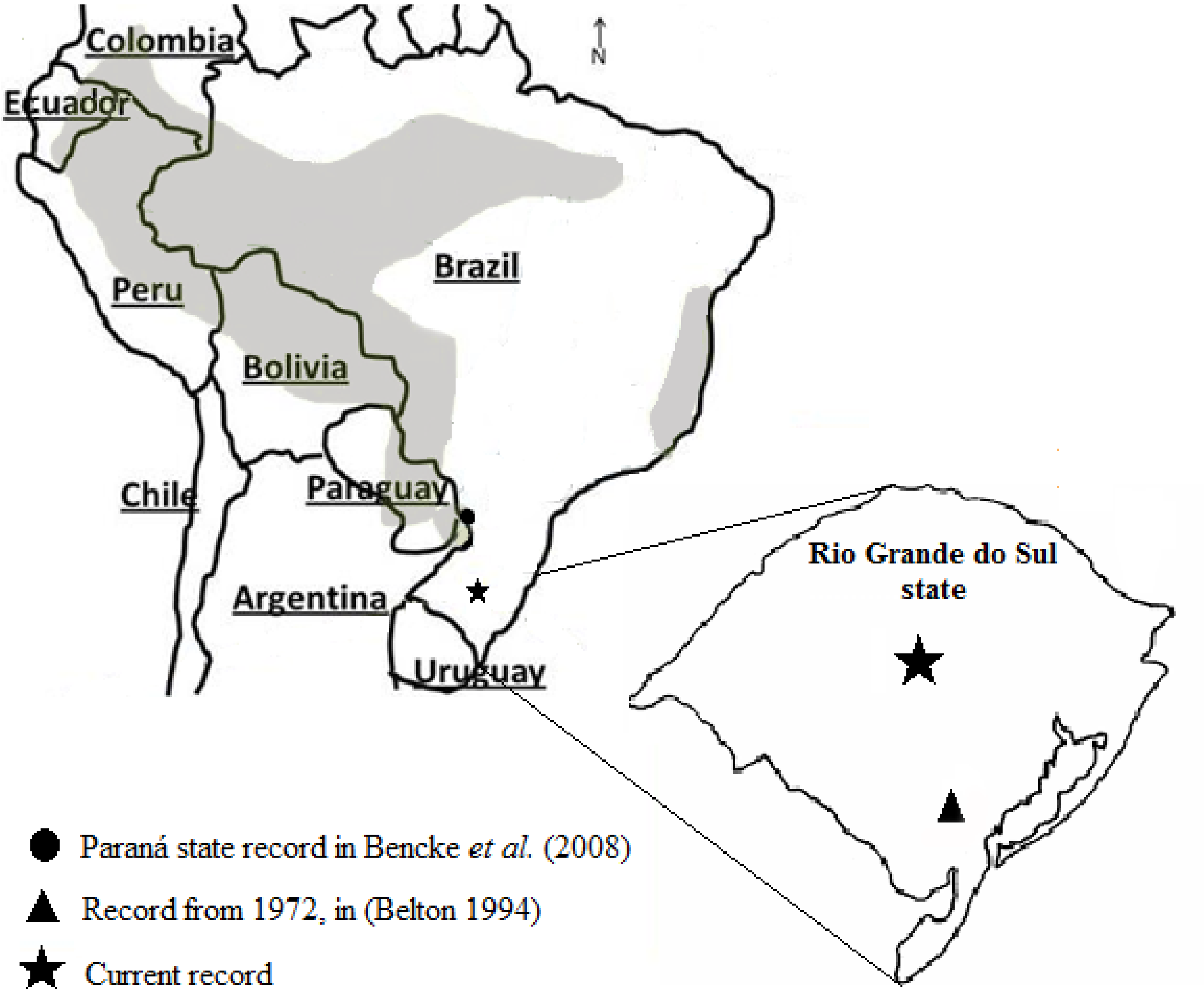

FIGURE 2. Distribution map of *Campylorhynchus turdinus* (shaded area) and records mentioned in the text. Map based on www.birdlife.org and Belton (1994). Base map: Google Maps.

of the province of Misiones, has provided suitable habitat for several bird species occurring along the Paraná Valley, *e.g. Buteo platypterus* (Vieillot, 1823) (Meller & Bencke 2012), *Falco rufigularis* (Daudin, 1800) (Meller 2013), *Turdus flavipes* (Vieillot, 1818) (Meller 2013), and *Harpia harpyja* (Linnaeus, 1758) (Meller & Guadagnin 2016).

