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**Cover:** Nestling of Yellow-olive Flycatcher (*Tolmomyias sulphurescens*) preyed by a Eastern Green Whiptail (*Philodryas olfersii*), removed from the nest. Marini (in this issue) provided a comparison of nesting success and predation levels of eggs and chicks in open cup and closed nests of Passerines in an Atlantic Forest fragment in Brazil. Photo author: Nicelio A. da Silva (http://www.wikiaves.com.br/ 1276721).

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# Nesting success of birds from Brazilian Atlantic Forest fragments

**Miguel Ângelo Marini**[1,2]

[1] Departamento de Zoologia, Instituto de Ciências Biológicas, Universidade de Brasília, 70910-900, Brasília, DF, Brazil.
[2] Corresponding author: marini@unb.br

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**ABSTRACT:** Several aspects of the ecology of tropical birds remain unresolved both descriptively and experimentally, in spite of the high diversity of birds and the high deforestation rates. Here, I evaluate, apparently for the first time, nesting success and predation levels of open and closed-cupped nesting birds in an avian community from Atlantic Forest fragments in southeastern Brazil. The monitoring of 257 nests of more than 22 species from 1995 to 1999 revealed that overall apparent nest success (42.4%) was in the upper range for tropical species. Daily survival rates (DSR) for 18 species ranged from 0.900–0.987. Total average survival probability was 55.9 for open cup and 60.1% for closed nests. There was no evidence for an edge effect on the success of either open cup or closed nests. Against predictions, apparent success of closed nests (43.6%) did not differ from open cup nests (38.1%). However, there were differences in apparent success within three types of closed nests. Closed nests higher above the ground had greater apparent nest success than lower nests, but this pattern did not occur for open cup nests. This study demonstrates that some patterns of nesting success might not hold for all Neotropical sites, especially disturbed ones.

**KEY-WORDS:** breeding, Mayfield, nest, predation, survival.

## INTRODUCTION

Low nesting success has been proposed as a key reason for the decline of bird populations in fragmented landscapes (Gates & Gysel 1978, Robinson 1989, Robinson *et al.* 1995). Most studies however, have evaluated nest predation and brood parasitism rates in temperate forest fragments, and little is known about nesting success of birds in Neotropical forests (Skutch 1985, Robinson *et al.* 2000, Young *et al.* 2008, Brawn *et al.* 2011), though exceptions for some species (*e.g.* Snow 1962, Aguilar *et al.* 2000) and some artificial nest studies do exist (Tabarelli & Mantovani 1997, Leite & Marini 1999, Duca *et al.* 2001). Tests of edge effects on the success of natural nests are scarce in the Neotropics (*e.g.* França & Marini 2009), and a meta-analysis of 20 Neotropical forest nest predation studies revealed no support for an edge effect (Vetter *et al.* 2013). Studies with artificial nests alone have provided mixed evidence for edge effect on nest survival in the Neotropics, with the majority showing no effect (Melo & Marini 1997, Duca *et al.* 2001, França & Marini 2009, but see Tabarelli & Mantovani 1997). Thus, our knowledge on the cumulative effect of forest fragmentation on nest success in the Neotropics remains incomplete.

In addition, we still lack descriptive and experimental tests of several aspects of the ecology of tropical birds both in natural and disturbed habitats (Martin 1996). For example, few studies of nesting success in the Neotropical region have large sample sizes that can be used to test proposed patterns and existing hypotheses, such as the higher predation levels in the tropics compared to temperate regions (Martin 1993, Robinson *et al.* 2000). Also, differences in the predation rates between open cup and closed nests (Lack 1948, Martin & Li 1992) or across nest heights (Reynolds & Knapton 1984, Robinson *et al.* 2000, Santo *et al.* 2003) are seldom tested in tropical areas (Mezquida & Marone 2001, Auer *et al.* 2007). Thus, it remains unclear if patterns influencing nest success that were demonstrated primarily in temperate areas, apply more broadly to tropical regions.

Habitat disturbance can alter predator communities, the contact rates between predators and nests, and thus nest predation rates (Borges & Marini 2010). This is particularly alarming given the high deforestation rates across several biomes. For example, primary Atlantic Forest cover is currently estimated at 11.4–16% (Ribeiro *et al.* 2009), and a high percentage of Atlantic Forest birds are threatened (*e.g.* 10% in Brazil, review in Marini & Garcia 2005). Thus, information on avian nest success and the factors that influence it are not only desirable, but also urgent as deforestation continues to fragment

Atlantic Forest (Tabarelli *et al.* 2005) and other biomes.

This study evaluates nesting success and predation levels of open cup and closed nesting birds from Atlantic Forest fragments in southeastern Brazil, apparently for the first time. I tested the following hypotheses: 1) that nest predation is higher along borders than in the interior of forest fragments; 2) that nest predation varies according to nest structure, being higher for open-cup than for closed nests; and 3) that nest predation varies with nest height above the ground, being lower at greater heights.

## METHODS

### Study area

I conducted this study at the "*Área de Proteção Especial para fins de Preservação dos Mananciais do Barreiro*" (Barreiro therein), owned by *COPASA (Companhia de Saneamento de Minas Gerais)* and located within the municipality of Belo Horizonte, state of Minas Gerais (20°02' – 20°00'S; 43°59' – 44°00'W) (Marini 2010). From 1995 to 2000, I monitored nests at two forest fragments of 50 and 200 ha at the Barreiro. The forests have a 15–25 m high canopy, with and estimated successional stage of approximately 150 years (CETEC 1993). These forest fragments exist in an area of transition between the Atlantic Forest and the Cerrado Biomes. However, the community composition of bird species is more characteristic of the Atlantic Forest. The landscape around the forests is composed mostly of grasslands and Cerrado (around 2000 ha), surrounded by urbanized areas of Belo Horizonte and neighboring cities (Marini 2010). The climate of the region has warm and rainy summers and dry and cool winters with most precipitation falling between October and March. Temperatures generally vary between 9°C and 37°C (Source: *"Estações Climáticas da Mutuca e Catarina"* monitored by COPASA and M*BR – Minerações Brasileiras Reunidas*).

### Field methods

I began nest searches usually in July, mostly along ravines and roadbeds, but also inside forests away from these landmarks. To mark nests, I placed a pink plastic tape approximately 5–10 m from them. I made several visits every 3–5 days to monitor nests and determine their fate, assuming that nest content (eggs or nestlings; active or inactive) and status (hatching, fledging and predation) occurred at the midpoint between nest checks, following Mayfield (1961, 1975). Nest monitoring scheme and the classification of nest fate followed standard procedures largely accepted and used in studies of nest success (Mayfield 1961, 1975, Robinson *et al.* 2000, Lopes & Marini 2005). Thus, a nest was considered successful when at least one bird fledged, and predated when all its contents had disappeared before the expected time of nest fledging. Part nest losses were disregarded since predators usually take the entire nest content (Ricklefs 1969, Martin 1993). A nest was considered abandoned when eggs remained in the nest for a time period that was longer than expected for the species or when nestlings were found dead without signs of predation.

Most nests had their height above the ground measured with a tape (to the nearest cm) and all nests were classified as open-cup or closed. To enable statistical analysis, I divided nests into two classes of height above the ground: up to 1 m and more than 1 m, and performed separate tests for open-cup and closed nests. Then, closed nests were subdivided in cavity in the ground (usually narrow 0.5–1.0 meter-long cavities in ravine walls), domed pensile (globular or elongated closed nests with a side entrance) or domed on or close to the ground (globular closed nests with a side entrance). I also classified most nests in five groups with respect to distance to the forest edge: up to 50 m, 51–100 m, 101–150 m, 151–200 m and greater than 200 m.

### Statistical analyses

Reproductive success was calculated in two ways: 1) apparent predation rates (*i.e.* simple percentage of predated nests); and 2) daily survival rates (DSR) (Mayfield 1961, 1975). I applied Chi-square tests to test if apparent predation rates of nests 1) varied with distance from the edge to the interior of forest fragments; 2) differed between open-cup and closed nests; and 3) varied with nest height above the ground. Multivariate analyses where not possible to use since two parameters (nest height and distance to the edge) where not estimated for all nests due to logistical constraints in the field, reducing sample sizes even further. Sample sizes were too small to calculate predation rates at different stages (eggs or nestlings) of the nest cycle for different species. Nests of unidentified species (Pipridae sp., Formicariidae sp., *Turdus* sp., 10 unknown) were usually depredated before the owner of the nest was identified. Since all these nests were depredated earlier in the nest cycle, to avoid overestimating nest success of all species of open-cup and all closed nests they were used for the estimate of average survival probability and average apparent success. However, the nests of Pipridae are probably from Blue Manakin, *Chiroxiphia caudata*. All nests belong to Passeriformes, except for the nest of Crescent-chested Puffbird, *Malacoptila striata*. Nomenclature follows Brazilian Ornithological Records Committee - CBRO (Piacentini *et al.* 2015).

I calculated daily survival rates (DSR) (Mayfield estimates) based on Mayfield (1961, 1975) and Hensler & Nichols (1981). I did not calculate these estimates individually for unidentified nests since they could not be ascribed to any species, and would have little biological relevance as such. However, I calculated these estimates for Formicariidae, Pipridae and *Turdus* sp. since the number of days of their nest cycle is likely consistent between members of a bird genus (Bennett & Owens 2002, del Hoyo *et al.* 2017). Detailed nesting biology of species with small sample sizes is provided in Marini *et al.* (2007) and with larger sample sizes (Gray-hooded Flycatcher *Mionectes rufiventris*, Euler's Flycatcher *Lathrotriccus euleri*, Yellow-olive Flycatcher *Tolmomyias sulphurescens* and Sepia-capped Flycatcher *Leptopogon amaurocephalus*) in Aguilar *et al.* (1999, 2000), Anciães *et al.* (2012), and Aguilar (2001).

## RESULTS

Overall apparent nest success (%), independent of nest structure or location, was of 42.4% (*n* = 257 nests) across 95 open cup nests of at least eight species and 162 closed nests of at least 10 species over the five years of the study (Table 1). Overall apparent nest predation levels, independent of nest structure or location, was 44.7%

**Table 1.** Sample sizes of nest fates, daily survival rates (DSR) and survival probability following Mayfield (1961, 1975), and apparent success of forest birds with open cup and closed nests.

| **Species name** | **Nest fate[a]** | | | | **Exposure days** | **Daily survival rates (DSR)** | **Survival probability % (mean ± SD)** | **Apparent success (%)[e]** |
|---|---|---|---|---|---|---|---|---|
| | **S** | **P** | **A** | **NC** | | | | |
| **Open cup nests** | | | | | | | | |
| *Lathrotriccus euleri* | 21 | 13 | 1 | - | 753 | 0.983 | 68.5 ± 0.07 | 60 |
| *Platyrinchus mystaceus* | 2 | 1 | - | - | 57 | 0.983 | 71.4 ± 0.24 | 67 |
| *Chiroxiphia caudata* | 1 | 1 | - | - | 52 | 0.981 | 60.4 ± 0.31 | 50 |
| Pipridae sp. | 1 | 5 | - | - | 120 | 0.958 | 42.7 ± 0.17 | 17 |
| *Thamnophilus caerulescens* | 3 | 3 | - | - | 104 | 0.962 | 50.7 ± 0.18 | 50 |
| *Dysithamnus mentalis* | 2 | 5 | - | - | 98 | 0.949 | 48.0 ± 0.16 | 29 |
| Formicariidae sp. | - | 3 | 1 | - | 31 | 0.903 | 34.9 ± 0.22 | 0 |
| *Conopophaga lineata* | 3 | 5 | 1 | - | 147 | 0.966 | 53.0 ± 0.15 | 33 |
| *Turdus leucomelas* | 2 | 5 | 1 | 1 | 134 | 0.963 | 48.3 ± 0.16 | 22 |
| *Turdus rufiventris* | 1 | - | - | - | 13 | | | 100 |
| *Turdus* sp. | - | 5 | 1 | - | 46 | 0.891 | 34.7 ± 0.17 | 0 |
| Not identified | 1 | 4 | 2 | - | | | | 14 |
| Total open cup nests | 47 | 40 | 7 | 1 | 1555 | | 55.9[f] | 49.5[f] |
| **Closed nests** | | | | | | | | |
| *Malacoptila striata*[b] | 1 | - | - | - | 31 | | | 100 |
| *Philydor rufum*[b] | 2 | 1 | 1 | - | 77 | 0.987 | 71.5 ± 0.24 | 50 |
| *Lochmias nematura*[b] | 1 | - | - | - | 9 | | | 100 |
| *Tersina viridis*[b] | 2 | 1 | - | - | 35 | 0.971 | 71.3 ± 0.24 | 67 |
| *Tolmomyias sulphurescens*[c] | 23 | 28 | 8 | 1 | 1394 | 0.980 | 57.4 ± 0.06 | 38.3 |
| *Leptopogon amaurocephalus*[c] | 30 | 25 | 8 | 1 | 1655 | 0.985 | 63.3 ± 0.06 | 46.9 |
| *Mionectes rufiventris*[c] | 7 | 6 | 3 | 2 | 290 | 0.979 | 62.7 ± 0.12 | 38.9 |
| *Todirostrum poliocephalum*[c] | 1 | - | - | - | 32 | | | 100 |
| *Basileuterus culicivorus*[d] | - | 5 | - | - | 55 | 0.909 | 35.1 ± 0.17 | 0 |
| *Myiothlypis flaveola*[d] | - | 2 | - | - | 20 | 0.900 | 34.9 ± 0.28 | 0 |
| Not identified pensile[c] | 1 | - | 1 | - | | | | 50 |
| Not identified domed[d] | - | 1 | - | - | | | | 0 |
| Total closed nests | 62 | 75 | 21 | 4 | 3598 | | 60.1[f] | 38.3[f] |

[a] Nest fate: S = success, P = predation, A = abandonment, NC = natural causes.
[b] Cavity inside the ground.
[c] Domed pensile.
[d] Domed on or close to the ground.
[e] Apparent success = all successful nests/all nests.
[f] Average survival probability or average apparent success of all species.

(*n* = 115 nests). The other 12.9% of failed nests were the result of nest abandonment or other natural causes such as tree falls.

Daily survival rates (DSR) (Mayfield estimates) of 18 species ranged from 0.900 to 0.987 (Table 1). For four species with >18 nests monitored, the daily survival rate ranged from 0.979 to 0.985. Total average survival probability was 55.9% for open cup and 60.1% for closed nests. We refrain from making further comparisons with daily survival rates because sample sizes were too small for most species.

### Forest border *vs.* forest interior

Apparent nest success was similar along the edge to interior forest gradient. When open-cup and closed nests were considered together, nest success was similar among the five edge distance categories ($\chi^2 = 0.425$, $df = 4$, $P = 0.980$). This lack of edge effect was maintained when either open-cup ($\chi^2 = 0.830$, $df = 3$, $P = 0.842$) or closed ($\chi^2 = 1.093$, $df = 4$, $P = 0.895$) nests were analyzed separately (Fig. 1).

### Nest structure

Open cup and closed nests had similar nest success, contrary to expectation. Mean nest success over the five years was similar ($\chi^2 = 3.077$, $df = 1$, $P = 0.105$) between open-cup (49.5%) and closed (38.3%) nests. Nest predation levels were also very similar between closed (46.3%) and open-cup nests (42.1%). However, nest success and nest predation levels varied among different types of closed nests, though small and uneven sample sizes precluded proper statistical analyses. Domed nests on or close to the ground (*n* = 8 nests of three species) had the highest predation level (100%) and lowest nesting success (0%). Domed pensile nests (*n* = 145 nests of five species) had intermediate predation levels (40.7%) and nesting success (42.8%), whereas cavity nests inside the ground (*n* = 9 of four species) had the lowest predation levels (22.2%) and the highest nesting success (66.6%).

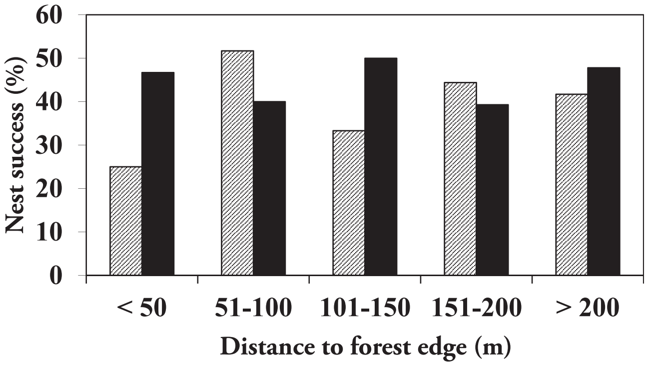

**Figure 1.** Percentage of open-cup (cross-hatched bars) and closed (solid bars) successful nests at five distances (m) from the forest edge.

For all open cup nests, apparent nest success and predation levels varied little among the five years of study. Nest success varied from 30.0 to 42.9% (mean for the five years = 38.1 ± 5.1%). Nest predation varied from 47.6 to 61.5% (mean for the five years = 53.8 ± 6.4%). Nest losses due to other causes varied from 0 to 12.5%, but in four out of five years ranged from 8.3 to 12.5%.

For all closed nests, nest success had an almost two-fold variation among the five years, from 30 to 56.5% (mean for the five years = 43.6 ± 10.8%). The same pattern occurred with nest predation, which varied from 36.1 to 57.5% (mean for the five years = 43.2 ± 8.7%). Nest losses due to other causes varied almost six-fold, ranging from 4.4 to 25% (mean for the five years = 13.3 ± 7.7%). This last result was mostly due to a very high rate of nest abandonment in 1996 (25%) probably caused by the experimental manipulation of nests of Yellow-olive Flycatcher that year. If nests from 1996 are excluded from the analyses, mean loss to other causes drops to 10.4%.

### Nest height above the ground

Nest success varied according to nest height for closed nests, but not for open cup nests. Closed nests higher above the ground (> 1 m) (*n* = 48) had significantly ($\chi^2 = 8.47$, $df = 1$, $P = 0.004$) higher nest success than nests lower to the ground (< 1 m) (*n* = 16). However, open cup nests placed above (*n* = 34) and below (*n* = 27) 1 m had similar ($\chi^2 = 1.57$, $df = 1$, $P = 0.297$) nest success.

## DISCUSSION

Overall nest success recorded here is twice as high as average values reported for real nests of Neotropical birds of about 20% (Snow 1962, Oniki 1979, Robinson *et al.* 2000, Mezquida & Marone 2001, Lopes & Marini 2005, Medeiros & Marini 2007). Nest success in Atlantic Forest fragments is higher than that of other Neotropical regions, but most studies were conducted in areas with several levels of habitat fragmentation and degradation. As pointed out by Martin (1996), nest predation rates may be similar between North America and Central and South America. Indeed, few studies with sufficient sample sizes of real nests exist in the Neotropics and temperate South America (but see Martin *et al.* 2000, Borges & Marini 2010, Brawn *et al.* 2011, França *et al.* 2016), and further study is required to test this difference.

Edge effects on nest success have rarely been tested in the Neotropical region and studies have revealed mixed results. Here, nest success was similar from the edge to the interior of the forests, even though open cup nests close (< 50 m) to forest border had a tendency of lower nesting success. Sample sizes, however, were low in the < 50 m distance class, and further study is necessary. Similar nest success rates were found for both natural and artificial nests between the edge and interior in a Cerrado reserve in Brazil (França & Marini 2009). One study with artificial nests did not demonstrate an edge effect (Tabarelli & Mantovani 1997), but neither Melo & Marini (1997) nor (Duca *et al.* 2001) found edge effects on nest success. Overall, most of the evidence from both natural and artificial nests in southeast central Brazil points to the lack of edge effects on the probability of avian nest success. Evidence for edge effects on avian nesting success is also mixed in other regions of the world (review in Lahti 2001). Specificities from each region, such as predator community and landscape features, might account for the lack of a general edge effect pattern among studies (Lahti 2001, Vetter *et al.* 2013).

We rejected the prediction that open cup nests have lower nesting success than closed nests (Ricklefs 1969, Oniki 1979). Similarly to our results, Ramo & Busto (1984) and Mezquida & Marone (2001) also did not detect higher nesting success for closed nests. However, closed nests had higher success than open-cup nests at the Brazilian Caatinga (França *et al.* 2016). The decrease in the success of the Yellow-olive Flycatcher in 1996 due to manipulation had little effect on the overall estimate of nest success of closed nests, since these nests represented less than 3% of all closed nests, and predation would have destroyed around half of them anyway. The difference among the three types of closed nests in this study is noteworthy as it reveals that predation pressure and life history constraints differ among them. Only arboreal or aerial predators can depredate a domed pensile nest, whereas a different suite of predators may depredate nests on the ground. For example, birds, primates and snakes have been reported to depredate the pensile nests of Icteridae in the Amazon (Robinson 1985) and in the Atlantic Forests (Duca & Marini 2004). Our results suggest that an open cup-closed nest dichotomy may be too simple to explain biological patterns in nest success and predation among birds.

The average nest survival probabilities (Mayfield) for open cup nests (49.5%) is above most values reported for other Neotropical sites, such as the Cerrado (29.4%) (Borges & Marini 2010), the Caatinga (< 15%) (França *et al.* 2016), and lowland forests in Panama (7.1% for the Dusky Antbird *Cercomacroides tyrannina*) (Robinson *et al.* 2000). Nest survival probabilities (Mayfield) of closed nests (38.3%) is in the range of other closed nesting Neotropical species, such as Ochre-bellied Flycatcher *Mionectes oleagineus* in Central American forests (12.1–51.5%) (Skutch 1985, Robinson *et al.* 2000), the Red-rumped Cacique *Cacicus haemorrhous* in the Atlantic Forest (40.5%) (Duca & Marini 2008), and closed nests at the Caatinga (seasonal range = 13.2–69.8%) (França *et al.* 2016). Thus, nest success in these forest fragments was average (closed) to high (open cup) compared to other Neotropical sites.

Closed nests were more successful when positioned higher above the ground, but nest success was similar for high and low open cup nests. Similarly, cavity-nesting passerines had higher nesting success when higher above the ground (Li & Martin 1991). Also, the closed nests of Winter Wren *Troglodytes troglodytes* were more successful when higher above the ground (Santo *et al.* 2003). The same pattern, however, has also been found for an open-cup nester, Chipping Sparrow *Spizela passerina* (Reynolds & Knapton 1984). The reason for this difference between open cup and closed nests may be related to the community of predators within the forest fragments of our study site. At least 256 species of mammals, birds, reptiles and arthropods depredate bird nests in the Neotropical region (Menezes & Marini 2017). Among them, snakes, toucans, raptors, small mammals and monkeys could enter or reach inside closed nests and at high densities could increase nest predation rates above average expected values. For example, Black-necked Aracaris (*Pteroglossus aracari*) depredated closed nests of *Cacicus haemorrhous* in the Atlantic Forest (Duca & Marini 2004). Thus, the reason for these high predation rates of closed nests at Atlantic Forest fragments should be investigated further.

This study revealed that some patterns of nesting success found in the literature might not hold for all Neotropical sites, especially disturbed ones such as ours (see also Marini *et al.* 2012). Here, predation levels in the fragmented forests were not different from the levels of most Neotropical studies. Also, closed nest success was similar to that of open cup nests, but there seems to be differences in success among types of closed nests. The breeding biology and ecology of many Neotropical species and ecosystems remains poorly studied (*e.g.* Heming *et al.* 2013), and reproductive success studies in novel systems are still rare (but see França *et al.* 2016). This rarity in tropical regions is probably related to small sample sizes due to low population densities compared to temperate species, high species diversity with varied nest types including many undescribed nests, and the need of field-intensive nest monitoring programs. However, the present study demonstrates how a small amount of new field data from a novel study site can add to the discussion of avian life history.