We reject the hypothesis that the observed individual originated from illegal trade or casual release for two reasons. First, Helmut Sick observed individuals of *C. turdinus* on 26 November 1972, in Invernada farm, near Canguçu city (31°23'44"S; 52°41'11"W) (Belton 1994). Second, the species is absent from lists of seizure of wild birds illegally traded (Ferreira & Glock 2004, Araujo *et al.* 2010, RENCTAS 2011, Destro *et al.* 2012, Felker *et al.* 2013). Moreover, several residents from the city of Santa Maria (where the individuals were sighted in 2015) asserted not to know the bird. The record of the *C. turdinus* for the state of Rio Grande do Sul update the list of birds for this state (Bencke *et al.* 2010), as this species was assumed to be hypothetical for this state, but had been documented in the current study.

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Curlew Sandpipers *Calidris ferruginea* in the western Atlantic: the first, second, and third Brazilian records from Ceará and Maranhão

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ABSTRACT: Curlew Sandpiper (*Calidris ferruginea*) is a rare spring migrant along the east coast of North America and a casual visitor to Central American and the Caribbean. Here we present documentation for the first, second, and third Brazilian records of *C. ferruginea* from Icapuí, Ceará, and Coroa dos Ovos, Maranhão. In addition, we provide insight into this species' current status and distribution in the western Atlantic in the context of these new records. The appearance of *C. ferruginea* on the Atlantic coast of North America, the Caribbean, Central America, and now, Brazil, suggests that individuals may be displaced from their regular southbound migration along the Palearctic-Afrotropical flyway by northeastern trade winds. Given that *C. ferruginea* is regularly detected on northbound migration throughout the United States, and in light of these three new records for South America, it seems likely that small numbers of this species may be wintering annually undetected in the Atlantic coast of South America.

KEY-WORDS: migration, shorebirds, trade winds, transatlantic vagrancy.

The Curlew Sandpiper (*Calidris ferruginea*) is a monotypic shorebird species (Scolopacidae) that breeds in coastal regions of central Siberia, and migrates through Europe and Asia to wintering grounds spanning from West Africa to New Zealand (O'Brien *et al.* 2006). Fall movements through Europe generally take place in a southeasterly direction between July and October, and occur predominantly via the eastern Atlantic, Black, Caspian, and Mediterranean Seas (Hayman *et al.* 1986). Northbound migration generally occurs from April through May following similar routes.

Hanson (2006) summarizes the historical status of *C. ferruginea* within North America, noting that the species is a regular spring migrant along the Atlantic coast. Despite the regularity of *C. ferruginea* in North America, there have been relatively few Western Atlantic records from outside the USA and Canada. *Calidris ferruginea* is a casual visitor to Central America and the Caribbean (Hayman *et al.* 1986, Stiles & Skutch 1989, Raffaele *et al.* 1998). In the Caribbean, records exist from the western islands extending from Puerto Rico to Trinidad and Tobago (Raffaele *et al.* 1998, Kenefick & Hayes 2006, Buckley *et al.* 2007, Sullivan *et al.* 2009). Despite the frequency of records in Central America, there are only three records from South American countries: two from the Pacific coast in Ecuador and Peru, and one from the Atlantic coast of Chubut in Argentina (Graves & Plenge 1978, Ridgely & Greenfield 2001, Kovacs *et al.* 2005).

In northeastern Brazil, the mangroves and mudflats of the Gulf of Maranhão, and the salt marshes and beaches around Icapuí, Ceará are well known to be major refuges for many wintering migratory shorebirds (Morrison & Ross 1989, Rodrigues 2000, Rodrigues 2007, De Luca *et al.* 2009). The region hosts internationally important populations of Semipalmated Plover (*Charadrius semipalmatus*), Black-bellied Plover (*Pluvialis squatarola*), Short-billed Dowitcher (*Limnodromus griseus*), Red Knot (*Calidris canutus*), Semipalmated Sandpiper (*C. pusilla*), Sanderling (*C. alba*), Hudsonian Whimbrel (*Numenius hundsonicus*), and Spotted Sandpiper (*Actitis macularius*) among others (Rodrigues 2000). With such large concentrations of shorebirds regularly wintering in northeastern Brazil, it is likely that the region hosts many vagrant, or even "pseudo-vagrant" (*sensu* Gilroy & Lees 2003) shorebirds. Critically, northeastern Brazil's eastward protrusion into the Atlantic and relatively close geographic proximity to West Africa (<2,900 km), makes it a logical and predictable conduit for transatlantic vagrancy. Some vagrant Palearctic waterbirds such as Bar-tailed Godwit (*Limosa lapponica*), Eurasian Whimbrel (*Numenius phaeopus*), and Ruff (*Calidris pugnax*), among others, have been observed in the states of Maranhão, Ceará, and Pará, as well as in the Atlantic islands of Fernando de Noronha, Atol das Rocas, and the Saint Peter and Saint Paul Archipelago (Girão *et al.* 2006, Kober *et al.* 2006, Silva & Olmos 2006, Fedrizzi *et al.* 2007, Almeida *et al.* 2013, Lees *et al.* 2014).

Despite the increasing frequency of detection of vagrant *C. ferruginea* in the western Atlantic in recent years, especially in the Caribbean, there have been no published records from Brazil. Furthermore, we are aware of only one documented record from the South American Atlantic coast (see Kovacs *et al.* 2005). Here we present documentation for the first, second, and possibly third records of *C. ferruginea* for Brazil. We additionally provide insight into this species' current status and distribution in the western Atlantic in the context of these new records.

On 12 December 2010, CEF and JMH accompanied by Fabio Nunes located a *C. ferruginea* while conducting shorebird surveys on the Banco dos Cajuais, Icapuí, state of Ceará, Brazil, (04°41'S; 37°21'W) (Figure 1). The bird was seen foraging with *C. pusilla* before flying east over the ocean.

On 25 January 2013, LM photographed a *C. ferruginea* in basic plumage feeding with *C. pusilla* on the beach at low tide on the island of Coroa dos Ovos, state of Maranhão, Brazil (Figure 2; 01°26'S; 45°9'W). The bird was recorded at the same place again on 28 and 29 January (Figure 3) roosting high on the beach with *C. pusilla* during the high tide. One year later, on 12 January 2014, Thomas Magarian discovered a *C. ferruginea* (either a returning bird or another individual) at the same location (Figures 4 and 5).

FIGURE 1. Curlew Sandpiper, *Calidris ferruginea* (center), with Ruddy Turnstone, *Arenaria interpres*, on 12 December 2010 on Banco dos Cajuais, Icapui, State of Ceará, Brazil. Note long decurved bill, long legs, gray breast, and white supercillium. Photo: Fabio Nunes.

FIGURE 2. Curlew Sandpiper, *Calidris ferruginea* (center right), with Semipalmated Sandpipers, *Calidris pusilla*, in flight, taken at Coroa dos Ovos on 25 January 2013. Note clean white rump. Photo: Lukas Musher.

FIGURE 3. Curlew Sandpiper, *Calidris ferruginea* (center), with Semipalmated Sandpipers, *Calidris pusilla* (background), on Coroa dos Ovos, photographed on 29 January 2013. Note long decurved bill that is pointed at the tip, long legs, gray mantle and breast. Photo: Lukas Musher.

FIGURE 4. Curlew Sandpiper, *Calidris ferruginea* (center), with Semipalmated Sandpipers, *Calidris pusilla*, roosting at high tide on Coroa dos Ovos, photographed on 12 January 2014. Photo: Lukas Musher.

FIGURE 5. Curlew Sandpiper, *Calidris ferruginea* (center back), with two Semipalmated Sandpipers, *Calidris pusilla*, in flight at Coroa dos Ovos on 12 January 2014. Photo: Lukas Musher.