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**SHORT-COMMUNICATION**

# The nest and nestlings of the Black-tailed Flycatcher, *Myiobius atricaudus snethlagei* (Passeriformes: Onychorhynchidae)

**Daniel Fernandes Perrella[1,3] & Jefferson Luis Gonçalves de Lima[2]**

[1] Programa de Pós-graduação em Ecologia e Recursos Naturais, Universidade Federal de São Carlos, Rodovia Washington Luís, km 235, 13565-905, São Carlos, SP, Brazil.
[2] Sítio Pau Preto, 10, Zona Rural, 63160-000, Potengi, CE, Brazil.
[3] Corresponding author: dfperrella@gmail.com

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**ABSTRACT:** The Black-tailed Flycatcher, *Myobius atricaudus*, is a Neotropical insectivorous bird species with seven recognized subspecies. This contribution focuses on *M. a. snethlagei*, a subspecies from northeastern Brazil that can be identified based on plumage characters. To our knowledge, information on the breeding of the Black-tailed Flycatcher is scarce and is restricted to the other two subspecies, *M. a. atricaudus* and *M. a. ridgwayi*. We describe an active nest observed on 15 February 2017 in the northeastern slope of the Araripe Plateau, Ceará state, Brazil. The nest containing two nestlings was a long and closed pensile structure, attached from the tip to a slender branch and suspended 89 cm over a small stream inside the forest. The nest was mainly composed of long rootlets, strips of dried leaves, tendrils and some fine sticks. It was found in the Brazilian Caatinga Dry Forest during the rainy season, which does not correspond to the breeding period of birds in other localities of northeastern Brazil. Despite several similarities among the nests of *M. a. atricaudus*, *M. a. ridgwayi* and *M. a. snethlagei*, leaves and spider web were not observed among the materials used to build the nest of *M. a. snethlagei.* This might be a useful feature to differentiate between the nests of this species and the other subspecies. Furthermore, the nest description is consistent with the pattern of nest architecture known for the members of Family Onychorhynchidae.

**KEY-WORDS:** Araripe Plateau, Caatinga, Neotropical bird, northeastern Brazil, rainy season.

The genus *Myiobius* Gray, 1839 comprises three or four species of Neotropical insectivorous birds with large eyes and long rictal bristals (Clements *et al.* 2016, Farnsworth & Lebbin 2017, Remsen *et al.* 2017). The genus used to be classified in the family Tyrannidae, until more recent phylogenetic studies suggesting that it is closely related to *Onychorhyncus* Fischer von Waldheim, 1810 and *Terenotriccus* Ridgway, 1905, which belong to the family Onychorhynchidae (Ohlson *et al.* 2013).

The Black-tailed Flycatcher *Myobius atricaudus* Lawrence, 1863 is a medium-sized bird (12–12.7 cm) with dark olive-green crown and back, grey face, long rounded black tail, dark wings and yellow coronal patch, rump and belly (Farnsworth & Lebbin 2017). It includes seven recognized subspecies, occurring from southwestern Costa Rica to southern and western Colombia. This contribution focuses on the subspecies *M. a. snethlagei*, from northeastern Brazil (including the states of Maranhão, Piauí, Ceará, west Bahia and southeast Goiás) (Clements *et al.* 2016, Farnsworth & Lebbin 2017). There, *M. a. snethlagei* inhabits mainly the understory of both humid and dry forests, and vegetation of Cerrado domain (Nascimento *et al.* 2000). This subspecies can be distinguished from the others by its plumage on the throat and breast, which is brighter yellow, and rump with some orange-buff tinge (Farnsworth & Lebbin 2017).

To our knowledge, information on the breeding of the Black-tailed Flycatcher is scarce and is restricted to only two subspecies, with few dimensions provided (Table 1). Description of the nest architecture, measurements, and characteristics of the eggs and nestlings of *M. a. atricaudus* were provided by various authors (Stone 1918, Skutch 1960, Gross 1964, Wetmore *et al.* 1972, Willis & Eisenmann 1979). Information on *M. a. ridgwayi* is even scarcer. A female was recorded with incubation patch, and a brief description of the nest was given (Davis 1945, Kirwan 2009). In this short communication we aim to describe the nest and nestlings of *M. a. snethlagei* from northeastern Brazil.

An active nest of the Black-tailed Flycatcher was observed on 15 February 2017 (7°19'59.6''S; 39°24'40.9''W, 733 m a.s.l.) near Nascente do Farias, on

**Table 1.** Measurements of the nests and nest characteristics (in mm) of *Myiobius atricaudus* subspecies (in mm) Caatinga Biome, northeast Brazil.

| Subspecies | High above ground/ water | Outside height | Outside diameter | Nesting chamber height | Nesting chamber diameter | Entrance length | References |
|---|---|---|---|---|---|---|---|
| *M. a. ridgwayi* | 7000 | 300 | 120 | | | | Kirwan 2009 |
| *M. a. atricaudus* | 3048 | | | | | | Skutch 1960 |
| | 500 | 510 | | | | 38 × 45 | Gross 1964 |
| *M. a. snethlagei* | 890 | 410 | 52.5 | 62.9 | 44.6 | 43.6 × 31 | This study |

**Figure 1.** Lateral view of the nest, depicting the attachment, architecture and material of *Myiobius atricaudus snethlagei* in the Caatinga Biome, northeast Brazil. Photo author: D.F. Perrella.

the slope of the Araripe Plateau, Ceará state, northeastern Brazil. The area is located in the Cariri Valley, where several permanent water sources such as springs and streams maintain an evergreen humid forest in the midst of the semi-arid Brazilian Caatinga (Bencke *et al.* 2006). The mean annual temperature there varies between 24.1 and 27.4°C, with annual precipitation averaging 1033 mm (Linhares *et al.* 2010). The climate is arid steppe with hot temperatures – BSh description according to Köppen-Geiger classification (Peel *et al.* 2007).

Measurements of the nest for description were collected with a metal caliper nearest 0.1 mm and the main measurements (height above the water and nest total length) were taken with a measuring tape. The classification of the nest type followed Simon & Pacheco (2005) and nest dimension patterns followed Hansell (2000).

The nest (Fig. 1), containing two nestlings in their initial stage of development, was over a small stream inside the forest and near the border (Fig. 2A). It consisted of a long, closed, pensile structure attached from the tip to a slender branch and suspended 89 cm above water. It was pyriform with lots of tightly bonded material and ended in a chamber with circular lateral entrance, located on the lower portion of the nest. The nest had the following dimensions: total outside height 41 cm; widest outside diameter 52.5 mm; outside height of nesting chamber 62.9 mm; inside diameter of nesting chamber 44.6 mm; circular chamber entrance 43.6 mm (horizontal length) per 31 mm (vertical length). The nest wall was composed mainly of long rootlets, strips of dried leaves, tendrils and some fine sticks, making the nest pale brown on the outside. In the bottom, there were loose rootlets dangled irregularly forming a "tail" measuring 43 cm. The same material in the walls was projected over the entrance of the nest chamber, covering it. The outer surface was poorly adorned with some sticks, and the inner lining was composed of thin rootlets.

The nestlings had their eyes closed and were totally devoid of down. The skin on their bodies was dark reddish, and on their heads, dark grey. Their bills were dark, the swallow flanges and the interior of their mouth was bright yellow (Fig. 2B). During approximately one hour of nest observation, only one parent came to attend the nestlings. This parent brought whole arthropods to the nest, in its beak. After provisioning the nest, the adult brooded the nestlings while its tail projected to the outside, remaining totally covered by the projection of material over the chamber's entrance.

The observed nest was found during the rainy season in the northeastern slope of the Araripe Plateau (Linhares *et al.* 2010). However, this does not correspond to the breeding period of birds in other localities of northeastern Brazil, where reproduction activities were detected from

**Figure 2.** Nest placement over the stream inside forest (**A**) and nestlings (**B**) of the Black-tailed Flycatcher, of *Myiobius atricaudus snethlagei* in the Caatinga Biome, northeast Brazil. Photo author: D.F. Perrella.

March to July in Rio Grande do Norte state (Cavalcanti *et al.* 2016), and from June to August in the state of Paraíba (Telino-Júnior *et al.* 2005). It is possible that the different reproductive phenology of the Black-tailed Flycatcher is associated to seasonal rains, that influences the timing of breeding cycles in the Caatinga, as found by other studies conducted in semi-arid habitats (Illera & Díaz 2006, Cavalcanti *et al.* 2016).

Although definitive conclusions cannot be drawn from one nest, the data presented here is useful to compare the characteristics of the nest of *M. a. snethlagei* with the nests of the other subspecies of *Myiobius*. It is known that both *M. a. atricaudus* and *M. a. ridgwayi* construct closed and elongated nests attached by the tip and that those nests are mainly composed of rootlets and leaf fibers (Stone 1918, Skutch 1960, Gross 1964, Wetmore *et al.* 1972, Kirwan 2009), matching the information provided here on *M. a. snethlagei*. Hatchings with no down, with dark skin and yellow mouth also seem to be conditions present in the other subspecies (Skutch 1960, Gross 1964). However, according to Gross (1964), the birds of the nominate subspecies use spider web to bond the nest material and entire leaves to compound the outer surface of the nest. We did not find such materials in the nest of *M. a. snethlagei*.

Despite considerable volume of material on the nest, the chamber has a small size. So when the bird sits for brooding, with the head facing the back of the nest, its tail projects out of the entrance. This has been observed in other members of the genus *Myiobius*, *Onychorhynchus* and *Terenotriccus* (Skutch 1960). The projected material over the nest entrance might represent a strategy to hide or to keep both the access to the chamber and parents safe. Another characteristic shared among the species of the family Onychorhynchidae and reinforced by the information provided here is the nest architecture pattern (Tello *et al.* 2009), depicted as an elongated and closed pendulous structure with the incubation chamber bellow and lateral entrance (Fitzpatrick *et al.* 2004 and references therein).

Here, we provide additional information on the reproduction of the Black-tailed Flycatcher, and present the first data on the nest and nestlings of *M. a. snethlagei*. Despite other similarities among the nests of the three subspecies, we did not find evidence that *M. a. snethlagei* uses leaves and spider web, as the nominate subspecies does, in nest construction. Furthermore, this nest description further strengthens the known pattern of nest architecture of other members of the Family Onychorhynchidae.

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SHORT-COMMUNICATION

# Predation of the Rufous-tailed Hawk (*Buteo ventralis*) on the Chilean Hawk (*Accipiter chilensis*) in Alerces National Park, Argentina

**Freddy Burgos-Gallardo[1,4], Baltasar Ramos[2] & Cristian Vellido[3]**

[1] Instituto de Ecorregiones Andinas (INECOA), Universidad Nacional de Jujuy - Consejo Nacional de Investigaciones Científicas y Técnicas (UNJU-CONICET), Facultad de Ciencias Agrarias, Catedra de Evolución, Alberdi 47, C.P. 4600, San Salvador de Jujuy, Jujuy, Argentina.
[2] Seccional Lago Krugger, Parque Nacional Los Alerces, Argentina.
[3] Seccional Los Arrayanes, Parque Nacional Los Alerces, Argentina.
[4] Corresponding author: freddygburgos@gmail.com

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**ABSTRACT:** This study describes the observation of a predation event upon Chilean Hawk (*Accipiter chilensis*) by a Rufous-tailed Hawk (*Buteo ventralis*) in the Austral Forests of Argentina. The Rufous-tailed Hawk seems not only feeding on small birds but also on birds of prey, according to our observations in Alerces National Park, where this had not been recorded previously.

**KEY-WORDS:** Austral Forest, intraguild predation, Patagonia, raptor.

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The concept of intraguild predation consists of one species killing and consuming another species that competes for similar feeding sources. In other words, such species behaves as a competitor and predator within the same trophic level (Polis *et al.* 1989, Lourenço *et al.* 2014). Limited information exists regarding intraguild predation on raptors (Sergio & Hiraldo 2008,the killing of species that use similar resources, has been largely overlooked in raptor investigations. To help fill this gap in knowledge, we conducted a literature review, focusing on studies that tested the behavioural and demographic impact of intraguild predation on individuals, populations, and assemblages of diurnal and nocturnal raptorial species. Overall, data were available for 39 empirical and experimental studies on 63 populations belonging to 11 killer species and 15 victim species. An overview of these studies suggested that intraguild predation was a widespread, size-based phenomenon. Results from multiple studies on the same species at different locations were usually consistent across wide geographical areas. Individual-level demographic impacts included reduced site-occupancy, breeding success and survival. Individuals of the prey species responded to predation pressure through direct spatial avoidance, risk-sensitive habitat selection, short-term behavioural avoidance (e.g. reduced vocal activity and escape to refugia after predator detection López-López *et al.* 2016). In Argentina, Bó *et al.* (2007) reported an extensive synthesis on trophic ecology of raptors, yet they did not report this type of interaction for any Argentinian raptor.

The distribution of the rare and mysterious Rufous-tailed Hawk (*Buteo ventralis*) is restricted to the Temperate Austral Forests in southern Chile and Argentina, ranked as "Vulnerable" on a global scale due to its natural rarity (Ferguson-Lees & Christie 2001, Gelain & Trejo 2001, BirdLife International 2016). The Rufous-tailed Hawk preys mainly upon birds (55%) and small mammals (38%) (Figueroa *et al.* 2000). The few data available about the feeding of Rufous-tailed Hawk indicates that it normally preys upon *Vanellus chilensis*, *Columba araucana*, *Colaptes pitius*, *Sturnella loica*, *Turdus falcklandii*, without ruling out poultry such as *Phasianus* spp., *Gallus* spp., C*olumba* ssp., and in a lesser degree, reptiles and insects (Figueroa *et al*. 2000, Pastore *et al*. 2007).

On 6 June 2013 at 12:00 h in the Central Arrayanes in Alerces National Park (42º44'37.26''S; 71º44'21.39''W), to the west of the province of Chubut, Argentina, we observed a *Buteo ventralis* flying with a prey and after on the branch of an Coihue Tree (*Nothofagus dombeyi*) holding a prey in its claws. The prey was identified as an *Accipiter* sp., assumed to be the Chilean Hawk (*Accipiter chilensis*) since it is the only hawk of the genus *Accipiter* that inhabits the region (Ferguson-Lees & Christie 2001). The observation lasted between

45–60 min, when photographs were taken of the species consuming its prey (Fig. 1). The *B. ventralis* was tearing apart Accipiter's chest muscles and some feathers with its beak, while consuming them assiduously. Afterwards it flew toward the forest interior, making us unable to observe the total consumption of the *Accipiter*. This is the first record of Rufous-tailed hawk in Alerces National Park—which was created in 1937 and protects 259,570 ha of well-preserved Andean Patagonian Forest - where, at the very least, the Rufous-tailed Hawk seems to maintain a healthy population, given its frequent sightings (Ramos B. pers. obs.).

**Figure 1.** Predation of the Rufous-tailed Hawk (*Buteo ventralis*) on the Chilean Hawk (*Accipiter chilensis*) in Central Arrayanes, Argentina (**A**, **B**, **C**), on 06 June 2013. Adult of Rufous-tailed Hawk on 03 April 2014 in Parque Nacional Los Alerces, Argentina (**D**).

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ARTICLE

# Bird mortality due to collisions in glass panes on an Important Bird Area of southeastern Brazil

**Lucas Penna Soares Santos[1,2,3], Vinícius Ferreira de Abreu[1] & Marcelo Ferreira de Vasconcelos[1]**

[1] Museu de Ciências Naturais, Pontifícia Universidade Católica de Minas Gerais. Avenida Dom José Gaspar, 290, Bairro Coração Eucarístico, 30535-901, Belo Horizonte, MG, Brazil.
[2] Programa de Pós-graduação em Biologia de Vertebrados, Pontifícia Universidade Católica de Minas Gerais. Avenida Dom José Gaspar, 500, Bairro Coração Eucarístico, 30535-610, Belo Horizonte, MG, Brazil.
[3] Corresponding author: penna.lucas@gmail.com

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**ABSTRACT:** Human-caused alterations to the environment are important causes of the loss of bird biodiversity globally. Collisions with windows are the second leading human cause of mortality for birds, and it is estimated that 100 million to one billion birds die due to window collisions annually in the US alone. However, in Brazil there have been no systematic studies on bird mortality due to collisions with man-made structures. Our aims with this study were to record the bird species that died due to collisions with windows in an Important Bird Area of southeastern Brazil, accessing the effects of species characteristics (forest dependence, wing type, threaten status, endemism, migratory habits) and climatic seasonality on bird-window collisions. Dead birds were collected daily during 2010 to 2013 and occasional records were obtained from 2000–2009 and 2014–2015 in *Reserva Particular do Patrimônio Natural Santuário do Caraça*, Minas Gerais, southeastern Brazil. We found 168 birds individuals of 57 species dead due to collisions against windows. Individuals classified as forest dependent and with elliptical type wings were the most common among birds dead due to collisions. There was no difference between the number of dead individuals in the dry and rainy seasons, and rainfall was not correlated with bird collisions. The occurrence of threatened, endemic and migrant species in our sample demonstrates the importance to continue this type of research in Brazil and other localities throughout the Neotropics. Our data can support studies that investigate the influence of other factors and characteristics of natural history of bird collisions, particularly in areas with similar man-made structures as at our study site.

**KEY-WORDS:** bird collisions, mortality, natural history, RPPN Santuário do Caraça, seasonality.

## INTRODUCTION

Human activities can negatively alter natural regions and biological systems, as has been recently discussed in many reports and environmental impact analyses of wild communities (Loss *et al.* 2012). Such human interference can cause significant damage, especially among birds (*e.g.* Bevanger 1994, Piorkowski 2006, Johnson *et al.* 2002, Drewitt & Langston 2008), due to their diversity and their frequent cohabitation with humans in a variety of environments (Le Corre *et al.* 2009, Ryder *et al.* 2012).

Collisions with man-made structures are the second greatest source of human-caused bird mortality worldwide (Klem-Jr. 2008). Such incidents have been documented globally (Avery *et al.* 1978, Avery 1979, Klem-Jr. 1990a, Morrinson 1998, Erickson *et al.* 2001, 2005, Veltri & Klem-Jr. 2005, Hager *et al.* 2008) and represent an important source of negative anthropic influence on nature (Banks 1979, Drewitt & Langston 2006, 2008).

The vulnerability to human impacts and the potential risk of bird collision is related differently for each species and their biological characteristics (Bevanger 1994). The magnitude of the problem is so significant that major changes in the ecology and behavior of birds have been reported (Johnson *et al.* 2002), especially regarding migratory species (Rybak *et al.* 1973, Klem-Jr. 1990a, b, Erickson *et al.* 2001, 2005, Manville 2001, Diehl *et al.* 2014). Some examples include changes in flight routes and lower flight altitudes caused by an increase in obstacles such as wind farms and electric transmission towers (Winkelman 1995, Leddy *et al.* 1999, Borden *et al.* 2010).

Some studies have related the characteristics of particular bird species with human impacts. For example, forest dependent species are more susceptible to negative changes in the environment (Marini 2001, Maldonado-Coelho & Marini 2003, Roma 2006, Ramos *et al.* 2011). Maneuverability, including wing type and flight speed, of each species relates to flight behavior and thus collisions risk (APLIC 2012, Sporer *et al.* 2013). Thus, slow-flying or walking birds do not cover large areas and thus are less prone to collisions than long-distance or fast-flying species (Klem-Jr. 1989, Bevanger 1994). Lastly, seasonal and weather conditions have been reported to influence variation in the annual number of bird collisions (Bevanger 1994, Drewitt & Langston 2008). For example, the collision frequency is directly related to the increase in rainfall, which generally coincides with the reproductive period in southeastern Brazil (Marini & Durães 2001), and is a function of foraging and other biological activities, as well as reduced visibility (Gabrey & Doolber 1996, Steele 2001).

Studies of bird collisions are usually conducted in urban, suburban or rural environments and rarely in protected areas or regions that have been identified as important conservation areas (Klem-Jr. 2008, Gelb & Delacretaz 2009). Important Bird Areas (IBAs) represent a global network of important sites for the conservation of birds and biodiversity. Worldwide, 12,000 IBAs have been identified, with 234 IBAs mapped in Brazil, where endemic and threatened species occur (Develey & Goerck 2009, BirdLife International 2014). Nevertheless, several problems have been reported regarding human interference in areas devoted to conservation, for example, exploration of land use in surroundings, fragmentation, wildfires and ineffective surveillance (Lima *et al.* 2005, Rylands & Brandon 2005).

Records for bird collisions with aircraft, power lines and vehicles have been increasing in Brazil, but there remains much to be understood about this phenomenon (Nascimento *et al.* 2005, Laurance *et al.* 2009, Rosa & Bager 2012). Only a few studies have focused on bird mortality due to collisions with man-made structures in Brazil (ACS 2006, Carrano 2006, Muhlenberg College 2009, Santos *et al.* 2011, Soares *et al.* 2011, Stolk *et al.* 2015), making it difficult to make comparisons and determine influential factors. This is particularly true given the great bird diversity of Brazil and the large size of the country, thereby confounding attempts to develop preventive measures or finding solutions.

In this paper, we report on bird collisions with windows in a Brazilian protected area and IBA, considering characteristics such as forest dependence, wing type, threaten status, endemism and migratory habits of each species. We also tested for a seasonal relationship between seasons (dry and rainy) and the number of dead birds.

## METHODS

### Study area

The *Reserva Particular do Patrimônio Natural Santuário do Caraça* (hereafter RPPNSC - 20°05'51"S; 43°29'18"W; elevation 1290 m a.s.l.), located in the municipalities of Catas Altas and Santa Bárbara, state of Minas Gerais, southeastern Brazil, is a private reserve with 11,233 ha (Santuário do Caraça 2013), in the *Quadrilátero Ferrífero* (Iron Quadrangle) region in the southern portion of the Serra do Espinhaço (Espinhaço Mountain Range; Fig. 1). The region lies within the Atlantic Forest domain, yet close to the Cerrado domain, two world hotspots of biodiversity (Myers *et al.* 2000, Vasconcelos 2000). A very heterogeneous vegetation and different phytophysiognomies are found in RPPNSC, such as high altitude rocky fields (*campos rupestres*), semideciduous and cloud forests (Mota 2006). In contrast, historically, this protected area suffers anthropic pressure in its surroundings, such as mining and farming, interrupting the landscape connectivity, with others protected and natural areas (Vasconcelos 2013).

The climate of RPPNSC is seasonal, with well-defined dry (April to September) and rainy (October to March) seasons, with mild mean annual temperatures (18–19°C) and low (0°C or less) temperatures mainly at higher elevations (Dutra *et al.* 2002). The Köppen-Geiger climatological classification defines this area as Cwb (humid temperate climate with dry winters and temperate summers, similar to tropical climate of altitude) (Alvares *et al.* 2013) and the annual average rainfall is above 1500 mm.

In the area 372 bird species had been recorded, including 13 threatened species, 75 migrants, 74 Atlantic Forest endemics, four Cerrado endemics and four species restricted to mountain-tops of southeastern Brazil (Chesser 1994, Vasconcelos 2013). Serra do Caraça has one of the richest avifaunas of eastern Brazil, it is an important area for bird conservation on both regional and global scales (Vasconcelos & Melo-Júnior 2001, Bencke *et al.* 2006, Develey & Goerck 2009). The area is located in an IBA (BR145; BirdLife International 2009, 2012, Develey & Goerck 2009), an Endemic Bird Area (EBA 073; Stattersfield *et al.* 1998) and a Biosphere Reserve (UNESCO 2005).

### Data collection

The RPPNSC is locally well known for its historical man-made architecture. One of the buildings is the Caraça Museum (Fig. 1), which is 70 m nearly from the forested vegetation and has sides that comprised large, reflective tempered glass windows (Fig. 2). On those windows (408.5 $m^2$) occur bird collisions under investigation in the present study.

Dead birds were collected daily, but stored in freezer by monthly lots, during 2010 to 2013, with the assistance of the environmental team of RPPNSC. Additional casual non-systematic records were carried out during 2000–2009 and 2014–2015. Specimens found dead were placed in individual plastic bags with a label

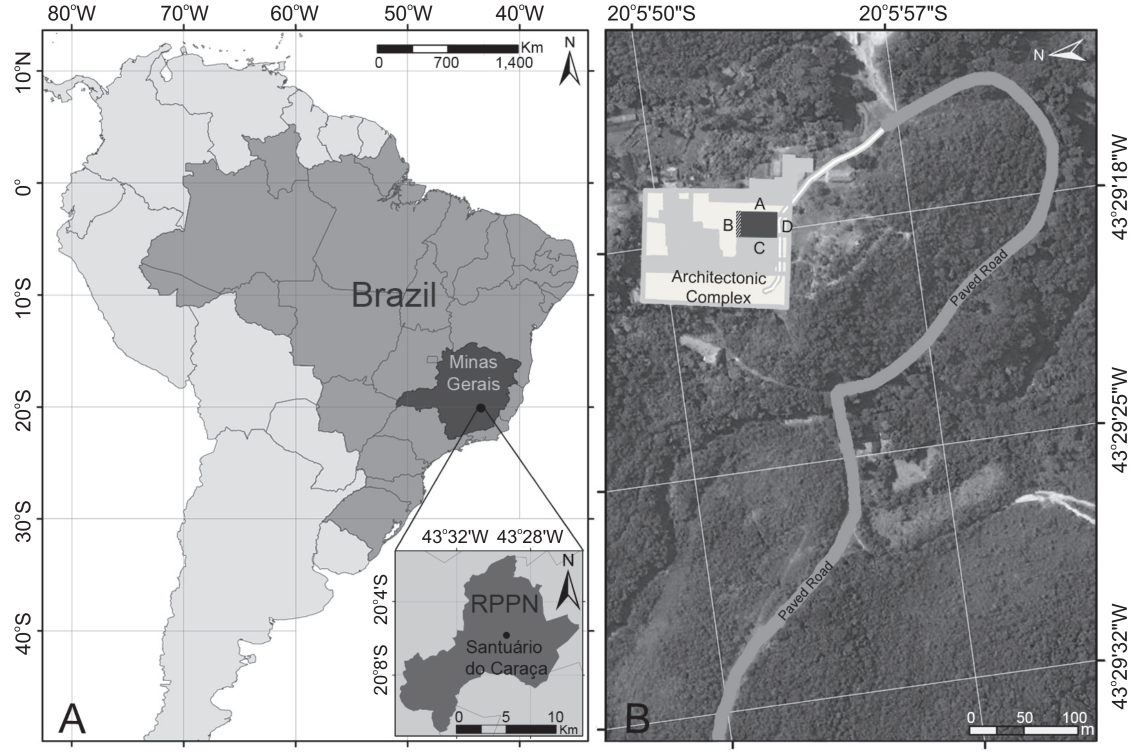

**Figure 1.** Location map (**A**) and aerial image of the *Reserva Particular do Patrimônio Natural Santuário do Caraça*, showing the architectural complex (**B**). The dark grey box is the Caraça Museum with sides (**A–D**) comprised of windows.

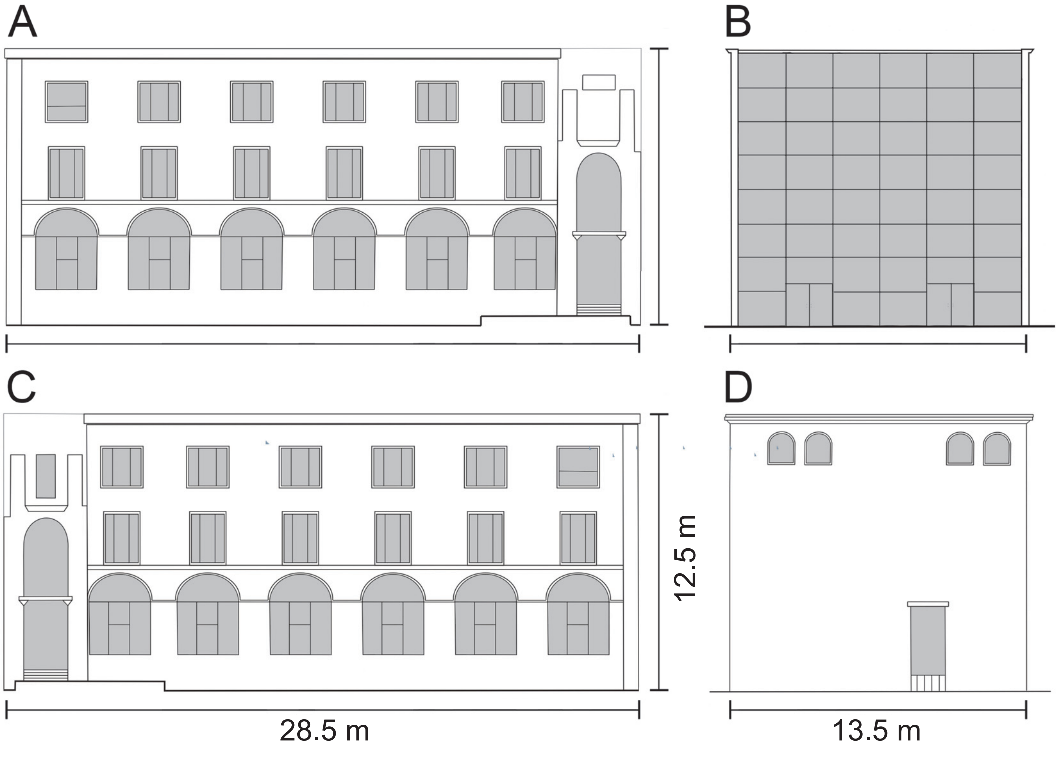

**Figure 2.** Architectural sketch of Caraça Museum showing the details of the building and the width, height and depth of its sides. Percentage and area (in m$^2$) of glass (grey areas) on each side of the Caraça Museum: (**A**) ≅ 31% (110); (**B**) ≅ 90% (151.5); (**C**) ≅ 34.9% (124.2); (**D**) ≅ 13.6% (22.8).

containing basic collection data and frozen. Specimens were deposited (mostly as study skins and/or skeletons) in the following collections: *Museu de Ciências Naturais da Pontifícia Universidade Católica de Minas Gerais* (MCNA), Department of Zoology of the *Universidade Federal de Minas Gerais* (DZUFMG) and *Museu de Zoologia da Universidade de São Paulo* (MZUSP). We identified all individuals to species level following nomenclature in Piacentini *et al.* (2015).

### Data analysis

We classified the specimens qualitatively and quantitatively for attributes from the literature: I) Forest dependence (Silva 1995, Parker-III *et al.* 1996): 1) independent (species that occur in open vegetation), 2) semi-dependent (species that occur in open vegetation and forest), and 3) dependent (species found mainly in forest habitats); II) Wing types (Scott & McFarland 2010): 1) elliptical, 2) game bird, 3) high-aspect ratio, 4) high-speed, and 5) slotted high-lift; III) Threat status: 1) global (IUCN 2015), 2) national (MMA 2014a, b), and 3) state (COPAM 2010); IV) Endemism: 1) Cerrado (Silva 1995), 2) Atlantic Forest (Brooks *et al.* 1999) and 3) mountaintops of eastern Brazil (Vasconcelos 2008); and V) Migration: austral migrants (*sensu* Chesser 1994).

To test for significant differences in the proportions of collided birds among categories of forest dependence and wing types, we use separate Chi-Square tests with no difference among categories as the expected proportion. We also performed Partition Likelihood Ratio Chi-Square to evaluate relationships between categories of both of these characteristics.

To test for differences in the number of birds dead from collision between the two seasons (dry and rainy) we used the Shapiro-Wilk test for normality and, subsequently, *t*-test for two independent samples (parametric). The *F*-test was used to compare sample distributions of the two seasons. We analyzed the seasonality only for specimens for which the month of their collision was known. A rate per day (the number of collided birds by the total of days in each season) was used for comparison between the systematic sampling periods.

Using monthly rainfall (in mm) at RPPNSC during 2010–2013, we assessed differences in rainfall for each season using factorial ANOVA. To evaluate rainfall as a factor of bird mortality, we performed a Pearson product moment correlation between average monthly rainfall and number of individuals found dead from collision.

Statistical analyses were conducted in R Software (R Core Team 2017; $\alpha = 0.05$) and used all birds found dead as a result of colliding with the windows of the Caraça Museum. Plotrix package v. 3.6-1 (Lemon *et al.* 2015) was used for producing the radial graph.

## RESULTS

A total of 168 specimens of 57 species (Appendix I) were found dead presumably due to collisions with glass panes of the Caraça Museum. The mortality rates for the period of systematic sampling (102 individuals in 2010–2013) were of ≅ 2.12 deaths/month and 25.50 deaths/year.

The orders most affected were Passeriformes (102 individuals) and Columbiformes (44) (Table 1). Regarding families, the most affected were Columbidae (44 individuals), Thraupidae (35), Trochilidae (16) and Hirundinidae (15), whereas the most affected genera were *Turdus* (13) and *Tangara* (11). The most commonly

**Table 1.** Orders of birds dead due to collisions with windows of the Caraça Museum, Minas Gerais state, Brazil, and the number of individuals for each category of forest dependence and wing type.

| | Galiiformes | Accipritiformes | Columbiformes | Psitaciformes | Apodiformes | Coraciiformes | Piciformes | Passeriformes | Total |
|---|---|---|---|---|---|---|---|---|---|
| Dependent | 2 | 1 | 41 | 0 | 9 | 0 | 0 | 44 | 97 |
| Semi-dependent | 0 | 0 | 3 | 1 | 6 | 1 | 1 | 27 | 39 |
| Independent | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 31 | 32 |
| Elliptical | 0 | 1 | 44 | 0 | 0 | 1 | 0 | 87 | 133 |
| High-speed | 0 | 0 | 0 | 1 | 16 | 0 | 0 | 15 | 32 |
| Slotted | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Game Bird | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | 2 | 1 | 44 | 1 | 16 | 1 | 1 | 102 | 168 |

encountered species were the Plumbeous Pigeon (*Patagioenas plumbea*) (35 individuals) and the Blue-and-white Swallow (*Pygochelidon cyanoleuca*) (13).

We found greater mortality for forest dependent (97 individuals; 57.8%) and semi-dependent (39; 23.2%) species than independent species (32; 19.0%). Forest dependence had the greatest influence on bird mortality ($\chi^2 = 46.46$; $P < 0.0001$).

Among wing types, species classified as having elliptical wings were the most affected (133 individuals; 79.2%), followed by high-speed (32; 19%), game bird (2; 1.2%) and slotted high-lift (1; 0.6%) wings. Elliptical wings differed significantly from the other categories of wing types ($\chi^2 = 277.67$; $P < 0.0001$).

The interaction between the natural history characteristics of forest dependence and wing type had a significant general value (Table 2). A significant difference was found for partition one ($\chi^2_{2\times3\ \text{tables}} = 24.11$; $P = 0.0001$), demonstrating that individuals classified as forest dependent with elliptical wings are more frequently affected by collisions.

In relation to threaten status, only two species were considered globally "Near Threatened": the Hyacinth Visorbearer *Augastes scutatus* (1 individual) and the Swallow-tailed Cotinga *Phibalura flavirostris* (2 individuals); the latter is also considered "Vulnerable" in the state of Minas Gerais. All other specimens were classified as "Least Concern" species at the global, national and/or state levels.

Endemic species were represented by 38 specimens of the Atlantic Rain Forest and one (Hyacinth Visorbearer) from the mountains of eastern Brazil. Twenty-seven individuals of 10 species of austral migrants were found dead by collisions throughout our study.

No significant seasonal mortality pattern was found between the rainy (44 individuals; rate [collided birds/rainy days] = 16.56) and dry (54; rate [collided birds/dry days] = 13.55) seasons ($t = 0.96$; $P = 0.362$; $F = 1.01$; $P = 0.99$) (Fig. 3). The significant difference in monthly rainfall between the seasons ($F$(seasons) = 37.44; $P < 0.0001$) was not correlated with bird mortality.

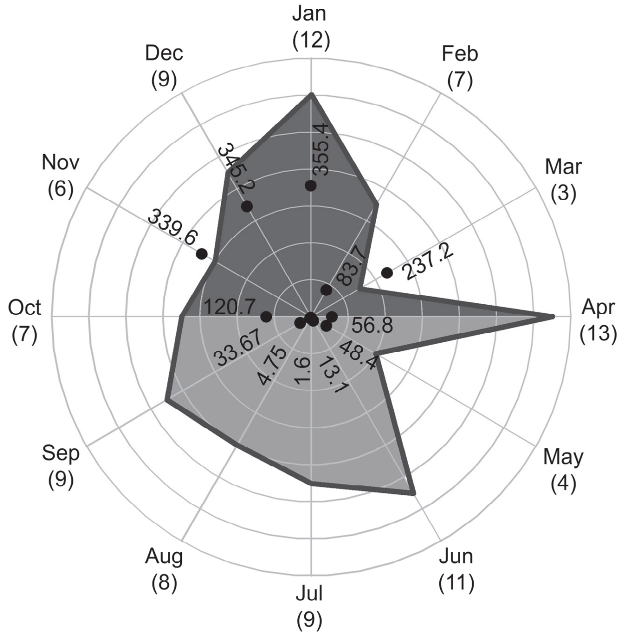

**Figure 3.** Radial graph of the average number of individuals found dead in each month of the two study seasons (polygon; light grey: dry season; dark grey: rainy season; grid scale: 0–14). Data points (in black) and respective numbers reveal the average monthly rainfall (mm) for 2010–2013 in *RPPN Santuário do Caraça* (grid scale: 0–700).

## DISCUSSION

Sixteen percent of the total number of bird species known to occur in RPPNSC was affected by collisions with the studied structure. However, it is important to stress that, even with the helpful assistance of the environmental team of the reserve, it is possible that several dead specimens were overlooked. Specimens may have been missed due to their rapid decomposition due to natural factors such as weather, sunlight, rain, necrophagous animals (invertebrates such as ants, flies, beetles) and other biological agents (bacterial digestion) (Crawford 1971, Balcomb 1986, Pain 1991, Wobeser & Wobeser 1992). Scavengers and opportunist vertebrate predators also can remove small bird carcasses within a matter of a

**Table 2.** Number of individuals dead due to collisions with windows of the Caraça Museum, Minas Gerais state, Brazil, classified by category of interaction between forest dependence and wing type.

| Categories | Dependent | Semi-dependent | Independent |
|---|---|---|---|
| Elliptical | 86 | 31 | 16 |
| High-speed | 9 | 7 | 16 |
| Game bird | 2 | 0 | 0 |
| Slotted high-lift | 0 | 1 | 0 |
| Chi-square value | | | 30.295 |
| Significance level | | | $P < 0.0001$ |

few minutes after death and it is also believed that many collisions may not result in immediate death, which may imply that most of the studies on bird mortality due to human factors are underestimates (Klem-Jr. 1990a, Morris 2002, Antworth *et al.* 2005, Kummer *et al.* 2016).

Forest dependent birds were most frequently affected by collisions in RPPNSC. We interpret this as the Caraça Museum building disrupts a natural corridor formed by the surrounding vegetation, and forest birds fail to recognize this obstacle as a change of habitat. In contrast, the lower number of forest independent species can be attributed to their ability to recognize edges in open areas, since these species should have a better perception of obstacles, and thus be more able to avoid them.

In general, forest dependent species react more negatively to environmental changes than forest independent species. For example, the presence of forests next to roads increased roadkill of forest species (Marini 2001, Ramos *et al.* 2011). Although it is known that forest birds avoid crossing large open areas (Grubb-Jr. & Doherty-Jr. 1999, Develey & Stouffer 2001), these species perform frequent movements in their environments and may cross-forest fragments, especially those species adapted to patchy environments (Marini 2001, Yabe *et al.* 2010).

The high incidence of collisions by native pigeons (Columbidae), especially the Plumbeous Pigeon, significantly influenced the interpretation of our analysis. Perhaps the abundance of this species in RPPNSC, and the patterns of its biological activities, such as feeding, dispersal and reproduction are responsible for the high collision rate of this species. In conjunction, the abundance and differential use of specific habitats by bird populations is also of fundamental importance to predicting collisions (De Lucas *et al.* 2008, Marques *et al.* 2014). Other studies also report a high incidence of accidents with Columbidae species, including birdstrikes on aircrafts and windows collisions (Dolbeer 2006, Kitowski 2011, Ocampo-Peñuela *et al.* 2016).

Different wing types are associated with different flight performances (Warham 1977, Copete 1999). In the case of power lines, flight behavior is one of the most important biological features for bird collisions (Bevanger 1994, Janss 2000). The prominent number of collisions by birds with elliptical wings in the present study indicates that birds with this characteristic have a greater tendency for collisions. Scott and McFarland (2010) explain that birds with elliptical wings have quick bursts of speed and are most adept at navigating densely vegetated habitats. This fact contextualizes the high representation of this category in our sample, especially due to the proximity of vegetation to the Caraça Museum. Further, the strong association of elliptical wings and forest dependent birds, which the most represented orders were Passeriformes and Columbiformes, can be related with the susceptible when they cross open environments and other characteristics, such as photophobia and forest proximity.

Sporer *et al.* (2013) noted that high-speed and elliptical-winged birds frequently collide with power lines. High-speed birds were represented in our sample by some species of Trochilidae and Hirundinidae, which not only possess fast flight, but also can remain in flight for a greater period of time (Scott & McFarland 2010). Jenkins *et al.* (2010) pointed out that high speed affects the reaction time of birds to avoid collisions with anthropic structures. Game birds, which generally have slotted and high-aspect wing types, were not abundant in our sample, and exhibit other flight performances such as soaring, lift and difficult take-offs.

The frequency of collisions with the large windows of the Caraça Museum can be evaluated in the context of the surrounding landscape and thus the reflections of the vegetation in the windows (Ogden 1996, Gelb & Delacretaz 2009, Klem-Jr. 2009). The Caraça Museum is adjacent to a large forested area, but is situated in an open space inside the architectural complex. Sensory analyses have determined that birds perceive such reflections as an extension of the physical environment, and their visual system is not exclusively dedicated to perceiving fixed obstacles, such as human structures, thus eventually leading to collisions with windows (Martin & Shaw 2010, Martin 2011).

Our data did not show any seasonal difference in bird mortality between dry and rainy seasons. The RPPNSC experiences high variation in monthly rainfall, but slight oscillations in other abiotic factors such as temperature and wind speed and direction, as has been reported previously (Moreira & Pereira 2013). A relationship between bird collisions with artificial structures and seasonal patterns can be more important in regions where climate conditions exhibit larger variations, but is also related to routes and additional types of migrant species (*e.g.* Klem-Jr. 1989, Borden *et al.* 2010).

Other weather and meteorological factors, such as daily temperature, air humidity, sunlight, clouds and mist, change the perception of, and interaction with, the physical environmental by birds (*e.g.* Bevanger 1994, Drewitt & Langston 2008, Martin 2011). In the Neotropical region, the influence of these conditions on bird collisions is still unknown, and there certainly are other environmental factors shaping this interaction, such as changes in the composition of food resources or patterns of other biological activities. Further exploration of seasonal patterns of birds may help to uncover fundamental answers about bird collisions, and provide important information for strategies to mitigate this problem (Borden *et al.* 2010).

It is important to stress that all bird species are not equally susceptible to mortality by collisions (Bevanger 1994, Drewitt & Langston 2008, Loss *et al.* 2014). Borden *et al.* (2010) mention that bird collisions are a complex question and there are no simple relationships that explain it in its entirety. Furthermore, species behavioral and ecological characteristics can be modified over time to adapt to man-made changes in nature.

Our data can be useful for preventing future negative impacts on the avifauna of several forested areas with man-made constructions similar to the Caraça Museum, a common type of building (large windows near forest areas) present in many natural places in Brazil, such as the Serra da Mantiqueira, for example (Vasconcelos & D'Angelo-Neto 2009). Some mitigating and preventive measures are indicated as practical ways to reduce bird mortality in several places, such as cover buildings with opaque curtains or safety nets and add colorful decals or predators silhouettes on windows (Klem-Jr. 1990b, 2009, Bevanger 1994).

Furthermore, there is a range of additional natural history and ecological characteristics to explore that may provide insight into collisions, such as wing biometry, speed/distance in flight and comparative optical systems. This information could be integrated with species survey, population dynamics and abundance data in analyses to better understand the causes of bird collisions.