After all three observations, the authors quickly decided that the bird in question could safely be identified as *C. ferruginea*. There are no regularly occurring similar species in Brazil (Piacentini *et al.* 2015), but separation from Dunlin (*Calidris alpina*) can be difficult. *Calidris alpina* is not unprecedented in Atlantic South America including a type specimen from Cayenne, French Guyana (Greenwood 1983), and sight records from Venezuela and Argentina (Lesterhuis & Clay 2003). It is normally a short distance migrant wintering in higher northern latitudes throughout its range, although Lesterhuis & Clay (2003) list 16 records from South America.

All three individuals can be readily separated from *C. alpina* by looking at 1) bill structure, 2) relative leg length, and 3) plumage characteristics. These individuals differ from typical *C. alpina* by having 1) a long, thin, decurved bill with a pointy tip, 2) relatively long legs, 3) gray upperparts with a pale white breast, and 4) a prominent white rump. *Calidris alpina* should have 1) a heavy bill decurved primarily at the rostral end, 2) relatively short legs, 3) brownish gray upperparts with a dark breast, and 4) a black vertical stripe on the rump (O'Brien *et al.* 2006). White-rumped Sandpiper (*C. fuscicollis*) is also superficially similar in having a white rump, but has a much shorter beak and very different structure with a squat appearance and long primary projection.

Given the difficulty of access and infrequent observer coverage of coastal regions of northeastern Brazil, vagrant and "pseudo-vagrant" species must be highly under-recorded (Lees *et al.* 2014). We are only just beginning to understand the status of many Palearctic and rare Nearctic shorebirds in Brazil including Bar-tailed and Marbled Godwits (*L. fedoa*), and Ruff, among others (Kober *et al.* 2006, Girão *et al.* 2006, Dias *et al.* 2013), including *C. ferruginea*. With *C. ferruginea* regularly moving through eastern North America (Hanson 2006), there may be small numbers wintering undetected on the South American Atlantic coast. Birders and ornithologists in Brazil should check for this species wherever large numbers of shorebirds congregate in migration and winter, especially when *C. pusilla* is present (O'Brien *et al.* 2006).

The regular appearance of *C. ferruginea* in the western Atlantic and now in northeastern Brazil suggests that individuals may be displaced from their regular southbound migration along the Palearctic-Afrotropical flyway rather than West-Pacific flyway, which likely accounts for records in Ecuador and Peru (Graves & Plenge 1978, Ridgely & Greenfield 2001). It is possible that northeastern trade winds regularly displace *C. ferruginea* across the Atlantic to Central and South Americas. This hypothesis is supported by the regularity of *C. ferruginea* in Barbados, the easternmost island in the Lesser Antilles, which included a record from September 1969 of an individual banded only 14 days prior in Belgium (Hayman *et al.* 1986). Northeast and southeast Trade Winds meet along the equator and blow from east to west, potentially concentrating the landfall of *C. ferruginea* and other Palearctic migrants in coastal regions of northeastern Brazil (see also Fedrizzi *et al.* 2007).

These basic-plumaged birds are difficult to detect on wintering grounds in South America due to their scarcity, inconspicuous plumage, and low birder density. In spring these individuals, now in breeding plumage, follow coastlines north and are detected by birders at well-watched coastal hotspots in the USA and Canada, facilitated by their unmistakable plumage (Howell *et al.* 2014). This hypothesis, albeit speculative, may explain the relative rarity of the species as an autumn vagrant in North America.

Similar patterns are found in other transatlantic vagrants, such as the Little Egret (*Egretta garzetta*; Murphy 1992), Western Reef-Heron (*Egretta gularis*; Fedrizzi *et al.* 2007), and White Wagtail (*Motacilla alba*; Ingels *et al.* 2010). If small numbers of Palearctic shorebirds have established wintering "pseudo-vagrant" populations in the Neotropics, then understanding the links between Palearctic breeding grounds, migration routes, and South American wintering grounds may have important implications for shorebird conservation and management (see Lees & Gilroy 2004). With shorebird numbers at all time lows and falling annually (Prŷs-Jones *et al.* 1994, Bart *et al.* 2007, Sutherland *et al.* 2012), it is of paramount importance to understand the status and distributions of shorebirds globally. Species and regions of high conservation importance and ecological value can then be prioritized for management.