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## APPENDIX I

List of species found dead due to collisions with the Caraça Museum (*RPPN Santuário do Caraça*) and their respective data, as follow: Forest dependence: D - Dependent; S - Semi-dependent and; I - Independent; Wing type: E - Elliptical; HS - High-Speed; ST - Slotted; GB - Game Bird; Conservation Status: LC - Least Concern; NT - Near Threatened; $^{G}$ Globally Level; $^{N}$ National Level; $^{S}$ State Level; Seasonality: month of collision (number of individuals that collided); $^{AF}$ Atlantic Rain Forest Endemism; $^{MT}$ Mountaintops of Southeastern Brazil Endemism; $^{M}$ Migratory species.

| **Taxon** | **Number of individual** | **Forest dependence** | **Wing type** | **Conservation status** | **Seasonality** |
|---|---|---|---|---|---|
| **Cracidae Rafinesque, 1815** | | | | | |
| Dusky-legged Guan<br>*Penelope obscura* Temminck, 1815 | 2 | D | GB | LC$^{G, N, S}$ | 2 (1), 4 (1) |
| **Accipitridae Vigors, 1824** | | | | | |
| Bicolored Hawk $^{M}$<br>*Accipiter bicolor* (Vieillot, 1817) | 1 | D | E | LC$^{G, N, S}$ | - |
| **Columbidae Leach, 1820** | | | | | |
| Blue Ground-Dove<br>*Claravis pretiosa* (Ferrari-Perez, 1886) | 1 | S | E | LC$^{G, N, S}$ | 11 (1) |
| Plumbeous Pigeon<br>*Patagioenas plumbea* (Vieillot, 1818) | 35 | D | E | LC$^{G, N, S}$ | 1 (4), 2 (2), 4 (2), 5 (1),<br>6 (1), 9 (1), 12 (2) |
| White-tipped Dove<br>*Leptotila verreauxi* Bonaparte, 1855 | 2 | S | E | LC$^{G, N, S}$ | 1 (1) |
| Gray-fronted Dove<br>*Leptotila rufaxilla* (Richard & Bernard, 1792) | 4 | D | E | LC$^{G, N, S}$ | 4 (2) |
| Ruddy Quail-Dove<br>*Geotrygon montana* (Linnaeus, 1758) | 2 | D | E | LC$^{G, N, S}$ | 6 (1), 9 (1) |
| **Psittacidae Rafinesque, 1815** | | | | | |
| White-eyed Parakeet<br>*Psittacara leucophthalmus* (Statius Muller, 1776) | 1 | S | HS | LC$^{G, N, S}$ | - |
| **Trochilidae Vigors, 1825** | | | | | |
| Planalto Hermit<br>*Phaethornis pretrei* (Lesson & Delattre, 1839) | 1 | S | HS | LC $^{G, N, S}$ | - |
| Scale-throated Hermit $^{AF}$<br>*Phaethornis eurynome* (Lesson, 1832) | 1 | D | HS | LC $^{G, N, S}$ | 7 (1) |
| White-vented Violetear<br>*Colibri serrirostris* (Vieillot, 1816) | 1 | S | HS | LC $^{G, N, S}$ | 4 (1) |
| Glittering-bellied Emerald $^{M}$<br>*Chlorostilbon lucidus* (Shaw, 1812) | 3 | S | HS | LC $^{G, N, S}$ | 3 (1) |
| Violet-capped Woodnymph $^{AF}$<br>*Thalurania glaucopis* (Gmelin, 1788) | 1 | D | HS | LC $^{G, N, S}$ | 7 (1) |
| Versicolored Emerald<br>*Amazilia versicolor* (Vieillot, 1818) | 1 | D | HS | LC $^{G, N, S}$ | 10 (1) |
| Sapphire-spangled Emerald<br>*Amazilia lactea* (Lesson, 1832) | 3 | D | HS | LC $^{G, N, S}$ | 4 (1), 6 (1), 7 (1) |
| Brazilian Ruby $^{AF}$<br>*Heliodoxa rubricauda* (Boddaert, 1783) | 3 | D | HS | LC $^{G, N, S}$ | 10 (1) |
| Hyacinth Visorbearer $^{MT}$<br>*Augastes scutatus* (Temminck, 1824) | 1 | I | HS | NT $^{G}$; LC $^{N, S}$ | 4 (1) |
| Amethyst Woodstar $^{M}$<br>*Calliphlox amethystina* (Boddaert, 1783) | 1 | S | HS | LC $^{G, N, S}$ | - |

| **Taxon** | **Number of individual** | **Forest dependence** | **Wing type** | **Conservation status** | **Seasonality** |
|---|---|---|---|---|---|
| **Alcedinidae Rafinesque, 1815** | | | | | |
| Green Kingfisher<br>*Chloroceryle americana* (Gmelin, 1788) | 1 | S | E | LC$^{G, N, S}$ | 1 (1) |
| **Ramphastidae Vigors, 1825** | | | | | |
| Toco Toucan<br>*Ramphastos toco* Statius Muller, 1776 | 1 | S | ST | LC$^{G, N, S}$ | - |
| **Thamnophilidae Swainson, 1824** | | | | | |
| Large-tailed Antshrike$^{AF}$<br>*Mackenziaena leachii* (Such, 1825) | 1 | D | E | LC$^{G, N, S}$ | 7 (1) |
| **Furnariidae Gray, 1840** | | | | | |
| Rufous Hornero<br>*Furnarius rufus* (Gmelin, 1788) | 1 | I | E | LC$^{G, N, S}$ | - |
| Pallid Spinetail$^{AF}$<br>*Cranioleuca pallida* (Wied, 1831) | 2 | D | E | LC$^{G, N, S}$ | 2 (1), 8 (1) |
| **Pipridae Rafinesque, 1815** | | | | | |
| Serra do Mar Tyrant-Manakin$^{AF}$<br>*Neopelma chrysolophum* Pinto, 1944 | 1 | D | E | LC$^{G, N, S}$ | 9 (1) |
| White-bearded Manakin<br>*Manacus manacus* (Linnaeus, 1766) | 1 | D | E | LC$^{G, N, S}$ | 5 (1) |
| Pin-tailed Manakin$^{AF}$<br>*Ilicura militaris* (Shaw & Nodder, 1809) | 2 | D | E | LC$^{G, N, S}$ | 9 (1) |
| Swallow-tailed Manakin$^{AF}$<br>*Chiroxiphia caudata* (Shaw & Nodder, 1793) | 4 | D | E | LC$^{G, N, S}$ | 4 (1), 5 (1), 6 (1) |
| **Tityridae Gray, 1840** | | | | | |
| White-winged Becard$^{M}$<br>*Pachyramphus polychopterus* (Vieillot, 1818) | 1 | S | E | LC$^{G, N, S}$ | 9 (1) |
| **Cotingidae Bonaparte, 1849** | | | | | |
| Swallow-tailed Cotinga$^{M}$<br>*Phibalura flavirostris* Vieillot, 1816 | 2 | D | E | NT$^{G}$; LC$^{N}$; VU$^{S}$ | 11 (1) |
| **Rhynchocyclidae Berlepsch, 1907** | | | | | |
| Gray-hooded Flycatcher$^{AF}$<br>*Mionectes rufiventris* Cabanis, 1846 | 5 | D | E | LC$^{G, N, S}$ | 6 (2), 11 (1) |
| Hangnest Tody-Tyrant$^{AF}$<br>*Hemitriccus nidipendulus* (Wied, 1831) | 2 | S | E | LC$^{G, N, S}$ | 6 (2) |
| **Tyrannidae Vigors, 1825** | | | | | |
| Great Kiskadee$^{M}$<br>*Pitangus sulphuratus* (Linnaeus, 1766) | 2 | I | E | LC$^{G, N, S}$ | - |
| Velvety Black-Tyrant$^{AF}$<br>*Knipolegus nigerrimus* (Vieillot, 1818) | 6 | S | E | LC$^{G, N, S}$ | 5 (1), 6 (2) |
| **Hirundinidae Rafinesque, 1815** | | | | | |
| Blue-and-white Swallow$^{M}$<br>*Pygochelidon cyanoleuca* (Vieillot, 1817) | 13 | I | HS | LC$^{G, N, S}$ | 1 (3), 10 (1), 12 (4) |
| Southern Rough-winged Swallow$^{M}$<br>*Stelgidopteryx ruficollis* (Vieillot, 1817) | 2 | I | HS | LC$^{G, N, S}$ | - |
| **Turdidae Rafinesque, 1815** | | | | | |
| Yellow-legged Thrush$^{M}$<br>*Turdus flavipes* Vieillot, 1818 | 3 | D | E | LC$^{G, N, S}$ | 4 (1) |
| Pale-breasted Thrush<br>*Turdus leucomelas* Vieillot, 1818 | 1 | S | E | LC$^{G, N, S}$ | - |
| Rufous-bellied Thrush<br>*Turdus rufiventris* Vieillot, 1818 | 2 | I | E | LC$^{G, N, S}$ | 12 (1) |

| Taxon | Number of individual | Forest dependence | Wing type | Conservation status | Seasonality |
|---|---|---|---|---|---|
| Creamy-bellied Thrush $^{M}$<br>*Turdus amaurochalinus* Cabanis, 1850 | 2 | S | E | LC$^{G, N, S}$ | 10 (2) |
| White-necked Thrush<br>*Turdus albicollis* Vieillot, 1818 | 5 | D | E | LC$^{G, N, S}$ | 7 (1), 8 (1), 12 (1) |
| **Passerellidae Cabanis & Heine, 1850** | | | | | |
| Rufous-collared Sparrow<br>*Zonotrichia capensis* (Statius Muller, 1776) | 1 | I | E | LC$^{G, N, S}$ | 1 (1) |
| **Icteridae Vigors, 1825** | | | | | |
| Red-rumped Cacique<br>*Cacicus haemorrhous* (Linnaeus, 1766) | 2 | S | E | LC$^{G, N, S}$ | 2 (1), 11 (1) |
| Shiny Cowbird<br>*Molothrus bonariensis* (Gmelin, 1789) | 1 | I | E | LC$^{G, N, S}$ | - |
| **Thraupidae Cabanis, 1847** | | | | | |
| Cinnamon Tanager<br>*Schistochlamys ruficapillus* (Vieillot, 1817) | 1 | I | E | LC$^{G, N, S}$ | 11 (1) |
| Sayaca Tanager<br>*Tangara sayaca* (Linnaeus, 1766) | 6 | S | E | LC$^{G, N, S}$ | 2 (1), 8 (1), 9 (1), 10 (1) |
| Palm Tanager<br>*Tangara palmarum* (Wied, 1821) | 1 | S | E | LC$^{G, N, S}$ | 8 (1) |
| Golden-chevroned Tanager $^{AF}$<br>*Tangara ornata* (Sparrman, 1789) | 2 | D | E | LC$^{G, N, S}$ | 2 (1) |
| Burnished-buff Tanager<br>*Tangara cayana* (Linnaeus, 1766) | 2 | I | E | LC$^{G, N, S}$ | - |
| Saffron Finch<br>*Sicalis flaveola* (Linnaeus, 1766) | 3 | I | E | LC$^{G, N, S}$ | - |
| Uniform Finch $^{AF}$<br>*Haplospiza unicolor* Cabanis, 1851 | 4 | D | E | LC$^{G, N, S}$ | 4 (1), 7 (1), 12 (1) |
| Black-goggled Tanager $^{AF}$<br>*Trichothraupis melanops* (Vieillot, 1818) | 1 | D | E | LC$^{G, N, S}$ | 8 (1) |
| Ruby-crowned Tanager $^{AF}$<br>*Tachyphonus coronatus* (Vieillot, 1822) | 4 | D | E | LC$^{G, N, S}$ | 4 (1), 8 (1), 9 (1) |
| Swallow Tanager<br>*Tersina viridis* (Illiger, 1811) | 1 | D | E | LC$^{G, N, S}$ | 4 (1) |
| Blue Dacnis<br>*Dacnis cayana* (Linnaeus, 1766) | 5 | S | E | LC$^{G, N, S}$ | 7 (1) |
| *Sporophila* sp. | 2 | I | E | - | 1 (1) |
| Yellow-bellied Seedeater<br>*Sporophila nigricollis* (Vieillot, 1823) | 1 | I | E | LC$^{G, N, S}$ | 7 (1) |
| Green-winged Saltator<br>*Saltator similis* d'Orbigny & Lafresnaye, 1837 | 1 | S | E | LC$^{G, N, S}$ | - |
| **Fringillidae Leach, 1820** | | | | | |
| Blue-naped Chlorophonia<br>*Chlorophonia cyanea* (Thunberg, 1822) | 6 | D | E | LC$^{G, N, S}$ | 3 (1), 6 (1), 7 (1) |

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# Body condition of five passerines in a forest fragment and associated factors

**Daniella Reis Fernandes Teles**[1,2], **Thaís Dantas**[1] **& Celine de Melo**[1]

[1] UFU – Universidade Federal de Uberlândia, Programa de Pós-graduação em Ecologia e Conservação de Recursos Naturais, Rua Ceará s/n, 38400-902, Uberlândia, MG, Brazil.
[2] Corresponding author: daniellarfteles@yahoo.com.br

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**ABSTRACT:** Body condition is a qualitative evaluation of an animal and is directly related to its fitness, with the relative mass index (RMI) as a tool for indirect estimation of energy reserves. This study evaluated if the body condition of birds differs between guilds, if it is reflected in levels of subcutaneous fat, and if it is influenced by the weather season and ectoparasite presence. The RMI was calculated for *Antilophia galeata* (frugivorous), *Arremon flavirostris*, *Eucometis penicillata* (omnivorous), *Basileuterus culicivorus*, and *Myiothlypis leucophrys* (insectivorous). It varied among guilds ($F_{2, 295} = 187.92$; $P < 0.05$), with insectivorous species having negative values. The RMI varied between the wet and dry seasons only for *A. galeata* ($F_{1, 1} = 7.28$; $P < 0.05$) but remained positive throughout the year in omnivorous species. The RMI did not vary with the presence/absence of ectoparasites nor among the different levels of subcutaneous fat, which were predominantly low. The negative RMI of insectivores and its variation in frugivorous between seasons suggest that the body condition is influenced by the type of diet and the availability of food resources, indicating that birds with a specialized diet may be more sensitive to environmental variations that result in fluctuations in the food supply.

**KEY-WORDS:** Cerrado, feeding guild, subcutaneous fat, tick, weather season.

## INTRODUCTION

Studies of fauna that assess the individual physical condition by means of physiological indicators, such as body condition and hormonal status, may be advantageous in obtaining responses from the bird population based on landscape changes (Johnson *et al.* 1985, Janin *et al.* 2011), evaluation of environments in various degrees of conservation (Costa & Macedo 2005), and the conditions of these environments (Møller & Erritzøe 2003, Costa & Macedo 2005). Body condition is a qualitative evaluation of an animal and is directly related to fitness (Gosler 2005, Peig & Green 2010). This condition reflects the amount of energy reserves, the capacity to survive in adverse situations, resistance to parasites or diseases, and/or the ability to attract partners (Costa & Macedo 2005, Gosler 2005, Schulte-Hostedde *et al.* 2005).

The biotic or abiotic conditions, such as reduction in vegetation cover, can increase energy expenditure in defense against predators and therefore positively or negatively affect the body condition of an animal (Amo *et al.* 2007). Furthermore, they can change the viability as to the investment against parasites (Smallridge & Bull 2000) and even force individuals to move from ideal habitats (Amo *et al.* 2007). There are several physiological, biochemical, and morphological methods for evaluating the body condition of an individual (Stevenson & Woods-Jr. 2006, Labocha & Hayes 2012). According to Johnson *et al.* (1985), to assess fat reserves, the options are direct extraction of lipids, a method considered to be the most accurate and costly; measurement of the dry biomass through water extraction; measurement of fat deposits through animal dissection; and the RMI. This index is easily obtained through the mass of individuals caught in the field associated with a morphometric measurement (Jakob *et al.* 1996, García-Berthou 2001, Schulte-Hostedde *et al.* 2001, Velando & Alonso-Alvarez 2003, Ardia 2005, Gosler 2005, Schulte-Hostedde *et al.* 2005, Serrano *et al.* 2008, Peig & Green 2010).

Semideciduous seasonal forests are probably among the most threatened and fragmented ecosystems due to the intensification of land use for agriculture (Oliveira-Filho *et al.* 1994, Lopes *et al.* 2012). As birds are sensitive to habitat loss and in the face of fragmentation (Turner 1996, Marini 2001) it is possible that their body condition reflects environmental and physiological pressures and interactions. Thus, the objectives of this study were to evaluate if the body condition of birds varies among guilds — testing the hypothesis that species with more generalist diets will present a better body condition than the most specialist species — and to check if the body condition is related to subcutaneous fat levels and if it is influenced by the weather season and the presence of ectoparasites.

## METHODS

### Study area

This study was carried out in a forest fragment of 30 ha in the Cerrado Biome (18°57'03''S; 48°12'22''W) on the *Fazenda Experimental do Glória*, Uberlândia, state of Minas Gerais, Brazil, considered a peri-urban area. This area includes gallery forest formations and semideciduous seasonal forest, as well as total isolation in an agricultural matrix (Lopes *et al.* 2011).

The climate of the region is tropical, with a wet season (October to March) and a dry season (April to September). The mean temperature and rainfall vary between seasons (dry: 18°C and 12.1 mm; wet: 22.9°C and 228.5 mm), with 50% of the annual rainfall (1500 to 1600 mm) concentrated in December and February (Alves & Rosa 2008).

### Bird sampling

Birds were captured with mist nets (12 × 3 m and mesh size 19 mm), with 17 to 25 nets arranged in linear transects, between 06:30 and 17:00 h. Bird catches were carried out monthly between September 2011 and August 2012.

Captured individuals were identified and received metal bands provided by CEMAVE/ICMBio (permit no. 359076 for projects no. 2943 and 3238). The nomenclature proposed by the Brazilian Ornithological Records Committee was followed (Piacentini *et al.* 2015). The measurements of the right tarsus were taken with a digital caliper (Lotus®) with 0.01 mm precision, and body mass was measured by means of dynamometer-type weighing (Pesola®) scales, with scales of 30, 60, and 100 g. The subcutaneous fat scale was adapted from IBAMA (1994), with four levels used (Fig. 1), and verified by blowing the feathers covering the wishbone, chest, abdomen, and flanks. Ticks were analyzed qualitatively (presence/absence) through bird body inspection while blowing among the feathers. The prevalence rate of ticks by species was calculated using the number of infested individuals divided by the number of individuals examined (Tolesano-Pascoli *et al.* 2010). Included in the analyses were species with at least five individuals caught in each season (dry and wet), in which it was possible to evaluate the biomass, length of right tarsometatarsus, presence/absence of ectoparasites, and level of subcutaneous fat.

### Data analysis

*Body condition*: was calculated by means of a simple linear regression between the log-transformed (log10) values of biomass and the right tarsus length of every individual. The residuals were used as body condition indices (RMI). The RMI with a negative value indicates poor body condition when compared to positive values (Schulte-Hostedde *et al.* 2005).

*Statistical analysis*: The analysis of variance (ANOVA) verified if the RMI varied among the trophic guilds and among the subcutaneous fat levels of each species. The effect of season weather (dry and wet) and

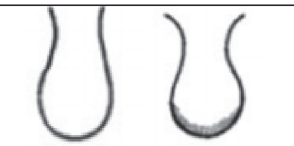
| | | |
|---|---|---|
| 1 |  | With or without a small amount of fat stored in the furcula's cavity but not enough to fill the cavity's bottom. No fat under the wings, abdomen, or elsewhere. |
| 2 |  | The bottom of the furcula's cavity is totally filled, completing 1/3 of the total cavity. |
| 3 |  | The furcula's cavity is 2/3 filled. Some fat can also be seen under the wings and usually in the abdomen. |
| 4 |  | The furcula's cavity is completely filled. A compact layer of fat can also be observed under the wings and abdomen. |

**Figure 1.** Subcutaneous fat scale for birds. Adapted from IBAMA (1994), *Centro de Pesquisas para Conservação das Aves Silvestres* (CEMAVE-ICMBio).

ectoparasites (presence/absence of ticks) on the RMI of each species analyzed, as well as a potential interaction between these factors, was verified through the factorial analysis of variance (Factor ANOVA). Tests were carried out by Systat® 10.2 software (Systat Software, Inc 2002) at a significance level of 5% (Zar 2010).

## RESULTS

Among the 470 individuals captured (39 species), 298 (five species, four families) were used in analyses: *Antilophia galeata* (*n* = 152), *Arremon flavirostris* (*n* = 34), *Basileuterus culicivorus* (*n* = 58), *Myiothlypis leucophrys* (*n* = 28), and *Eucometis penicillata* (*n* = 26) (Fig. 2).

These species are distributed in three feeding guilds: frugivorous, insectivorous, and omnivorous (Table 1). Positive values of RMI in both seasons were detected for *E. penicillata* (omnivorous), followed by *A. galeata* (frugivorous) and *A. flavirostris* (omnivorous) (Table 1). The RMI differed between guilds ($F_{2, 295}$ = 187.92; $P < 0.05$), with lower values for insectivores (-0.127 ± 0.130; Fig. 3).

Only *A. galeata* presented a difference in RMI between seasons ($F_{1, 1}$ = 7.28; $P < 0.05$; Table 2), with values higher in the wet season (0.086 ± 0.047) than in the dry season (0.064 ± 0.041) (Table 1). The species belonging to the Parulidae family, which are strictly insectivorous, had a negative RMI in both seasons (Table 1), thus presenting a body condition inferior to the other species analyzed.

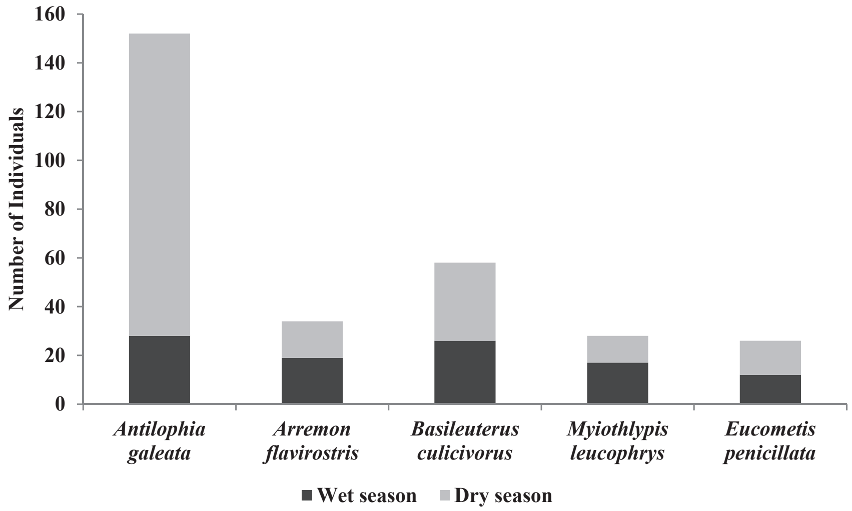


**Figure 2.** Number of individual birds, by species, captured during the wet and dry seasons in Uberlândia, state of Minas Gerais, between September 2011 and August 2012.

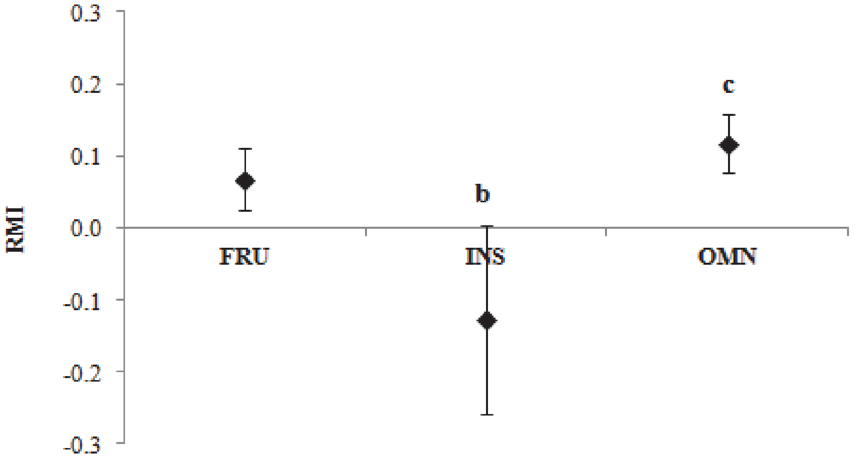


**Figure 3.** Mean ± standard deviation of the relative mass index (RMI) by feed guilds (FRU – frugivorous, INS – insectivorous, OMN – omnivorous) of birds captured at Uberlândia, state of Minas Gerais, between September 2011 and August 2012.

**Table 1.** Bird species recorded, relative mass index values (RMI) (mean ± SD) and prevalence rate of ticks (%). *Feed guild: FRU – frugivorous; INS – insectivorous; OMN – omnivorous, according to Moojen *et al.* (1941), Motta-Júnior (1990), Marini & Cavalcanti (1993), Silva (1996), Marini (1992b; 2001), Francisco & Galetti (2002), Piratelli & Pereira (2002), Manhães (2003), Durães & Marini (2003, 2005), Lopes *et al.* (2005), Scherer *et al.* (2005), Telino-Júnior *et al.* (2005), Lima (2008), Manica *et al.* (2010).

| **Families/species (*n*)** | **Guild*** | **RMI (mean ± SD)** | | | | **Prevalence rate of ticks (%)** | |
|---|---|---|---|---|---|---|---|
| | | **Wet season** | **Dry season** | **No Ticks** | **Ticks** | **Wet season** | **Dry season** |
| **Pipridae** | | | | | | | |
| *Antilophia galeata* (Lichtenstein, 1823) (152) | FRU | 0.086 ± 0.047 | 0.064 ± 0.041 | 0.067 ± 0.042 | 0.075 ± 0.047 | 18 | 19 |
| **Passerellidae** | | | | | | | |
| *Arremon flavirostris* Swainson, 1838 (34) | OMN | 0.062 ± 0.040 | 0.047 ± 0.036 | 0.056 ± 0.041 | 0.053 ± 0.024 | 5 | 33 |
| **Parulidae** | | | | | | | |
| *Basileuterus culicivorus* (Deppe, 1830) (58) | INS | -0.206 ± 0.049 | -0.236 ± 0.068 | -0.221 ± 0.064 | -0.232 ± 0.031 | 4 | 16 |
| *Myiothlypis leucophrys* (Pelzeln, 1868) (28) | INS | -0.150 ± 0.023 | -0.147 ± 0.085 | -0.147 ± 0.035 | -0.151 ± 0.072 | 35 | 64 |
| **Thraupidae** | | | | | | | |
| *Eucometis penicillata* (Spix, 1825) (26) | OMN | 0.137 ± 0.016 | 0.099 ± 0.046 | 0.128 ± 0.028 | 0.096 ± 0.051 | 17 | 50 |

**Table 2.** Results of the Factorial Analysis of Variance (Factorial ANOVA) for seasons (wet and dry) and ectoparasites ticks (presence/absence); and Analysis of Variance (ANOVA) for subcutaneous fat.

| **Species** | **Factors** | ***df*** | ***F*** | ***P*** |
|---|---|---|---|---|
| *Antilophia galeata* | Season | 1 | 7.276 | 0.008 |
| | Ectoparasites | 1 | 2.780 | 0.098 |
| | Interaction (season*ectoparasites) | 1 | 1.766 | 0.186 |
| | Subcutaneous fat | 3 | 1.215 | 0.306 |
| *Arremon flavirostris* | Season | 1 | 0.085 | 0.772 |
| | Ectoparasites | 1 | 0.006 | 0.937 |
| | Interaction (season*ectoparasites) | 1 | 0.281 | 0.600 |
| | Subcutaneous fat | 2 | 0.244 | 0.785 |
| *Basileuterus culicivorus* | Season | 1 | 0.242 | 0.625 |
| | Ectoparasites | 1 | 0.102 | 0.751 |
| | Interaction (season*ectoparasites) | 1 | 0.176 | 0.677 |
| | Subcutaneous fat | 3 | 0.717 | 0.546 |
| *Myiothlypis leucophrys* | Season | 1 | 0.028 | 0.869 |
| | Ectoparasites | 1 | 0.039 | 0.844 |
| | Interaction (season*ectoparasites) | 1 | 0.000 | 0.998 |
| | Subcutaneous fat | 2 | 0.896 | 0.422 |
| *Eucometis penicillata* | Season | 1 | 3.378 | 0.080 |
| | Ectoparasites | 1 | 1.442 | 0.243 |
| | Interaction (season*ectoparasites) | 1 | 0.000 | 0.993 |
| | Subcutaneous fat | 2 | 1.599 | 0.224 |

*Myiothlypis leucophrys* presented the highest prevalence rates for ectoparasites (ticks) in both seasons (Table 1). The RMI of the species was not influenced by the presence/absence of ectoparasites or by the subcutaneous fat (Table 2). The level of subcutaneous fat predominant for each species in both the wet and dry seasons was level 1 (Figs. 4A, B).

## DISCUSSION

The Pipridae family, in general, comprises birds that are easily collected and well represented in collections (Anciães & Peterson 2006, Magalhães *et al.* 2007). *Antilophia galeata* is typical to the Cerrado Forest environments (Silva 1995), present in semideciduous seasonal forests, including small urban fragments (Franchin & Marçal-Júnior 2004, Silva & Melo 2011). It is considered predominantly frugivorous but can be more omnivorous (Marini 1992a) when compared with, for example, *Pipra fasciicauda*, a more specialized frugivorous species. *Antilophia galeata* was the only species to vary in RMI between the dry and wet seasons, being greater in the latter. The reproduction of *A. galeata* at the beginning of the dry season (Marini 1992a), which generates high energy demand, coupled with greater availability of fruit during the wet season (Silva *et al.* 2009, Melo *et al.* 2013) may explain such variation in body condition. In addition, this variation in RMI can be explained by the isolation of the study area, which can be a limiting factor in meeting nutritional needs. This fragment presents a well-structured sub-forest, with no impact of grazing or cattle trampling. Regarding the degree of isolation, the mean distance from other forest patches is 1.9 km, one of which is located within an urban area.

*Arremon flavirostris* and *E. penicillata*, which are generalists, although not differing seasonally in RMI, had positive values, indicating a good and stable body condition

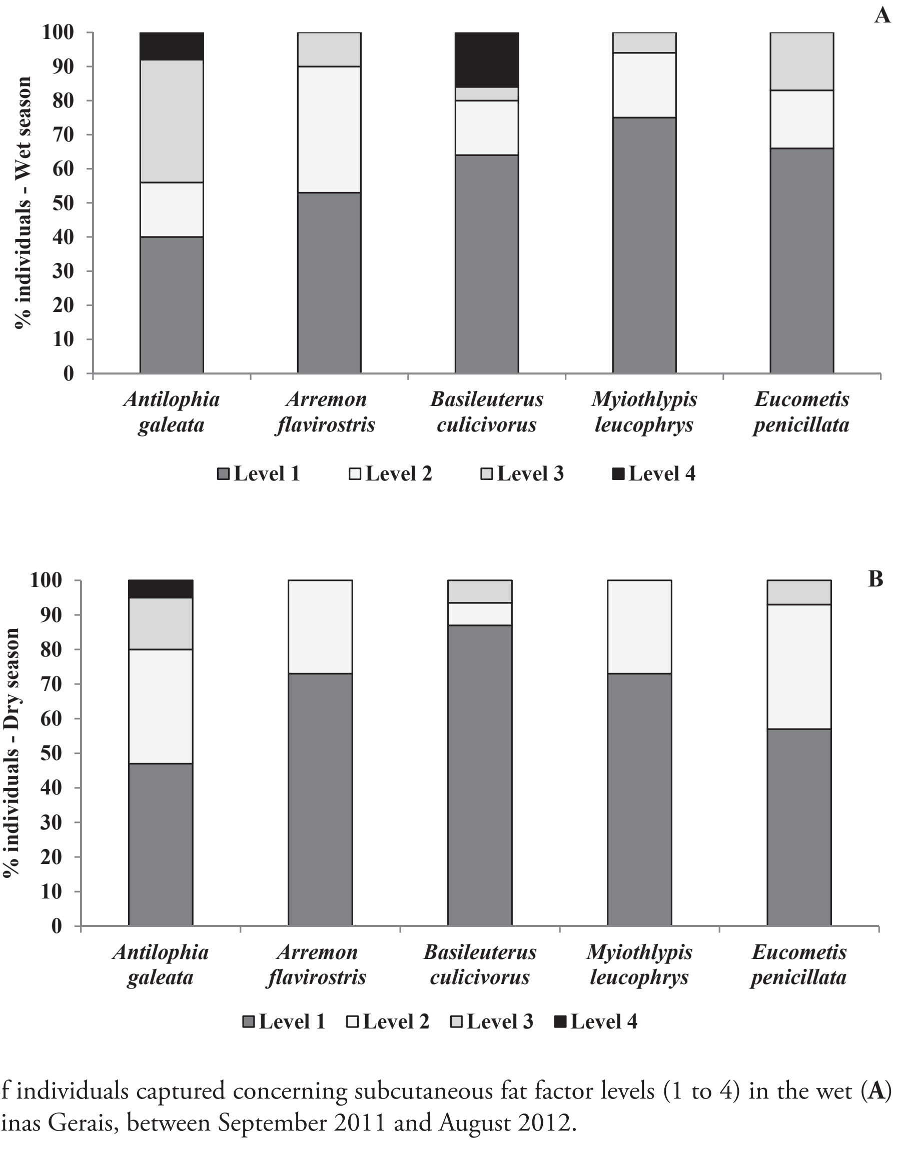


**Figure 4.** Percentage of individuals captured concerning subcutaneous fat factor levels (1 to 4) in the wet (**A**) and dry (**B**) seasons at Uberlândia, state of Minas Gerais, between September 2011 and August 2012.

throughout the year. Birds with a more generalized diet tend to keep their behavior and physiology stable in the face of variations in their habitat, as they feed on fruits of various species and are able to supplement their diet with animal items (Howe 1993, Scherer *et al.* 2007). The ability to shift the diet seasonally can be especially important in environments such as the Cerrado, which has well-defined dry and rainy seasons and large seasonal variations in productivity, especially fruits (Batalha & Montovani 2000, Silva *et al.* 2009, Melo *et al.* 2013). Furthermore, in the case of fragmented forests, omnivory may be a key characteristic, and this guild tends to predominate in small fragments (D'Angelo-Neto *et al.* 1998, Ribon *et al.* 2003).

On the other hand, despite the fact that the seasons had no effect on the RMI of insectivorous species, *B. culicivorus* and *M. leucophrys* showed negative values in both seasons. These species inhabit forest environments, foraging in the understory (Marini & Cavalcanti 1993), and may be affected by the dry season, when low humidity can interfere with the survival and reproduction of arthropods (Janzen & Schoener 1968, Battirola *et al.* 2007), resulting in lower availability of this resource (Teles 2013). In contrast, the absolute abundance of potential arthropods may not reflect their availability for foraging birds (Smith & Robertson 2008). It is expected that insectivorous birds restricted to a given stratum and foraging substrate, as is the case of *B. culicivorus* and *M. leucophrys*, are more susceptible to fragmentation (Marini & Cavalcanti 1993, Chatellenaz 2008, Lima & Manhães 2009).

Corroborating with Marini & Couto (1997) and Kanegae (2003), the prevalence rate of ticks in this study was greater in the dry season, a period in which food resources for birds may be scarcer. The presence/absence of ectoparasites did not affect the RMI of the species analyzed, so it is recommended that future studies assess possible interactive or synergic effects of parasite communities (endo-, hemo-, ectoparasites) on host birds (Cornelius *et al.* 2014, Biard *et al.* 2015).

No relationship was found between RMI values and subcutaneous fat levels in the species analyzed. Considering the predominance of low fat levels in both seasons, it is suggested the energy demand is stable throughout the year, explaining the lack of fat accumulation by these species. This fact may reflect an individual inability to obtain specific items from their diets or include new items in periods of food shortage.

Furthermore, there are two events in the life of birds with high energy demand that were not evaluated in this study: molt and breeding (Merilä 1997). Studies carried out in Brazil indicate that these two events overlap minimally throughout the year, given that breeding takes place preferably during the greater availability of food resources (Sick 1997, Oniki & Willis 1999, Piratelli *et al.* 2000, Marini & Durães 2001, Maia-Gouvêa *et al.* 2005).

Another factor that may contribute to the prevalence of individuals with low levels of fat in both seasons is that birds of this region do not need to accumulate large amounts of fat, since they are not migratory species and the region does not have a severe cold season. Fat accumulation influences the body mass of birds and can negatively affect flight aerodynamics (Witter & Cuthill 1993).

Therefore, the body condition of the species analyzed seems to be influenced by the diet and food availability, suggesting that birds with a specialized diet may be more sensitive to environmental variations, which result in fluctuations in resources. *Antilophia galeata* is a frugivorous species with an important role in the dynamics of seed dispersal and regeneration of forests. This highlights the importance of the maintenance and conservation of forest fragments as well as the maintenance of connectivity between them for the conservation of birds in this region.

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ARTICLE

# Breeding biology of Pale-breasted Thrush *Turdus leucomelas* (Turdidae) in the north of Atlantic Forest, Brazil

**Nicolás Luciano Ruiz[1,3], Priscilla Sabino Amorim de Araújo[1,2], José Victor Fernandes de Lima[2], Pedro Vitor Silva Ferreira[2], Lidiane Medeiros de Andrade[2] & Mauro Pichorim[1,2]**

[1] Programa de Pós-Graduação em Ciências Biológicas, Universidade Federal do Rio Grande do Norte, 59090-002, Natal, RN, Brazil.
[2] Laboratório de Ornitologia, Departamento de Botânica e Zoologia, Centro de Biociências, Universidade Federal do Rio Grande do Norte, 59078-900, Natal, RN, Brazil.
[3] Corresponding author: nicolaslruiz@hotmail.com

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**ABSTRACT:** Reproduction is a key process in the life of organisms and represents high-energy cost to the parents, and often a tradeoff between survival and reproductive success. The breeding biology is an important aspect to be studied, which has inspired theories about bird life history evolution, such as the latitudinal gradient in the clutch size related to different survival rates between the temperate and tropical regions. To contribute with the knowledge of breeding ecology of tropical birds we monitored two reproductive periods of the Pale-breasted Thrush *Turdus leucomelas* in the northeastern Brazil. The breeding period in the studied area occurred from December through April. We found the nests mainly on Facheiro cactus (Cactaceae) at 1.43 ± 0.35 m above the ground. They were composed by roots, mosses, fungus mycelium, leaves, twigs, and a mix of fragmented vegetal material with soil and sand at the base. We found clutch sizes of three (*n* = 9), two (*n* = 3) and one (*n* = 1) eggs. The eggs (*n* = 21) had mass of 5.1 ± 0.9 g and measured 26.6 ± 1.3 mm by 19.5 ± 0.5 mm. We observed 12 days of incubation and 14 days of nestling period. The Mayfield nest success in 2013 was 7.3% and in 2014 it was 4.5%, lower during the nestling period than during the incubation in both years. Our results show that *T. leucomelas* breeds in the area in the beginning of rainy season, when the frequency of occurrence of the migrant *Turdus amaurochalinus* is low. In addition, the low nest success observed may be a consequence of the localization of the studied area in the periphery of the species range, where limited resources probably result in reduced fitness.

**KEY-WORDS:** breeding success, egg, Mayfield, nest, northeastern Brazil, predation.

## INTRODUCTION

The breeding knowledge of many tropical species remains poorly understood, where we do not know many basic aspects, such as breeding season, nest characteristics, and clutch size (Martin 1996, Stutchbury & Morton 2000). In addition, accurate estimates of nest success are necessary for improving our understanding of life-history strategies of tropical birds, and how those strategies may differ among regions of the tropics and, also, from temperate zones. Reproduction is an important life history trait, which affects both parental fitness and population persistence (Berl *et al.* 2014). It is regulated basically by a density-dependent feedback of adult population (Ricklefs 1997), area-dependent changes (Hoover *et al.* 1995), habitat structure (Zanette & Jenkins 2000), predator assemblages (Thompson-III 2007, Klassen *et al.* 2012), food availability (Norris *et al.* 2013), weather conditions (Collister & Wilson 2007) and nest parasitism (Budnik *et al.* 2000). Basically, breeding depends on environmental and ecological circumstances throughout the annual cycle, necessitating the integration of these components to understand it (Sherry *et al.* 2015).

Density-dependent feedback is not restricted to the same population, sometimes the increase of competitor presence can be an important driver of nesting. Interspecific competition can reduce breeding opportunities for subordinate species, resulting in lower fledgling rates and breeding density (Brazill-Boast *et al.* 2011, Edworthy 2016). Competition-mediated habitat selection is widely believed to change the range of habitats or resources exploited by different species (Sherry & Holmes 1988, Dhondt 2012). The dominance is a primary factor in determining the realized niche among species and the community structure of an area (Dhondt 2012, Thornton *et al.* 2015). Thus, the seasonal variation in the frequency of occurrence of possible competitors may influence the breeding biology of a resident species.

Additionally, different predator assemblages can change in distinct ways the reproductive success of the species. Predators are widely accepted as one of the main cause of breeding loss in tropical bird populations (Lack 1954, Nice 1957, Ricklefs 1969, Oniki 1979, Skutch 1985, Martin 1993). Nest predation influences reproductive strategies and nest-site selection (Martin 1995, Fontaine & Martin 2006). Consequently, nests are not randomly spread across the environment, they are generally hidden in the habitat or in places difficult to access (Klopfer 1963, Cink 1976, Ricklefs 1984, Sonerud 1985, Martin & Roper 1988). Nest concealment is known to improve nest survival for a variety of open-cup avian species (Berl *et al.* 2014). The mechanism for this is linked to the effect of vegetative cover on predator foraging efficiency (Li & Martin 1991, Segura *et al*. 2012). In consequence, birds in general have applied a plethora of behavioral techniques to avoid predation (Martin 1998, Clark & Shutler 1999, Rauter *et al*. 2002, Davis 2005). Therefore, predators are a powerful ecological force shaping many aspects of breeding biology and life histories of birds (Clark & Wilson 1981).

Another important environmental aspect for bird nesting is the precipitation, considered the main weather condition perceived by birds at tropical areas (Boag & Grant 1984, Lloyd 1999, Hau *et al.* 2008). The onset of rains is associated with greater food availability, either fruits or arthropods (Wolda 1978, Grant & Boag 1980, Leigh-Jr. *et al.* 1996, Ahumada 2001, Dantas *et al.* 2002). Presumably, this peak must also match with the greater breeding period energy demand for egg production (Lack 1968, Ewald & Rohwer 1982, Martin 1987), parental care (Lack 1954) or juveniles' dispersal (Morton 1971). Additionally, the breeding season may be adjusted by molting process that also occurs most often in the rainy season, when there is plenty of food supply (Poulin *et al.* 1992).

The Pale-breasted Thrush (*Turdus leucomelas*) is a common species with breeding biology poorly studied (Collar 2005, Davanço *et al.* 2013). Its large occurrence in South America makes it a good model species to investigate the variations of reproductive traits among regions, habitats and climate conditions. The present study contributes to this knowledge describing the nesting biology of the species in the extreme of its distribution. In addition, our objectives were to correlate some aspects of the reproduction of the species with habitat characteristics, precipitation and molt occurrence. We also discussed the effects of the frequency of occurrence of the migrant congener Creamy-bellied Thrush (*Turdus amaurochalinus*), a possible competitor in the area.

## METHODS

### Study area and species

We monitored *T. leucomelas* breeding biology in a plot of 550 × 550 m (30.25 ha) formed by an array of eleven rows and columns (50 m apart) located at *Centro de Lançamento Barreira do Inferno - CLBI* (Barreira do Inferno Launch Center, Brazilian Air Force) city of Parnamirim, Rio Grande do Norte state, Brazil (05°54'S; 35°10'W, 1800 ha). The area has tropical coastal vegetation of Atlantic Forest sandbank (Scarano 2002) and classified as semi deciduous forest of lowlands (Cestaro 2002). According to the Köppen (1936) classification system, the climate of the region is AS (tropical and humid) with dry summer and rainy winter (IBAMA 2003). The species *T. leucomelas* is widespread in central, east and north of South America (Sick 1997, Collar 2005), where it inhabits pristine and disturbed humid forests, drier deciduous woodland, savannas, gallery woodland, and anthropogenic environments (Collar & Garcia 2016). This common, non-threatened, species feeds mainly on fruits, arthropods, worms and small lizards (Collar & Garcia 2016).

### Data collecting and analysis

From 2010–2012 we determined the breeding period of the species through records of the brood patches occurrence resulting from a monthly demographic monitoring captures at the same study area. In 2013–2014, we started the search for active nests one month before the breeding season and extended it to one month after to avoid loss of any reproduction attempt. During this time interval, we searched the whole study area for nests at least once a week in the early hours of the morning (05:00–10:00 h), using previous established parallel paths at 50 m each (1050 h-observer in total). We applied ordinary nest-searching methods through the area, looking for visual contacts and behavioral clues of adults in breeding activity (vocalizations, territory defense, carrying of nest materials or food for nestlings) (Lopes & Marini 2005). We photographed, georeferenced and described the active nests found according its stage (construction, incubation, nestling) and we monitored them and the parental behavior at intervals between 2 to 4 days until it became inactive. We manipulated the contents once in the incubation stage (to measure and to weigh the eggs with a 20 g scale and 0.05 mm caliper) and another time in the end of the nestling stage for ringing. The description of the egg shape was based on Baicich & Harrison (1997) and the colors on Smithe (1975). The nestlings were marked with aluminum bands provided by the *Centro Nacional de Pesquisa e Conservação* *de Aves Silvestres (CEMAVE/ICMBio)*, and with colored bands to follow them during the post-nestling period. We also monitored the nests after each breeding attempt (successfully or not) in order to check reuse.

We considered as incubation period the time between the laying and hatching of the last egg, and the nestling period between the hatching of the last egg and when the last nestling leaving the nest. When we could not register the exact day of an event, we assumed the day at half of the period from the last research visit to establish these periods. We considered successful nests those that produced at least one nestling, and failure when no eggs hatched (during incubation) or no offspring was produced (during nestling period). We estimated the breeding success as a simple ratio of successful nests to total nests found (apparent success, see Jehle *et al.* 2004) and by using Mayfield's method, which estimates the mortality rate as a ratio between failures and observation period (Mayfield 1961, 1975). Since the nests were not monitored daily, we assumed as the exact date of loss or success the middle day between the last two consecutive visits (following Mayfield 1975). Based on our results, we considered 12 days the incubation period and 14 days the nestling period to obtain the survival rates.

For each nest, we identified the plant species where it was built, the perpendicular distance of the superior ridge of the nest to the ground (height from the ground) and its position in the plant support (branches or main axis). We also measured the largest and smallest internal and external diameter, depth and height of the nest using a ruler and caliper. The description of the nests followed the proposal of standardization for Neotropical birds (Simon & Pacheco 2005). At the end of each reproductive period, we collected and dried each nest to identify the material composition of the base and the incubation chamber. The dried materials were weighed using a digital precision scale (0.01 g).

The frequency of occurrence of the migrant *T. amaurochalinus* was estimated monthly as the number of captures per 100 h-net (nets Ecotone® 18 × 3 m, mesh size 19 mm and five shelves). These records and the molt occurrence were obtained from our monthly demographic monitoring program developed at the same study area.

## RESULTS

During the monthly captures from demographic monitoring, we found brood patches mainly between January and April, with isolated records in November (1), December (2) and May (1). Thus, the nest searching and monitoring in the breeding seasons of 2012/2013 and 2013/2014 occurred from December through April. During the first breeding season monitored, we recorded 12 active nests, starting on 22 January and ending on 6 April 2013. In the second breeding season monitored, we recorded seven nests (from 12 January through 09 April 2014).

The apparent success of nests was 10.8% and 12.5% each year, respectively. The Mayfield success in 2013 was 33.6% during the incubation, and 21.7% during the nestling period, resulting in the annual success of 7.3%. In 2014 it was 49.7% during the incubation, and 9.0% during the nestling period, resulting in the annual success of 4.5% (Table 1, Fig. 1). The nest survival was lower during the nestling period than during the incubation for both years. The losses occurred on whole clutch, with none individual losses registered. Among the 16 nests preyed, 87.5% (*n* = 14) presented intact structure, and with no signs of destruction or displacement of the nest original position. After the use of the nest (with success or loss), there was no reuse or second attempt in all nest monitored.

All nests monitored (*n* = 19) were built above the ground on vegetation (average height from the ground of 1.43 ± 0.35 m, range between 0.86–2 m). Only once the nest was built away from the main trunk of the plant support (~95 cm), all others were built on forks of the main axis. The nests were mainly built on the arboreal cactus called locally as Facheiro (*Pilosocereus catingicola*,

**Table 1.** Nesting survival rates of *Turdus leucomelas* obtained on 2013 and 2014 in the north of Atlantic Forest, Brazil.

| Year | Breeding period | Exposure (days) | Nests lost (*n*) | Daily survival rate | Mayfield survival rate | Apparent survival rate |
|---|---|---|---|---|---|---|
| 2013 | Incubation | 46 | 4 of 7 | 0.9130 | 0.3355 | 0.4286 |
| | Nestling | 58 | 6 of 8 | 0.8966 | 0.2170 | 0.2500 |
| | Entire breeding period | | | | 0.0728 | 0.1071 |
| 2014 | Incubation | 53 | 3 of 6 | 0.9434 | 0.4970 | 0.500 |
| | Nestling | 19 | 3 of 4 | 0.8421 | 0.0902 | 0.250 |
| | Entire breeding period | | | 0.0448 | | 0.1250 |

Assumed 12 days for incubation period and 14 days for nestling period.