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SHORT-COMMUNICATION

First documented record of the Rufous-tailed Attila (Tyrannidae) for Corrientes, Argentina

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ABSTRACT: We report on the capture of an adult male Rufous-tailed Attila (*Attila phoenicurus*) in Mburucuyá National Park, Corrientes, Argentina. This is the first record for this protected area, and also the first record for the province. Records for this species are scarce in Argentina, where it had been registered previously only in Misiones province. Populations of this species are believed to be declining, and it is considered a "threatened species" in Argentina. If confirmed, the regular presence and perhaps even breeding of the Rufous-tailed Attila in Mburucuyá National Park would extend the species' distribution range approximately 200 km to the southwest, implying that this threatened species occurs in at least one large protected area of Argentina.

KEY-WORDS: *Attila phoenicurus*, documented record, Mburucuyá National Park.

Attila is a Neotropical genus composed of seven species (Clements *et al.* 2014). The only representative of the genus in Argentina is the Rufous-tailed Attila, *Attila phoenicurus*. It can be found in the canopy and middle level of humid forests and secondary woodland (Ridgely & Tudor 1994). It breeds in southeastern Brazil, eastern Paraguay and extreme northeastern Argentina (Fitzpatrick 2004, Figure 1), where it has only been recorded in Misiones province (Chebez 1994, Bodrati & Cockle 2006, Narosky & Yzurieta 2010). During winter it migrates north up to the Brazilian Amazon and southwestern Venezuela (Fitzpatrick 2004, Figure 1). Our objective is to report the first record of the Rufous-tailed Attila in the province of Corrientes, Argentina.

During 24–29 January 2015 we conducted a field trip in Mburucuyá National Park, Corrientes, Argentina. Mist nets were set up in areas restricted to the public, including an internal road located a few meters from the *Seccional* D'Orbigny (28°00'45.9''S; 58°01'20.6''W) within the park. The area is dominated by humid forest (Saibene & Montanelli 1997). In the morning of 28 May 2015 we captured an adult male Rufous-tailed Attila (Figures 2A and B), which was collected and deposited in the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (Buenos Aires, Argentina), under catalogue number MACN-Or-73447 (Figures 3A–C). Although this species is known to readily respond to playback (Ridgely & Tudor 1994), subsequent efforts failed to attract other birds using pre-recorded vocalizations (from López-Lanús 2010) at the collecting site.

We cannot rule out the possibility that this was a vagrant individual. However, the patches of Atlantic forest that can be found in the Mburucuyá National Park would make the presence and perhaps even breeding of this species in the area viable. The Rufous-tailed Attila is an uncommon species and probably overlooked by many surveys (Ridgely & Tudor 1994), possibly due to its similarity with the female of the Crested Becard (*Pachyramphus validus*) (Narosky & Yzurieta 2006, Figure 3). The female of the Crested Becard has a stouter bill, an overall less brilliant plumage, with no dark grey plumage on its cheeks and no blackish primaries (Ridgely & Tudor 1994, 2009; Figures 3D–F). Even though we did not capture or see any Crested Becard during this trip, it is considered a common species in the Mburucuyá National Park (Chatellenaz *et al.* 2010). Thus, the Rufous-tailed Attila could have been misidentified in the area as a female Crested Becard in the past.

Mburucuyá is the only national park in Corrientes and it is one of the 16 Important Bird and Biodiversity Areas (IBAs) in this province (Di Giacomo 2005). It is located in an ecotone with elements from Paranaense, Chaco and Espinal phytogeographical provinces (Cabrera 1976). Due to this environmental diversity, Mburucuyá is among the top-five national parks in Argentina in terms of avian species richness, as it includes 62% of all bird species recorded for Corrientes (Chatellenaz *et al.* 2010) and ~31% of the species recorded for Argentina (Mazar-Barnett & Pearman 2001).

FIGURE 1. Distribution of the Rufous-tailed Attila (*Attila phoenicurus*). The point indicates the collecting site of the specimen reported here. Modified from BirdLife International and NatureServe (2014).