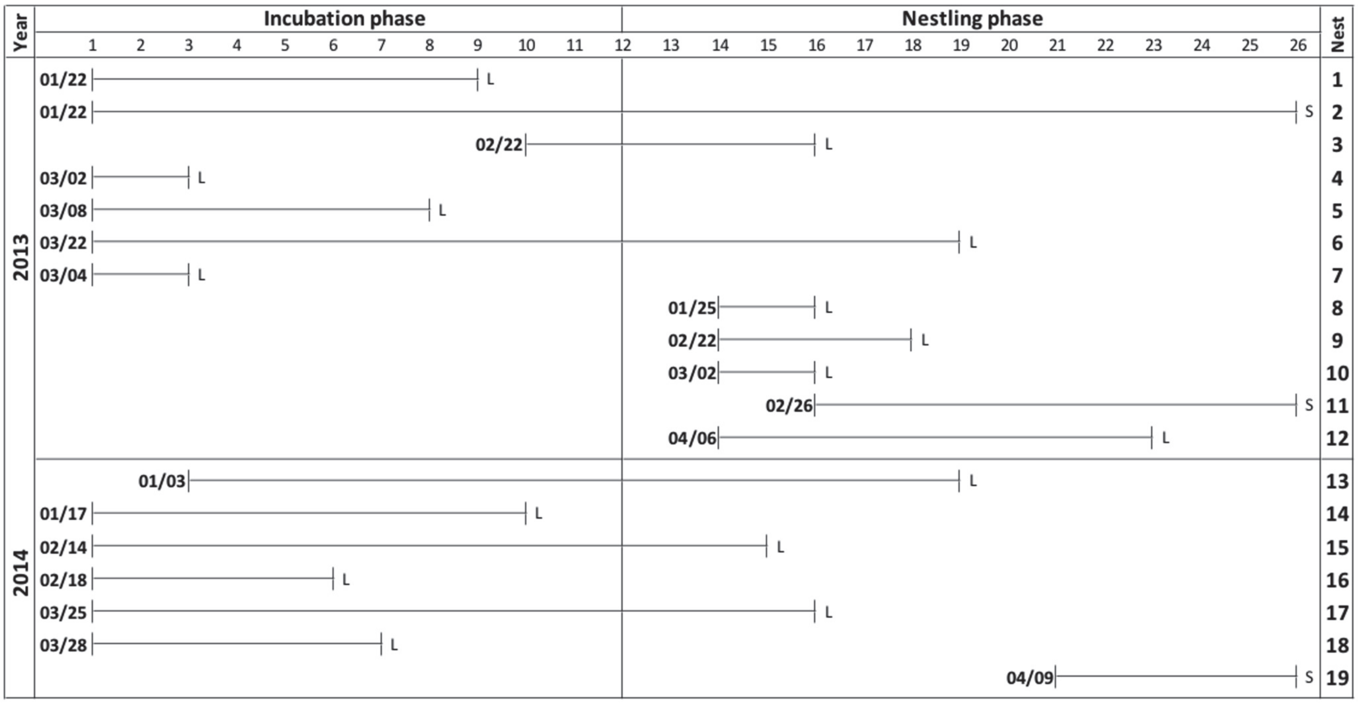

**Figure 1.** History of nests of Pale-breasted Thrush (*Turdus leucomelas*) monitored in 2013 and 2014 in the north of Atlantic Forest, Brazil (the numbers before each line means the date (day/month) when the nest was found; S = success and L = loss).

Cactaceae) (57.9%; *n* = 11) followed by the Mangabeira tree (*Hancornia speciosa*, Apocynaceae) (26.3%; *n* = 5), Myrtaceae (10.5%; *n* = 2) and *Coccoloba mollis* (Polygonaceae) (5.3%; *n* = 1). During the incubation period the apparent success of nests built on arboreal cactus was 73% (8 of 11), and during nestling period it was 25% (2 of 8).

The nest shape varied between circular and oval, with the diameter ranging from 94–155 mm (mean largest external diameter = 132.0 ± 12.8 mm; mean smallest external diameter = 113.3 ± 12.6 mm). The incubation chamber was oval with highest and lowest diameters ranging from 60–90 mm (mean largest internal diameter = 81.5 ± 6.8 mm; mean smallest internal diameter = 71.3 ± 4.9 mm) and its depth varied between 35–55 mm (mean depth = 44.9 ± 5.4 mm). The nest height ranged from 82–170 mm (mean height = 102.6 ± 22.6 mm). The general structure fits in the definition of "low cup/base" following Simon & Pacheco (2005) (Fig. 2).

The nests were composed basically by roots, mosses, fungus mycelium, leaves, twigs, and a mix of fragmented vegetal material with soil and sand at the base (Table 2). It is worth mentioning that the mycelia were found in 83.3% of the nests, however this last mass may be biased by the aggregate material added to it (*e.g.* sand, mosses, leaves), which was not separated in order do not compromise the integrity and identification. Also, it is noteworthy the representativeness of the roots, most used material at the nest bottom and the incubation chamber, composing 9.4% and 65.2%, respectively, and present on all the nests. Leaves and mosses had high representativeness in the bases and chambers of the nests; while the woody plant twigs had presented at high frequency on the bases. Instead, we recorded a few items in a single nest, but with a significant participation, as *Polycarpaea corymbosa* (Caryophyllaceae), Eriocaulaceae, Facheiro, bromeliad inflorescence and, in a lesser ratio, *Lycopodium* sp. (Lycopodiaceae).

During the incubation period, we found clutch sizes of three (*n* = 9), two (*n* = 3) and one (*n* = 1) eggs. The clutch with just one egg was preyed a day after the last visit, and probably it was not greater because the loss. The observed eggs (*n* = 34) had coloration ranging from 168D Light Sky Blue and 93 Robin's Egg Blue, with spots ranging from 121A Prout's Brown and 121B Brussels Brown. The spots concentration prevailed at rhombic pole, but we also recorded the fully spotted pattern, with intermediary stages (Fig. 3). The eggs shape were intermediate between "Oval" and "Short-Oval" and they measured (*n* = 21): length = 26.6 ± 1.3 mm (range 22.2–28.4 mm), width = 19.5 ± 0.5 mm (range 18.0–21.1 mm), and mass = 5.1 ± 0.9 g (range 4.2–6.1 g). At the nests in which we could follow the parental care during incubation (*n* = 3), we have always recorded the same parental (marked with colored bands) at incubation duties and territory defense. We observed in four nests the maximum incubation period of 12 days (Fig. 1).

During the nestling period, individuals of 0–3

**Table 2.** Nest materials of Pale-breasted Thrush (*Turdus leucomelas*) in the north of Atlantic Forest, Brazil (Σ Mass = sum of masses recorded for each item; % Relat = relative frequency of the item based on the mass; Freq = number of nests with the item).

| Material | Whole nest | | | Base | | | Camera | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Σ Mass (g)** | **% Relat** | **Freq** | **Σ Mass (g)** | **% Relat** | **Freq** | **Σ Mass (g)** | **% Relat** | **Freq** |
| Roots | 302.16 | 0.1468 | 19 | 177.21 | 0.0947 | 17 | 124.95 | 0.6661 | 13 |
| Mosses | 82.66 | 0.0402 | 15 | 74.23 | 0.0397 | 15 | 8.43 | 0.0449 | 8 |
| Fungus mycelium | 64.89 | 0.0315 | 15 | 64.89 | 0.0347 | 16 | 0.15 | 0.0008 | 2 |
| Leaves | 49.53 | 0.0241 | 19 | 46.73 | 0.0250 | 19 | 2.80 | 0.0149 | 11 |
| Bryaceae | 47.12 | 0.0229 | 9 | 46.84 | 0.0250 | 8 | 0.28 | 0.0015 | 4 |
| Woody plant twigs | 40.80 | 0.0198 | 17 | 39.86 | 0.0213 | 17 | 0.94 | 0.0050 | 5 |
| Araceae- *Anthurium affini* | 23.42 | 0.0114 | 13 | 22.25 | 0.0119 | 12 | 1.17 | 0.0062 | 4 |
| Bromeliaceae | 15.64 | 0.0076 | 10 | 18.65 | 0.0099 | 9 | | | |
| *Cattleya granulosa* (root) | 12.62 | 0.0061 | 3 | 12.62 | 0.0067 | 3 | | | |
| Gramineae | 11.73 | 0.0057 | 10 | 10.19 | 0.0054 | 10 | 1.54 | 0.0082 | 2 |
| *Microgramma* sp. | 9.53 | 0.0046 | 4 | 8.19 | 0.0044 | 4 | 1.34 | 0.0071 | 2 |
| Lichens | 4.87 | 0.0024 | 1 | 4.43 | 0.0024 | 1 | 0.44 | 0.0023 | 1 |
| Bromeliad inflorescence | 3.01 | 0.0015 | 1 | 3.01 | 0.0016 | 1 | | | |
| *Polycarpaea corymbosa* | 2.06 | 0.0010 | 1 | 2.06 | 0.0011 | 1 | | | |
| Eriocaulaceae | 1.17 | 0.0006 | 1 | 1.17 | 0.0007 | 1 | | | |
| Pilosocereus catingicola | 1.10 | 0.0005 | 1 | 1.51 | 0.0006 | 1 | | | |
| Unknown Vegetable Fiber | 0.99 | 0.0005 | 3 | 0.99 | 0.0005 | 3 | | | |
| *Lycopodium* | 0.77 | 0.0004 | 1 | 0.77 | 0.0004 | 1 | | | |
| Residues not identified * | 1383.66 | 0.6724 | 19 | 1338.11 | 0.7155 | 19 | 45.55 | 0.2428 | 6 |

(*) Fragmented vegetal material, including soil and sand.

**Figure 2.** Upper and lateral views of Pale-breasted Thrush (*Turdus leucomelas*) nest recorded in the north of Atlantic Forest, Brazil.

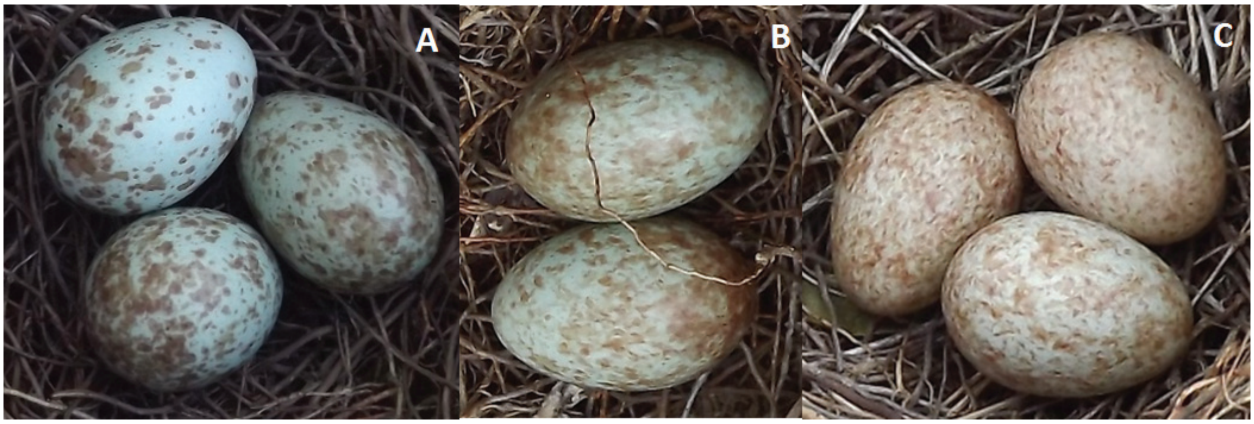

**Figure 3.** Pale-breasted Thrush (*Turdus leucomelas*) eggs spotted patterns (**A-C**) and shape (**B**) recorded in the north of Atlantic Forest, Brazil.

**Figure 4.** Nestlings development stages of Pale-breasted Thrush (*Turdus leucomelas*) in the north of Atlantic Forest, Brazil (A = 0–3 days; B = 4–5 days; C = 8–10 days; D = 11–12 days, age of ringing; E = 13–14 days).

days old ($n$ = 11) were naked with yellow skin and a narrow spinal pteryla (dorsal tract) extending from nape to rump with thin beige pinfeathers. The beak and the tarsus were beige, the eyes closed, the abdomen skin was pale and wrinkled, and they begged for food (Fig. 4A). Between 4–5 days the nestlings ($n$ = 10) began to open their eyes and being more active (begging behavior only with parents). The pinfeathers of the remiges were already visible as a narrow gray strip, but the tips had not yet erupted (Fig. 4B). Between 6–7 days ($n$ = 7 nestlings) the rectrices were visible, but without external tips. The spinal pteryla had pinfeathers from head to rump, and the beak and tarsus were slightly dimmed. At age of 8–10 days ($n$ = 5 nestlings) they always opened eyes during the visit, showing off dark brown iris, and they were curious with the surroundings, following movements. The pinfeathers of the spinal and ventral pteryla showed unsheathed tips (larger on back), and also the remiges began to show unsheathed tips (~2–5 mm, Fig. 4C). Between 11–12 days ($n$ = 5 nestlings) they had the body ~70% covered with feathers, naked areas remained on central belly and flanks, and the rectrices began to show unsheathed tips. They have tried to hide themselves with the researcher approaching, and after touched they moved up and flapped the wings. We ringed the nestlings at this age, and when they were being removed from the nest, they held fast to the nest material. On two occasions, two of them jumped out of the nest in this situation, and they were returned after handling (Fig. 4D). Between 13–14 living days the nestlings ($n$ = 3) had plumage similar of juvenile pattern, with beige and gray spots at belly and upper cover feathers. The tarsus and beak were dark gray, with yellow gape flanges in the later. At this age the nestlings leaved the nest (Fig. 4E), and the maximum nestling period observed was of 14 days (Fig. 1, Nest 2). From all nestlings monitored ($n$ = 29), we recovered two after leaving the nest (17 days and 108 days after ringing), both showed juvenile plumage pattern, and were captured close to their nests (< 40 m).

Finally, through the demographic analysis of ringing data from November 2010 until November 2014, we found in March a marked overlapping of brood patches and molt (remiges, rectrices and both of them) and the frequency on individuals captured with brood patch and the months considered as breeding period (Fig. 5). Also through this data, we have recorded the highest frequency of occurrence of the migrant *T. amaurochalinus* in June (2010 to 2014) in synchrony with the largest annual peak of rainfall (Fig. 5).

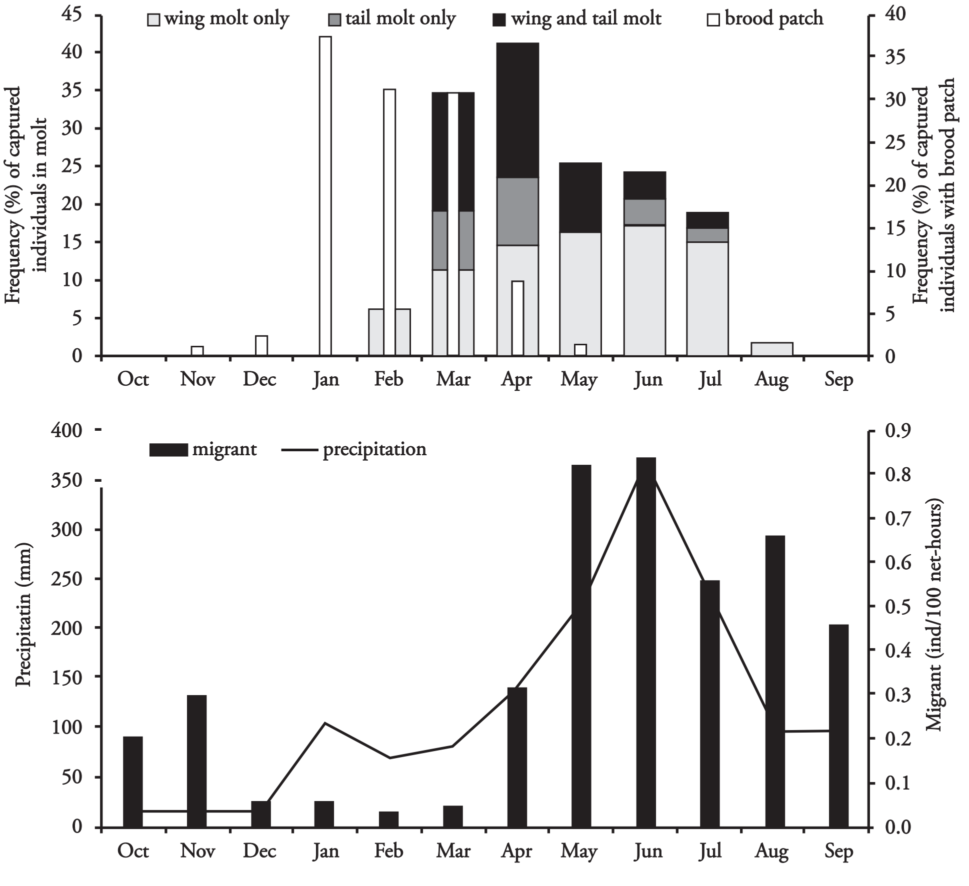

**Figure 5.** Annual conjugation between molt, brood patch, precipitation and migrant frequency of occurrence of Creamy-bellied Thrush *Turdus amaurochalinus* between 2010 and 2014 in the north of Atlantic Forest, Brazil.

## DISCUSSION

We estimated a very low (< 10%) and unexpected nest success for a tropical passerine. Previous estimate for *T. leucomelas* was of 57% in the southeast of Brazil (Davanço *et al.* 2013), and for *Turdus rufiventris* 35–41% in Argentina (Ferreti *et al.* 2005). For temperate thrushes, like *Turdus migratorius* and *Turdus merula*, the nest survival is ~30–50% (Knupp *et al.* 1977, Cresswell 1997, Djemadi *et al.* 2015). One explanation for the low nest survival we found is the fact that the studied area is in the periphery of the species range. In the extreme northeast Brazil *T. leucomelas* occurs in a narrow strip of forest close to the coast, and it is rarely found in the drier countryside covered by Caatinga vegetation. In addition, the numbers of nests that we found was low, even with a great effort (1050 h in total). It seems that the studied area represents an extreme of distribution with few nest attempts and low nesting success. In many species, reproductive success is lower near the boundary of distribution, where limited resources can result in reduced fitness (Sexton *et al.* 2009). Usually, in the border of occurrence of a species there are "sink populations" because of the environmental and ecological restrictions. It is possible that our results represent an example of this demographic limitation, where the local productivity is perhaps not enough to maintain the population level, an hypothesis which needs to be tested.

There are basically two factors that can potentially affect breeding performance in birds: resources and predation (Paradis *et al.* 2000). We did not measure the resource availability in our area, but considering the occurrence of other thrushes, and many other frugivorous species, we suspect that food *per se* is not a limitation. Actually, food limitation is much less important to life-history in birds than suggested by traditional theory (Ferreti *et al.* 2005). However, predation seems to be the main factor accounting for low nest success in our study area. The majority of nest losses that we detected was caused by predation, probably by reptiles and birds, due the intact structure of the left nests. Birds and snakes normally do not destroy the nest when they are preying, while mammals do (Martin 1993, Woodworth 1997, Marini *et al.* 2007). At the study area, there is a record of a *T. leucomelas* nestling predation by the snake *Leptophis ahaetulla* (Colubridae) (Ribeiro *et al.* 2014). Some other known bird predators recorded in the area were *Oxyrhopus trigeminus* (Colubridae) (Alencar *et al.* 2012), *Caracara plancus* (Falconidae), *Rupornis magnirostris* (Accipitridae), and *Cyanocorax cyanopogon* (Corvidae) (Sick 1997). For possible mammal predators, we frequently observed in the area the opossums (Didelphidae) *Didelphis albiventris* (Cáceres 2000) and *Caluromys philander* (Eisenberg & Redford 1999), and also the marmoset *Callithrix jacchus* (Cebidae). Marmosets have been recorded widely in the literature as a common predator of bird nests, including *T. leucomelas*, and they have skills to prey without nest destruction (Pontes & Soares 2005, Lyra-Neves *et al.* 2007, Alexandrino *et al.* 2012, Vinhas & Souza-Alves 2014). Therefore, the high level of predation in the studied area seems to constrain the nest productiveness of *T. leucomelas* in this extreme site of distribution of the species.

Another important aspect related to predation in the area was the preference for nest building on the Facheiro cacti. This plant support was the most common and provided greater nest success during incubation. Probably, the protection given by its thorny stems and branches is the main beneficial characteristic of this plant. It is interesting to highlight that those nests on cacti were more exposed and without concealment, even thus, this plant was the most frequent nest support.

The nest shape observed is consistent with what has been described by other authors for tropical thrushes (Euler 1900, von Ihering 1900, de la Peña 1987, Sick 1997). However, we identified the proportionality of the used items, where fragmented vegetal material, including soil and sand predominated at the base and roots in the incubator chamber. It is worth mentioning the plasticity of the species to adapt to the environment of its surroundings. In the study area, there is little availability of mud, because the soil is predominantly sandy. Hence, the base was composed of fragmented vegetal material, soil and sand mixed with fungal mycelium to promote the adhesion among these materials. In some cases, living roots of *Cattleya granulosa* and *Microgramma* sp., and mosses promoted the adhesion of the materials. Therefore, the nests were quite compact and adhered to the substrate, regardless of the absence of mud.

Our records about height of the nest, eggs measurements (mass, length and width) and predominance of clutch sizes of three eggs were similar to those reported previously for this species (Carvalho 1957, Haverschmidt 1959, Camargo & Höfling 1993, Collar 2005, Rodrigues 2005, Marini *et al.* 2007, Davanço *et al.* 2013). It seems that the clutch size in *T. leucomelas* does not vary much along its latitudinal gradient. The incubation period of 12 days that we observed was similar to other studies (Carvalho 1957, Haverschmidt 1959, Sick 1997, Collar 2005, Davanço *et al.* 2013). However, the nestling period has been reported as longer in the literature (16–17 days, Carvalho 1957, Haverschmidt 1959, Sick 1997, Collar 2005, Davanço *et al.* 2013). Maybe, the short nestling period that we recorded represents an adaptation against the high level of predation in the area. Sometimes young should grow faster to reduce predation risk (Bosque & Bosque 1995, Remeš & Martin 2002). Probably, the premature leaving from the nest is compensated by a longer period of parental care of the fledglings, behavior already cited to other tropical birds (Russell *et al.* 2004, Schaefer *et al.* 2006, Tarwater & Brawn 2010). We could record at least one juvenile close to the nest site after ~3.5 months. Inversely to our observations, several multiple breeding attempts of *T. leucomelas* during the breeding period were related (Davanço *et al.* 2013), even four different attempts for the same nest have been cited (Collar 2005).