FIGURE 2. The Rufous-tailed Attila individual captured at Mburucuyá National Park after it was removed from the mist net.

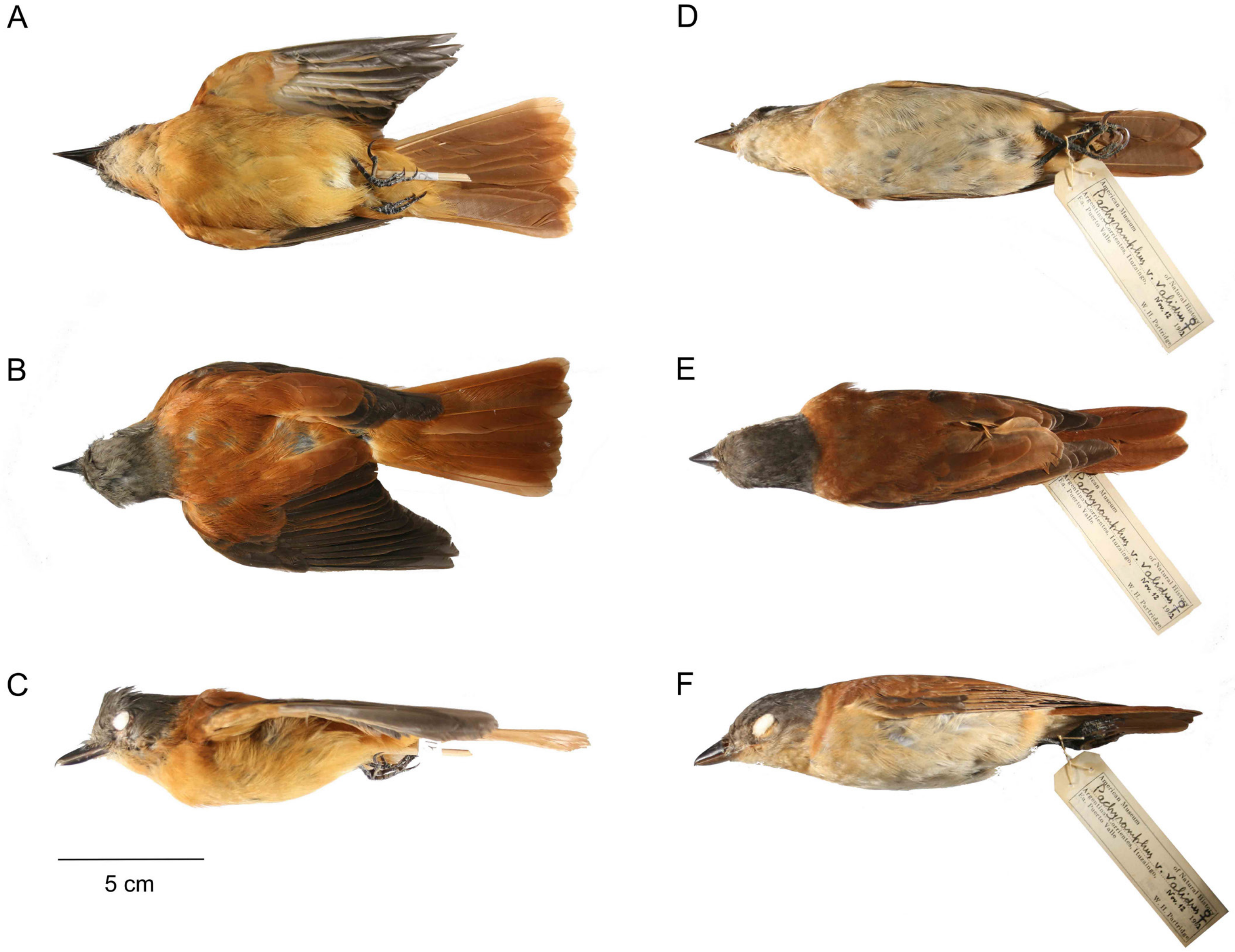

FIGURE 3. The Rufous-tailed Attila captured at Mburucuyá National Park (**A**, **B** and **C**: ventral, dorsal and lateral views, respectively) compared to a female Crested Becard from the Colección Nacional de Ornitología, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", catalogue number MACN-Or- 46929 (**D**, **E** and **F**: ventral, dorsal and lateral views, respectively).