Previous records have indicated that *T. leucomelas* breeds throughout the year, but in different periods among regions. The northernmost nest records (Surinam) are between November and May, avoiding the long rainy season in the region (April–August, Haverschmidt 1959). In Colombia, breeding occurs between January and August (Hilty & Brown 1986). In Brazil there are nest records in the north between July and February (Oniki & Willis 1983a, b), in the central between August and October (Antas & Cavalcanti 1988), in the southeast between August and January (Marini *et al.* 2007, Davanço *et al.* 2013), and in the south in November (Belton 1994). In Argentina, there is a record of nest in October (de la Peña 1987). These records show that the reproduction of the species starts at the end of the dry season or at the beginning of the rainy season, and rarely coincides with the peak of precipitation in each region. Our observations in the northeastern of Brazil reinforce this idea, because the reproduction occurred from December through April, before the annual peak of rainfall in the area. Probably, the extension of the breeding season is more associated with the rain cycle in the region than other factors, like latitude. We could not confirm the idea that the breeding season is extended in lower latitudes, as suggested in previous studies (Hemborg *et al.* 2001, Davanço *et al.* 2013). For example, we observed a breeding season of five months in our area (~6°S), while Davanço *et al.* (2013) reported the same period in the southeast of Brazil (~23°S). However, in the central Brazil it seems to be shorter (five months, Antas & Cavalcanti 1988). We suggest, for this tropical thrush, that the length of the breeding season is more influenced by rain than latitude.

Actually, this pattern of integrating the rainy season with the breeding period has been observed for other tropical bird species (Lack 1968, Morton 1971, Wyndham 1986, Martin 1987, Wikelski *et al.* 2000, Aguilar *et al.* 2000, Marini & Durães 2001, Mezquida & Marone 2002, Rubolini *et al.* 2002, Duca & Marini 2011). The avoidance of the peak of precipitation can be an adaptation to prevent nest loss, as mentioned for other species (Medeiros & Marini 2007).

Another important factor in our region is that the rainfall peak is associated with the highest capture rates of the migrant *T. amaurochalinus*. Probably, this species competes for resources with *T. leucomelas*, and its massive presence in the area during the rainy season is another variable possibly shaping the breeding period of resident birds in the studied area, avoiding the peak frequency of occurrence of this migrant. The breeding season can also be adjusted by the molting process. In general, for birds of temperate zones the feathers molt does not overlap with the breeding period (Miller 1961, Payne 1969, Foster 1975, Poulin *et al.* 1992, Ralph & Fancy 1994, Tallman & Tallman 1997, Stutchbury & Morton 2000, Newton & Rothery 2005). However, for tropical regions, these events may occur simultaneously (Foster 1975). We saw some individuals with brood patches and molt, but the peak of molting occurred at the middle of the rainy season. Thus, there was overlap only at the end of the breeding period.

Finally, our findings confirm some patterns of reproductive biology of tropical birds, as high nest predation and low clutch size. However, the nest survival was low, and the breeding season was not extended. These happened probably due to the studied area situated in the peripheral distribution of the species, coupled with a high frequency of competitors and the influence of the rainy season. These results show how poorly we understand the ecology and limiting factors of bird populations in the South America. Thus, we emphasize the necessity to expand geographical breeding analysis in tropical environments. This is essential for the comprehension of the factors that change the life history attributes across different ecosystems. Knowing the importance of limiting factors for a species, and when they operate, are essential for the understanding of life history traits and the evolutionary ecology in the tropics.

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SHORT-COMMUNICATION

# The juvenile plumage of Sharp-tailed Tyrant *Culicivora caudacuta* (Aves: Tyrannidae)

**Paul Smith**[1,2]

[1] Para La Tierra, Centro IDEAL, Mariscal Estigarribia 321 casi Tte Capurro, Pilar, Paraguay & FAUNA Paraguay, Encarnación, Paraguay.
[2] Corresponding author: faunaparaguay@gmail.com

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**ABSTRACT:** The juvenile plumage shortly after fledging of the globally threatened grassland flycatcher Sharp-tailed Tyrant *Culicivora caudacuta* (Aves: Tyrannidae) is described in full for the first time. This plumage is substantially different from the adult, most notably in the head pattern, tail length and dorsal coloration. Confusion in the field with female Bearded Tachuri *Polystictus pectoralis* is possible.

**KEY-WORDS:** Bearded Tachuri, natural grasslands, *Polystictus pectoralis*, vulnerable.

The Sharp-tailed Tyrant *Culicivora caudacuta* (Aves: Tyrannidae) is a small, unobtrusive, semi-social, insectivorous flycatcher that occurs in natural grasslands in central South America (eastern Bolivia, central and eastern Brazil, eastern Paraguay and northern Argentina) (Fitzpatrick 2004, Lopes *et al.* 2010). The species is locally common in most of its range, but its dependence on natural grasslands and inability to tolerate moderate levels of habitat perturbation means that it disappears rapidly from suboptimal areas and it is suspected to be declining rapidly. Consequently it is considered globally "Vulnerable" (BirdLife International 2017).

Little is known about the breeding ecology of the species. In northern Argentina breeding occurs from October to late March, with two or three cream-colored eggs (14–18.7 × 10.3–12.4 mm) laid in an elaborate open cup of grasses, spiderwebs, plant fibers and thistledown, located low in isolated shrubbery close to the ground. The cup has an external diameter of 5 cm, an internal diameter of 3 cm and a depth of 4 cm. The incubation period is 15 to 16 days, and chicks are in the nest for 9 to 14 days (Di Giacomo 2005).

The juvenile plumage has apparently never been satisfactorily described, with the only published references I was able to find stating simply that the juvenile is "buffy" (Parker-III & Willis 1997) or "more buffy overall" than the adult (Fitzpatrick 2004). However, field observations of three recently fledged juveniles at Estancia Kanguery, Área para Parque Nacional San Rafael, Itapúa Department on 5 April 2016 (Fig. 1) suggest that this greatly over-simplifies the differences from the adult plumage and consequently a more thorough description is provided here.

The most obvious difference distinguishing juveniles from adults is the rufous-orange head, slightly browner on the crown and nape and showing some trace of dark brown markings on the crown, but totally lacking the bold facial stripes. Throat and upper breast creamy. Rest of underparts warm buff, though slightly more creamy on the vent. Dorsally the mantle is brownish-rufous, broadly spotted darker. Wings and tail dark brown with pale brown feather edges, giving a hint of two pale wing bars. Edges of tertials more brownish-rufous like the mantle. Regarding soft parts, the bill is mostly black, with orange base to the lower mandible, gape is bright orange, legs are black and the iris is dark brown (Fig. 1).

The most notable change between this juvenile plumage and that of adults occurs on the head and upperparts. The rufous coloration of the head is almost entirely lost, being retained only on the ear coverts, and the mantle becomes browner and more heavily streaked. No data is yet available as to when or how these changes occur, but an online image of a begging juvenile with a fully grown tail from Reserva Provincial Santa Maria, Corrientes province, Argentina (Meoniz 2015) shows a paler breast and midbelly, only traces of dark streaking on the sides of the crown, a very thin dark ocular line and some slight whitening of the posterior superciliary, whilst the forehead and face remain strongly rufous and the bill color is retained from the juvenile. The image is dated 8 December 2015, which, assuming early breeding in October, suggests that the juvenile plumage may only

**Figure 1.** Juvenile *Culicivora caudacuta* in ventral (**A**) and dorsal (**B**) views at Kanguery, Área para Parque Nacional San Rafael, Itapúa Department, 5 April 2016. Photo author: P. Smith.

be retained for a few months before adult traits become visible.

The three juveniles were accompanied by two adult birds. The short tail of the juvenile birds and their reluctance to fly suggested that they had recently left the nest. The birds were approachable to within a few meters, but this elicited alarm-calling from the adults and gaping postures (revealing the bright orange mouth-lining) from the juveniles. All three birds were capable of limited flight, landing clumsily on low branches. At least during this early short-tailed stage confusion at distance is potentially possible with female or non-breeding plumages of the widely sympatric Bearded Tachuri *Polystictus pectoralis*. However, the much more rufous coloration of the head and the bright orange gape, coupled with the clearly juvenile state of the birds should suffice for a correct identification.

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SHORT-COMMUNICATION

# Brown plumage aberration records in Kelp Gull (*Larus dominicanus*) and Magellanic Penguin (*Spheniscus magellanicus*) in southern Brazil

**Maria Virginia Petry[1,2], Luiz Liberato Costa Corrêa[1], Victória Renata Fontoura Benemann[1] & Gabriela Bandasz Werle[1]**

[1] Laboratório de Ornitologia e Animais Marinhos, Universidade do Vale do Rio dos Sinos, Avenida Unisinos, 950, Bairro Cristo Rei, 93022-000, São Leopoldo, RS, Brazil.
[2] Corresponding author: vpetry@unisinos.br

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**ABSTRACT:** Plumage aberration records are widely reported for terrestrial bird species, although for seabirds those records are still scarce. The brown mutation is one of the most frequent color aberration in birds, and is defined as a qualitative reduction of eumelanin. Here we describe the first records of brown plumage aberration for two seabird species, in two individuals of *Larus dominicanus* and one individual of *Spheniscus magellanicus*, in coastal southern Brazil, thus contributing to the knowledge on color variations in wild birds.

**KEY-WORDS:** chromatic, coloration, mutation, seabirds, waterbirds.

Plumage aberrations in wild birds have been widely reported over several decades (*e.g.* Sage 1963, Piacentini 2001, Franz & Fleck 2009, Mancini *et al.* 2010, Crozariol *et al.* 2013, Frainer *et al.* 2015). Those color mutations occur due to the absence or excess of certain pigments in the birds' feathers and skin, which may result in distinct kinds of color variation, diverging from the original plumage pattern of the species. The most commonly reported mutations are cases of albinism, leucism, melanism, progressive greying, dilution and brown (Sage 1963, van Grouw 2006, van Grouw *et al.* 2011, Hume & van Grouw 2014). The brown mutation is a genetically-based plumage abnormality that may be caused by multiple mechanisms, including loci in autossomes or sexual cromossomes. Van Grouw (2006, 2012) suggested that the brown mutation may be caused by a single gene, and that its inheritance is recessively linked to the female sexual chromosome. On the other hand, studies have shown that the activation of the melanocortin-1 receptor (MC1R) gene may increase the synthesis of brown eumelanin (Robbins *et al.* 1993, Mundy 2005). However, most cases of plumage aberrations reported, attributed to the MC1R gene, are different degrees of melanism (Mundy *et al.* 2004, Mundy 2005, Nadeau *et al.* 2006).

In birds, the brown mutation affects qualitatively the eumelanin, which is the pigment responsible to produce black, grey and dark-brown tones. As a result of the incomplete oxidation of eumelanin, this pigment becomes less expressive, while the brown tones provided by the phaeomelanin pigment become more apparent, thus expressing the brown mutation. Additionally, it is known that feathers affected by brown mutation may depigment as a result of continuous sun exposure, becoming white-toned. In some cases, the bird tarsus may present depigmentation as well (van Grouw 2006, 2013).

Brown mutation cases are relatively common in wild birds, and were described for a large number of species, for instance *Agelasticus thilius*, *Columba maculosa* and *Nothura maculosa* (Urcola 2011), *Uria aalge*, *Uria* spp. and *Morus bassanus* (van Grouw *et al.* 2011), *Passer domesticus* (van Grouw 2012), *Megarynchus pitangua* (Crozariol *et al.* 2013), *Corvus monedula* and *Pica pica* (van Grouw 2013), *Ectopistes migratorius* (Hume & van Grouw 2014), *Corvus splendens* (Mahabal *et al.* 2015), *Fulmarus glacialis*, *Larus argentatus* (Flood & van Grouw 2015) and *Procellaria aequinoctialis* (Frainer *et al.* 2015). Although the brown mutation is a commonly reported color variation, caution must be taken in diagnosis of specimens, considering that many authors have erroneously described brown mutation cases as other color mutations, such as dilution or leucism (van Grouw 2012).

The Kelp Gull (*Larus dominucanus*) is a coastal bird widely distributed through the Southern Hemisphere, occurring in coastal environments from the Equator to the Antarctic continent (BirdLife International 2016a). The original color pattern of adult individuals consists in head, neck, tail, rump and undersides all white, presenting black tones in the back and top of the wings. Immature individuals present back and top of the wings mottled brownish, rump barred brownish and white. The bill-tip is reddish in adult individuals, while blackish in immatures (de la Peña & Rumboll 2001, Couve & Vidal 2003). The Magellanic Penguin (*Spheniscus magellanicus*) is a pelagic seabird distributed through the Pacific and Atlantic Oceans of South America, ranging coastal zones from Argentina, Chile and Falklands Islands. Immature individuals migrate northward during the non-breeding season, reaching the coast of Brazil in winter months (BirdLife International 2016b). The original color pattern of adults consists in white prevailing in the underparts, with a horseshoe-shaped black band on breast extending down the flanks, and another wider band crossing the upper breast. Black predominates in the dorsal region, upper side of the flippers and head, with a white collar descending from the top of the head and joining on the neck. Immatures present greyish plumage instead of black, lacking the bands on head, neck and breast (Williams 1995, de la Peña & Rumboll 2001). Neither species present apparent sexual dimorphism (Couve & Vidal 2003).

Since the early 1990s, the Laboratory of Ornithology and Marine Animals (LOAM) monitors the vertebrate fauna from the middle coast of the Rio Grande do Sul state, Brazil, between Balneário Pinhal (30°15'S; 50°14'W) and Mostardas (31°11'S; 50°50'W) (Petry *et al.* 2007, 2016). Differences in plumage pattern of coastal and seabirds are observed throughout the seasons, comprising differences between breeding and non-breeding periods of species (*e.g. Sterna hirundo*, *Calidris canutus* and *Pluvialis dominica*), age group variations (*e.g. S. magellanicus*, *Thalassarche melanophris* and *L. dominicanus*) and diet-driven color variations, such as pink tones in the plumage of some species caused by a carotenoid-rich diet (*e.g. Platalea ajaja* and *Phoenicopterus chilensis*). In May 2008 we observed an adult individual of *L. dominicanus* (30°57'18.1"S; 50°39'45.3"W), and in April 2009, we observed a sub-adult individual (30°39'01.9"S; 50°26'33.1"W), both presenting aberrant plumages. In March 2010 (30°55'00.5"S; 50°38'05.3"W) we recorded one immature individual of *S. magellanicus* presenting the same color variation. All three specimens presented plumage depigmentation on originally black parts of the body, described in literature as brown mutation (see van Grouw 2006, 2013) (Fig. 1).

**Figure 1.** Adult individual of *Larus dominicanus* reported in May 2008 (**A**). Note that this specimen presents almost complete depigmentation in some tail and wing feathers. The other *L. dominicanus*, a sub-adult individual reported in April 2009 (**B**), also presents depigmentation in some tail and wing feathers, as well as in the tarsus skin Immature individual of *Spheniscus magellanicus* reported in March 2010 (**C–D**). All cases described above are brown mutation cases reported in coastal Rio Grande do Sul, Brazil. Photos: LOAM archive.

Documented cases describing plumage aberrations in coastal and seabirds in Brazil are scarce, generally reporting cases of albinism and leucism mutations (Coelho & Alves 1991, Mancini *et al.* 2010, Frainer *et al.* 2015). However, many cases have probably gone unnoticed by researchers due to natural plumage variations presented by this group, such as breeding and non-breeding plumages, as well as immature plumaged individuals. Furthermore, several cases of aberrant plumage may have not been considered relevant for publication by researchers and birdwatchers, thus hiding important information on these cases. Van Grouw (2013) reported that, in some cases, diagnosing the type of mutation in wild specimens may be challenging due to natural variation in the plumage of some species, and due to depigmentation of feathers caused by the incidence of sunlight.

The knowledge on aberrant plumage and other chromatic variations in birds may contribute to future studies regarding population genetics and ecology of species, since chromatic mutations are caused by naturally rare recessive genes. Besides that, aberrant plumaged individuals may be more or less susceptible to predation, sexual selection and illegal wildlife trade, since these individuals are more noticeable that non-mutant ones because they present a different plumage (van Grouw 2006). Records presented in this study are, to our knowledge, the first brown mutation cases reported for both *S. magellanicus* and *L. dominicanus*, thus contributing to the knowledge regarding chromatic variations in wild marine birds.

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ARTICLE

# Status and distribution of the suborder Lari in Paraguay, including new country records

**Robert P. Clay[1,4], Arne J. Lesterhuis[1,2] & Paul Smith[3]**

[1] Western Hemisphere Shorebird Reserve Network, Rodríguez de Francia 869, Asunción, Paraguay.
[2] Guyra Paraguay, Av. Carlos Bóveda, Parque Ecológico Capital Verde, Asunción, Paraguay.
[3] FAUNA Paraguay, Encarnación, Dpto. Itapúa, Paraguay and Para La Tierra, Centro IDEAL, Mariscal Estigarribia 321 c/ Tte. Capurro, Pilar, Dpto. Ñeembucú, Paraguay.
[4] Corresponding author: robpclay@gmail.com

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**ABSTRACT:** The Lari of Paraguay are poorly known and only three species in two families occur regularly (Large-billed Tern *Phaetusa simplex*, Yellow-billed Tern *Sternula superciliaris* and Black Skimmer *Rynchops niger*). However, recent field studies have revealed that diversity is much greater than previously thought, and several new species have been added to the country list in recent years. With many of these species being of only transient presence, the distribution and status of Paraguayan species is reviewed here including first reports of four species (Laughing Gull *Leucophaeus atricilla*, Franklin's Gull *Leucophaeus pipixcan*, Gull-billed Tern *Gelochelidon nilotica*, and Whiskered Tern *Chlidonias hybrida*) and one subspecies (Black Skimmer *Rynchops niger cinerascens*). The first South American record of the Whiskered Tern *Chlidonias hybrida* is remarkable coming from a country in the center of the continent. Reports of three other species (Kelp Gull *Larus dominicanus*, Snowy-crowned Tern *Sterna trudeaui* and Royal Tern *Thalasseus maximus*) are discussed and treated as hypothetical. Basic breeding data is provided for three species (Large-billed Tern, Yellow-billed Tern and Black Skimmer), showing that clutch sizes fall within clutch size ranges of other studies.

**KEY-WORDS:** breeding biology, gull, Laridae, Rynchopidae, Black Skimmer, Sterninae, Tern, vagrant.

## INTRODUCTION

The suborder Lari is comprised of the families Laridae (including the subfamily Sterninae), Rynchopidae, Stercorariidae, Alcidae, Dromadidae and Glareolidae (Burger & Gochfeld 1996, Remsen-Jr. *et al.* 2017). Two of these families occur in Paraguay, the Laridae and Rynchopidae (del Castillo & Clay 2004). Despite the presence of major river systems and extensive wetlands in the country (occupying about 40% of Paraguay, Clay *et al*. 2004) just three representatives of these two families are common and widespread.

Félix de Azara (1805) was the first to report the presence of species of Lari in Paraguay. He reported two species of gull ("la cenicienta" and "la blanca"), various terns representing two species and Black Skimmer *Rynchops niger* ("el rayador"). It was then over 180 years until the next new species was documented as occurring in the country, the Arctic Tern *Sterna paradisaea* (Hayes 1995). Much new data have become available since then and we here provide a complete overview of the current state of knowledge of the species of Lari in Paraguay, including the first documentation of four species and one subspecies.

## METHODS

Records of gulls and terns in Paraguay were compiled from the published literature, museum specimens, on-line databases *e.g.* Worldbirds (http://www.worldbirds.org) and eBird (http://www.ebird.org), the Guyra Paraguay Biodiversity Database, the authors' own field observations and through consultations with ornithologists and birdwatchers. Abbreviations used in the text are: dept. – *departamento* (a geopolitical division of Paraguay); RMNH – Rijksmuseum van Natuurlijke Historia (Leiden, Netherlands); UMMZ – University of Michigan Museum of Zoology (Ann Arbor, USA). Nomenclature follows the South American Classification Committee (Remsen-Jr. *et al.* 2017).

## RESULTS

### Species accounts

*Rynchops niger*: Black Skimmer is a common species along most of the major rivers throughout Paraguay, and in associated wetland areas, including rice fields (at least occasionally). While the species is generally rare away from the major rivers, it can be quite numerous when conditions are appropriate (*i.e.* abundant freshwater); for instance, 150 were observed at Laguna Lucero (22°33'S; 59°26'W) (within the Yacaré Sur watershed in the central Chaco) during flood conditions in July 2012 (R.P.C. & P.S.). This watershed, along with Estero Patiño (24°05'S; 59°55'W) in the Pilcomayo watershed, form the westernmost limits of the species' normal distribution in Paraguay, though there are records from further west (*e.g.* 1 at Mariscal Estigarribia 22°02'S; 60°36'W, on 20 July 1990, by A. Madroño-Nieto, and 1 at Pozo Hondo 22°18'S; 62°31'W, on 13–15 November 2003, by E. Coconier).

During river surveys carried out between 14–15 and 26–27 October 2004 a total of 49 Black Skimmer nests were found in 19 colonies along 675 km of the Paraguay River between Concepción (23°25'S; 57°17'W) and Paso de Patria (27°13'S; 58°35'W). The number of eggs per nest varied from 1 to 5, with a mean of 3.04 eggs (A.J.L.). On 30 September 2007, 10 nests were found in a mixed colony situated in a sand dune on Isla Yacyretá (27°30'S; 56°16'W), Itapúa dept. Here, clutch size varied from 1 to 4 eggs and the mean was 3.2 eggs. These data are consistent with those from studies in the United States and Brazil where clutch size also varied from 1–5 eggs (mean 2.70–3.55) (Erwin 1977, White *et al.* 1984, King & Krynitsky 1986, Custer & Mitchell 1987, Krannitz 1989 & Molina 1996).

Most Paraguayan skimmers, including all birds that have been reported breeding, belong to the subspecies *intercedens* Saunders, 1895. This subspecies has white underwing coverts, a broad white border to the secondaries and innermost primaries, and greyish-white tail feathers (apart from the dark central pair). However, in recent years, birds of the northern South American subspecies *cinerascens* Spix, 1825 have also been recorded in the country. This subspecies has darker, greyish underwing coverts, a much narrower white border to the secondaries (barely apparent, and not extending onto the inner primaries), and the tail feathers are more uniformly sooty grey (Wetmore 1944).

In addition to describing adult and immature plumages of *intercedens*, de Azara (1805) refers to "other individuals…without white tips to those feathers (the secondaries). Furthermore, the underside of these feathers and the coverts is dark" (translated from the Spanish). Though long overlooked, these would appear to describe the first records of *cinerascens* for Paraguay as noted by Saunders (1806). In addition, Bertoni (1930) noted "inconsistencies in the subspecific descriptions" which may also be a reference to birds of the subspecies *cinerascens*.

The first modern record of *cinerascens* occurred during waterbird monitoring along the Paraguay River in October 2004; one individual was observed by A.J.L. among a flock of *intercedens* on 26 October 2004. On 20 January 2005, one adult *cinerascens* in non-breeding plumage was observed at the Bahía de Asunción (25°20'S; 57°35'W), Central dept. by R.P.C. and A.J.L. Since then, there have been occasional records of small numbers (usually one to three) *cinerascens* with flocks of *intercedens* at this same locality (R.P.C., A.J.L., Sergio Rios), with a high count of at least 9 seen on 23 January 2015 with a single *intercedens*. The first Chaco record is of at least three amongst a flock of *intercedens* at Chaco Lodge (22°32'S; 59°18'W), Presidente Hayes dept. on 21 September 2015 (R.P.C. & P.S.).

Using satellite telemetry, Davenport *et al.* (2016) documented an 1800 km southeast movement of a *cinerascens* from a breeding site on the Manu River in Amazonian Peru, to the vicinity of Fuerte Olimpo, Alto Paraguay dept., Paraguay, suggesting a potential origin for birds recorded in Paraguay.

*Chroicocephalus maculipennis*: Bertoni (1919) claimed the first record of the Brown-hooded Gull for Paraguay, a now lost specimen that was collected by his brother Werner during July 1916 at Puerto Bertoni, Alto Paraná dept. (25°39'S; 54°36'W). Though there have been no further records of the species in the country, it seems that Bertoni overlooked several previous reports.