Although the Rufous-tailed Attila is not considered globally threatened with extinction by the International Union for Conservation of Nature (IUCN), it is classified as "threatened" in Argentina (López-Lanús *et al.* 2008). Its global population size has not yet been quantified, and according to BirdLife International (2012) it may be decreasing. Its inclusion in Argentina Red List was based on several criteria, including that the species has been recorded in five or less localities during the last 10 years, and that it has not been registered in any protected area larger than 3000 ha (although there is an uncertain record for the Iguazú National Park, see Chebez 2009, and two other records in the Reserva de la Biósfera Yabotí, see Di Giacomo 2005 and Bodrati & Cockle 2006). Therefore, confirming the regular presence of the Rufous-tailed Attila in Mburucuyá National Park would represent not only a distributional range expansion, but would also imply that this threatened species in Argentina is included in at least one large protected area in the country (Mburucuyá National Park has 17,660 ha, Administración de Parques Nacionales of Argentina, www.parquesnacionales.gob.ar).

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Revista Brasileira de Ornitologia

Issue 24 – Number 1 – March 2016

CONTENTS

BEHAVIOR

Burrowing Owls *Athene cunicularia* (Strigidae) respond with increased vigilance to calls of the Curl-crested Jay *Cyanocorax cristatellus* (Corvidae) in the Paraguayan Cerrado
Victoria Austin, Joseph Savary and Paul Smith *1*

First records on nests of Pompadour Cotinga (*Xipholena punicea*) in Brazil, with notes on parental behavior
Marcelo Henrique Mello Barreiros *9*

ECOLOGY

Diet preference and density of the Greater Rhea (*Rhea americana*) in grasslands of the Flooding Pampa, Argentina
Viviana Comparatore and Cristina Yagueddú *13*

Exploitation of *Ceiba pubiflora* flowers by birds
Diego Matiussi Previatto, Daniel Irineu de Souza Dainezi and Sérgio Roberto Posso *21*

Foraging techniques of Swallow-tailed Cotinga (*Phibalura flavirostris*) on fruits of *Struthanthus marginatus* (Loranthaceae) in Monte Verde, Camanducaia, state of Minas Gerais, Brazil
Carlos Henrique Luz Nunes-de-Almeida and Verónica del Rosario Avalos *27*

A small homage to Maria Sibylla Merian, and new records of spiders (Araneae: Theraphosidae) preying on birds
João Vitor Campos e Silva and Fernanda de Almeida Meirelles *30*

SYSTEMATICS, TAXONOMY, AND DISTRIBUTION

A reassessment of the taxonomy of *Crypturellus noctivagus* (Wied, 1820)
Barbara Mizumo Tomotani and Luís Fábio Silveira *34*

Olive-sided Flycatcher, *Contopus cooperi*, in the Cerrado biome, and a review of records in Brazil
Karla Dayane de Lima Pereira *46*

Rediscovery of the Harpy Eagle *Harpia harpyja* (Accipitriformes: Accipitridae) for Rio Grande do Sul state, Brazil
Dante Andres Meller and Demétrio Luís Guadagnin *53*

A new southern limit for the distribution of the Thrush-Like Wren, *Campylorhynchus turdinus* (Aves: Troglodytidae)
Dilson Vargas-Peixoto and Mariane Bosholn *58*

Curlew Sandpipers *Calidris ferruginea* in the western Atlantic: the first, second, and third Brazilian records from Ceará and Maranhão
Lukas J. Musher, Alexander C. Lees, Bruno Jackson M. Almeida, Roberta C. Rodrigues, Carmen E. Fedrizzi, João M. Holderbaum and David Mizrahi *62*

First documented record of the Rufous-tailed Attila (Tyrannidae) for Corrientes, Argentina
Natalia C. García, Natalia Trujillo-Arias, Cecilia Kopuchian and Gustavo S. Cabanne *68*

Instructions to Authors *73*