Storer (1989) reported a first-year female (UMMZ 1647a) collected by W. Foster at Sapucay (25°40'S; 56°55'W), Paraguarí dept. on 17 August 1901 (not 1907 as given in that publication). He also noted the existence of two further specimens collected in 1863, one breeding adult and a young bird beginning to acquire nuptial plumage (Schlegel 1863) which Hayes (1995) suspected may have been collected outside of the boundaries of modern day Paraguay. A third specimen listed by Schlegel (1863) with "grey head" is an adult *C. cirrocephalus* (F. Mees, pers. comm. in Storer 1989). Schlegel treated *maculipennis* as a synonym of *cirrocephalus*.

Additionally, and following Saunders (1806), we refer de Azara's (1805) description of "la blanca" to this species. There are two populations of *C. maculipennis*: a "white-winged" form breeding on the Pacific coast of southern South America, and a "spot-winged" population on the Atlantic side of southern South America, north of Patagonia (Murphy 1936). De Azara's description is inconsistent with *C. cirrocephalus* (as noted by Hartlaub 1847) but closely fits "spot-winged" *C. maculipennis*, which would seem the most likely population (geographically) to occur in Paraguay. He noted flocks of up to 12 birds, in wet meadows with a lot of grass, rather than along rivers and lagoons. He described the birds thus: "The whole body is white with the wings ashy-white; but the first two primaries are black with a white shaft and sub-terminal spot. The next three primaries have the tip and the inner web dark, and the outer web white. The other primaries are similar, with a small white tip." (translated from Spanish).

The complete absence of modern records of *C. maculipennis* is of great interest, and this may be attributable to the more coastal habitat preference of that species. However recent sight reports of the species close to the Paraguayan border in Argentina at Laguna Yema (24°15'S; 61°14'W), Formosa province (16 May 2013; N. Oste, D. Almiron, J. Ubiría & C. Agulian); Puerto Iguazú (25°36'S; 54°34'W), Misiones province (7 December 2013; V. Sandage); and Laguna Iberá (28°32'S; 57°16'W), Corrientes province (1 September 2005; J. Ubiría) all suggest that future records are likely with increased field effort. Given the paucity of records currently available we consider the species a rare vagrant to Paraguay.

*Chroicocephalus cirrocephalus*: Grey-headed Gull is a relatively common species in southern South America, occurring along the Pacific coast of Ecuador and Peru, discontinuously along the Atlantic from north-east Brazil south to Argentina, and inland along river systems including the lower Paraná River (Burger & Gochfeld 1996, Lees *et al.* 2014). De Azara (1805) reported that he had never seen "la cenicienta" (referring to *C. cirrocephalus*) but had heard of a year in which they were very abundant, arriving from the south. Hayes (1995) considered the species to be a rare austral migrant to Paraguay. Contrary to the statement in Dwight (1925; possibly the source of a similar statement in Harrison 1985), there is no evidence of the species ever having bred in the country.

One of the three gull specimens collected at an unspecified locality (possibly outside of Paraguay) in 1863 is an adult *C. cirrocephalus cirrocephalus* (Schlegel 1863, Storer 1989, RMNH 46021). Other than this, the first documented record undoubtedly within the current borders of Paraguay are two females collected by H.E. Bender 120 km SE of Orloff, Presidente Hayes dept., on 1 September 1940 (Storer 1989; USNM 571,351 and 571,352). Storer (1989) speculated that the specific locality for these specimens was the salt lake at Laguna Salada (22°34'S; 59°20'W).

Ten birds reported from along the Paraguay River between 18 October and 4 November 1984 (López 1985) and a report lacking details from Misiones dept. (Contreras *et al.* 1989) were treated as hypothetical by Hayes (1995) and del Castillo & Clay (2004), but are within the realms of possibility.

Since 1990, there have been an additional 15 records, 13 of which are published here for the first time (Table 1). These include birds in both breeding (Fig. 1A) and non-

**Table 1.** Recent records of *Chroicocephalus cirrocephalus* in Paraguay.

| Date | No. individuals | Plumage | Locality (Latitude; Longitude) | Department | Observer/ Reference |
|---|---|---|---|---|---|
| July 1990 | 2 | | Villeta (25°28'S; 57°36'W) | Central | J. Escobar |
| January 1992 | 1 | | 2 km north of Isla Umbú (27°00'S; 58°26'W) | Ñeembucú | Contreras *et al.* (2014) |
| 5 November 1994 | 1 | | Asunción (Bahía de Asunción) | Central | J. Escobar |
| 4 October 2004 | 2 | Breeding | Asunción (Bahía de Asunción) | Central | P.S. & R. McCann |
| 21 May 2005 | 1 | Non-breeding | Asunción (Bahía de Asunción) | Central | C. Morales, S. Centrón, H. Cabral Beconi & R. Zarza |
| 16 September 2005 | 3 | Non-breeding | Fuerte Olimpo (21°2'S; 57°52'W) | Alto Paraguay | J. Escobar |
| 11 January 2009 | 1 | Non-breeding | Arroyo Aguapey (27°0"S; 56°17'W) | Itapúa | H. del Castillo |
| 11 August 2009 | 1 | Non-breeding | Asunción (25°16'S; 57°40'W) | Central | R.P.C. |
| 13 September 2009 | 3 | Breeding (2); immature | Asunción | Central | R.P.C. |
| 7 October 2009 | 16 | Intermediate | Arroyo Aguapey | Itapúa | J. Escobar (largest reported flock) |
| 11 October 2011 | 11 | At least 2 in breeding | Brazo Aña Cua (27°22'S; 56°40'W) | Itapúa | R.P.C., H. Swegen & B. Lorentzon |
| 23 August 2012 | 2 | Breeding | Carmen del Paraná (27°15'S; 56°10'W) | Itapúa | Roberto Derna |
| 26 March 2013 | 1 | Breeding | Laguna Blanca (23°44'S; 56°17'W) | San Pedro | Smith *et al.* 2016 |
| 3 February 2016 | 1 | Breeding | Asunción | Central | R.P.C. |
| 13 November 2016 | 1 | Breeding | Yacyretá hydroelectric dam (27°29'S; 56°44'W) | Itapúa | R.P.C. |

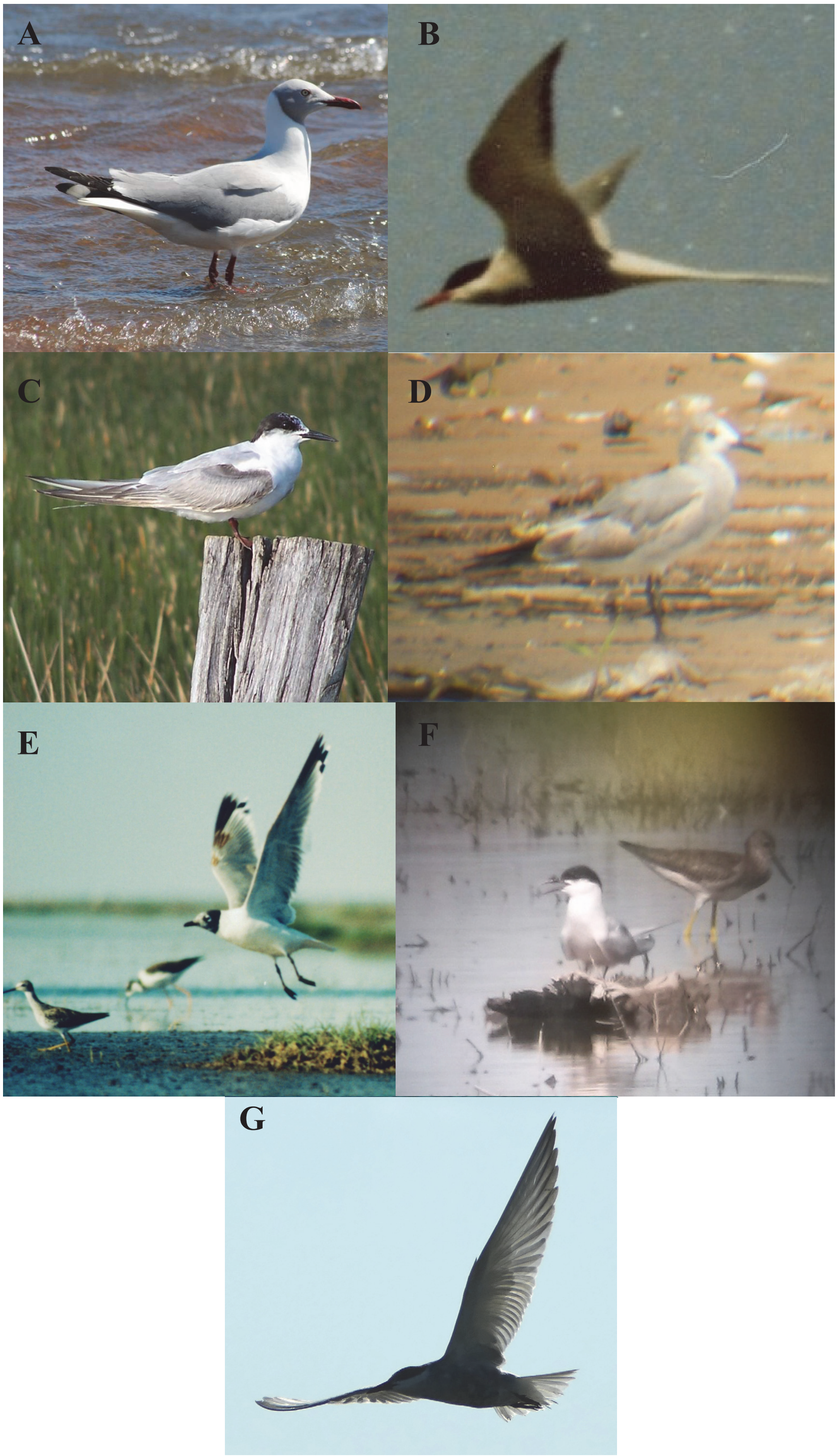

**Figure 1.** (**A**) *Chroicocephalus cirrocephalus*, Carmen del Paraná, dept. Itapúa (Photo author: R. Derna); (**B**) *Sterna paradisaea*, Bahía de Asunción, dept. Central (Photo author: F. Hayes); (**C**) *Sterna hirundo*, Laguna Blanca, dept. San Pedro (Photo author: P. Smith); (**D**) *Leucophaeus atricilla*, Bahía de Asunción, dept. Central (Photo author: M. Coath); (**E**) *Leucophaeus pipixcan*, Laguna Sanidad, dept. Presidente Hayes (Photo author: A.J. Lesterhuis); (**F**) *Gelochelidon nilotica*, Laguna Capitan, dept. Presidente Hayes (Photo author: A.J. Lesterhuis); (**G**) *Chlidonias hybrida*, Estancia Graciela, dept. Misiones (Photo author: H. Faithfull).

breeding plumage, as well as at least one immature. The species seems to be a regular vagrant in Paraguay and may be more numerous in some years than others.

*Sternula superciliaris*: Yellow-billed Tern is fairly common along the major rivers in Paraguay but is rather rare away from them. The farthest west the species has been recorded is on the lagoons of the Yacaré Sur watershed (22°33'S; 59°23'W) in the central Chaco, and the Estero Patiño wetlands associated with the Pilcomayo River (R.P.C., A.J.L., H. del Castillo). Yellow-billed Tern nests in colonies with both Large-billed Tern *Phaetusa simplex* and Black Skimmer along the Paraguay River and the lower reaches of the Paraná River (from the Yacyretá dam to the confluence with the Paraguay River). Colonies are located on sand banks and sandy beaches of islands, with breeding activity from August to December. During river surveys carried out between 14–15 and 26–27 October 2004, a total of 155 Yellow-billed Tern nests were found in 19 colonies along 675 km of the Paraguay River between Concepción (23°25'S; 57°00'W) and Paso de Patria (27°15'S; 58°33'W). The number of eggs per nest varied from 1 to 4, with a mean of 2.02 eggs (A.J.L.). On 30 September 2007, 13 nests were found in a mixed colony situated in a sand dune on Isla Yacyretá, Itapúa dept. (27°25'S; 56°49'W). Here the number of eggs varied from 1 to 3 and the mean was 2.7 eggs (A.J.L.). Krannitz (1989) reported a mean clutch size of 1.94 eggs and a range 1–3 eggs for 16 nests in Brazil.

*Phaetusa simplex*: Large-billed Tern is a common species along the major rivers and in associated wetlands, including (and perhaps increasingly) rice fields. The highest count is of 848 birds going to roost on the 4 November 2016 seen from Parque Solidaridad (25°16'S; 57°39'W, on the banks of the Paraguay River) by R.P.C. Though generally uncommon away from major rivers, it can become quite numerous when conditions are appropriate (*i.e.* abundant freshwater). For instance, the species is periodically abundant at the saline lagoons of the Yacaré Sur watershed in the central Chaco, *e.g.* 300–500 birds at various lagoons in July 2012 (R.P.C. & P.S.) which coincided with extensive fresh and brackish water flooding in the watershed. The Yacaré Sur watershed and the Estero Patiño wetlands of the Pilcomayo River watershed (both Presidente Hayes dept.) form the western limit of the normal range of the species in Paraguay.

Large-billed Tern breeds in mixed colonies with Yellow-billed Tern and Black Skimmer on sand banks and sandy beaches of islands. Although a common bird (del Castillo & Clay (2004), to date only small breeding colonies have been found of this species. During a river survey on 26 and 27 October 2004 a total of five Large-billed Tern nests were found in five mixed colonies along 300 km of the Paraguay River between Concepción and Asunción (25°15'S; 57°37'W). The number of eggs per nest varied from 2 to 3, with a mean of 2.6 eggs (A.J.L.). On 30 September 2007, one nest with 3 eggs was found in a colony with Yellow-billed Terns and Black Skimmers on a sand dune on Isla Yacyretá, Itapúa dept. Krannitz (1989) reported a mean clutch size of 2.3 from Brazil, based on 121 nests.

*Sterna paradisaea*: Hayes *et al.* (1990) recorded the Arctic Tern at the Bahía de Asunción, Central dept. on the 9 and 10 May 1989. Photos were deposited in VIREO and one is published here (Fig. 1B) for the first time. This record was the first of the species in the interior of South America.

*Sterna hirundo*: a winter adult Common Tern was photographed (Fig. 1C) and filmed on 17 and 18 September 2006 at Laguna Blanca, San Pedro dept. by P.S., and was also observed by H. del Castillo, Richard Smith and Kirti Chaudhurri (Smith & del Castillo 2006, Smith *et al.* 2016). It was identified based on the dark carpal bar, dark primaries, short tail, long black bill and flattened head. This represents the first record of Common Tern for Paraguay. Previous reports of the species in Paraguay (CDC 1995, 1997) are in error and refer to the first Paraguayan record of Arctic Tern which was initially misidentified as a Common Tern (del Castillo & Clay 2004). Common Tern has been reported from several inland localities in Argentina to the south of Paraguay (Mark Pearman, pers. comm.) and its occurrence in Paraguay as a vagrant or irregular passage migrant is unsurprising.

*Leucophaeus atricilla*: Laughing Gull breeds in the eastern United States and the Caribbean and winters in Central and South America (Burger & Gochfeld 1996). In South America it occurs along the Pacific coast as far south as northern Chile, and along the Atlantic coast to northeastern Brazil, occasionally as far south as Rio Grande do Sul (Burger 1996) and may be expanding its non-breeding distribution (Lima *et al.* 2010). It is considered primarily a coastal species and is only rarely observed inland (Lima *et al.* 2010).

On 2 February 2011, R.P.C., A.J.L. and Melanie & Dominic Coath observed a gull in a large flock of Large-billed Terns in the Bahía de Asunción (Fig. 1D). The bird was identified as a first-year Laughing Gull based on its relatively long bill, flattened forehead and elongated body, combined with grey wash on flanks and hind-neck, and mottled underwing, which distinguish the species from similar plumages of Franklin's Gull *Leucophaeus pipixcan* (Sibley 2000).

This represents the first record of the species for the country, and one of the southernmost records in South America. There is an undocumented report of a bird captured at Lagoa do Peixe (31°14'S; 50°57'W), Rio Grande do Sul, Brazil, in July 1985 (Sick 1993), but it was treated as requiring documentation by Bencke

(2001). Records of the species inland in South America are rare; previously published reports include three in Amazonas state, Brazil (Lima *et al.* 2010), one in western Amazonian Peru (O'Donnel & González 2003) and a handful of records from the western Amazon and Andes in Ecuador (Santander *et al.* 2011, Henry 2012).

*Leucophaeus pipixcan*: Franklin's Gull breeds in Canada and the United States, and winters along the Pacific coast of South America to southern Chile, also occurring in small numbers in Argentina from Córdoba to Chubut provinces, and rarely to Tierra del Fuego (Burger & Gochfeld 1996). In Bolivia it has been reported from La Paz, Cochabamba and Potosí depts. (Hennessey *et al.* 2003) and vagrants have reached Venezuela (Hilty 2003), French Guiana, both coastal and inland Brazil (Farias 2016), and Uruguay (Abreu 2015).

On 17 June 2004, A.J.L. photographed a dark-headed gull at Laguna Sanidad, Estero Patiño, Presidente Hayes dept. (Fig. 1E) that was also observed by H. del Castillo, M. de Bernard and M. Montiel. The bird was identified as a Franklin's Gull due to its blackish hood, prominent white eye crescents, dark grey upperwing and plain white underwings (Sibley 2000). The solid black wing tips, with some brown remaining on the secondaries and tertials indicated that the gull was in first summer plumage (Burger & Gochfeld 1996). This represents the first record of the species for Paraguay.

On 11 July 2007, a probable Franklin's Gull was observed by A.J.L. and S. Centrón at Campo María (22°34'S; 59°20'W) Presidente Hayes dept. The individual had an all black hood and in flight showed darkish grey upperwings with a white subterminal band. Unfortunately, the bird was seen only briefly before flying off. We consider this species a rare vagrant to Paraguay, though one which seems likely to occur again given that it winters in southern South American and its well-documented tendency to wander.

*Gelochelidon nilotica*: Gull-billed Tern breeds in southern Europe, northern Africa, central and east Asia, the southern United States, Mexico, the Caribbean and South America (Gochfeld *et al.* 2016a). Within the Americas, at least three subspecies breed, with North American breeding birds wintering as far south as Brazil and Peru (Gochfeld *et al.* 2016a). The subspecies *gronvoldi* has a disparate breeding distribution centered on the coast of the Guianan shield and southern coastal Brazil and the lower Paraná and Plata River Basins, where it is believed to be resident (Gochfeld *et al.* 2016a).

On 25 July 1999, H. del Castillo observed an adult Gull-billed Tern in non-breeding plumage at Laguna Sanidad, Estero Patiño, Presidente Hayes dept. On 3 July 2005, another non-breeding adult was found at the same locality by R.P.C., and seen later that day by H. del Castillo, H. Cabral, S. Centrón, F. Fragano and L. López. Presumably the same bird was seen again, albeit distantly, on 4 July (R.P.C.). F. Fragano documented the record with a distant photograph. The bird was easily identified by the stocky, black gull-like bill, all pale crown, and smudgy blackish-patch on the ear-coverts. The upperparts, including the long wings, rump and tail, were very pale pearly-grey, and the tail was only shallowly forked. A bird in full breeding plumage was photographed by A.J.L. at Laguna Capitán (22°33'S; 59°42'W), Presidente Hayes dept. on 25 October 2014 (Fig. 1F).

These are the first documented records of the Gull-billed Tern in Paraguay. The species had been previously listed for Paraguay without details (CDC 1995, 1997). We consider the species a rare vagrant in Paraguay. Paraguayan records presumably refer to the southern South American population of *gronvoldi*: the three records reported here were of birds in the plumage expected for individuals from an austral breeding population, with non-breeding plumaged birds being recorded in the austral winter and a breeding plumaged bird during the austral spring (when northern birds would be expected to show the opposite plumages).

*Chlidonias hybrida*: Whiskered Tern has migratory populations that breed in southern Europe to central Asia, and in east Asia (wintering in northern and central Africa and southern Asia), with resident populations found in southern Africa, southern Asia and Australia (Gochfeld *et al.* 2016b). Occasional transatlantic vagrancy has been recorded, *e.g.* to Iceland, Azores, USA (Gochfeld *et al.* 2016b) and vagrants have also been reported for Micronesia (Hayes *et al.* 2016).

A breeding plumage adult Whiskered Tern was observed and photographed at Estancia La Graciela, Misiones dept. (26°34'24"S; 56°51'42"W) on 14 January 2016 by R.P.C., Holly Faithfull and Lloyd Stetson (Fig. 1G). The bird had the typical structure of a "marsh tern" *Chlidonias* sp. with broad-based wings that appeared shorter and more round-tipped than *Sterna* terns, and a short tail with a shallow fork. Its plumage was uniformly mid-grey across the wings, mantle, rump, and tail; whilst blackish underparts contrasting markedly with the white cheek and undertail-coverts, and with the pale underwing. The foraging action was also classic marsh tern: dipping down to the water to surface-pick.

This represents the first record of Whiskered Tern for Paraguay and for South America, and one of very few records in the Americas. Previous records in the Americas are limited to three records from Cape May, New Jersey, USA (in July 1993, August 1998 and September 2014), one record from Delaware Bay, Delaware, USA in July/August 1993 (assumed to be the same as the first Cape May bird), three records from Barbados and a single record from Great Inagua, Bahamas (Howell *et al.* 2014, New Jersey Audubon 2014).

*Sterna trudeaui*: The only reports of Snowy-crowned Tern in Paraguay are those of Contreras & Contreras (1992), who recorded one at Itá Enramada (25°37'S; 57°30'W), Central dept., on 7 May 1989; one at Puerto Nuevo de Pilar (26°52'S; 58°23'W), Ñeembucú dept. on 10 January 1992; and at least 10 (1 in the morning, 10 in the afternoon) between Puerto Naranjito and Pilar (26°56'S; 58°27'W), Ñeembucú dept. on 17 September 1992. Hayes (1995) treated these records as hypothetical/possible because of the lack of description provided, and del Castillo & Clay (2004) listed the species as requiring documentation.

Both Large-billed Tern and Yellow-billed Tern can show plumages superficially similar to that of Snowy-crowned, and a recent record of the very similar Forster's Tern *Sterna forsteri* in Mar Chiquita Lagoon, Argentina (http://ebird.org/ebird/argentina/view/checklist/S15984614) underlines the need for caution in evaluating undocumented extralimital records of this species. Nonetheless, the species is of probable occurrence as a vagrant in Paraguay, and has been recorded at several Argentinian localities close to the Paraguayan border. These include (in addition to those listed by Contreras & Contreras 1992) a record 109 km from the Paraguayan border at Laguna Iberá, Corrientes province (10 May 2009; F. Schmitt & R. Barros McIntosh, eBird); 63 km away at Laguna de Gramado, Misiones province; 77 km away at La Escondida, Chaco province (A. Bodrati, pers. comm.); and 77 km away at Reserva El Bagual, Formosa province (Di Giacomo 2005). The latter locality is just 99 km from Pilar, one of the localities reported by Contreras & Contreras (1992).

*Thalasseus maximus*: The only report of Royal Tern in Paraguay is that of Contreras (1992), who observed one individual at Pilar, Ñeembucú dept. on 10 September 1992. Unfortunately, Contreras (1992) provides only a brief description of the bird, stating that it was in non-breeding plumage with the crown greyish-white. Hayes (1995) treated the occurrence of the species in Paraguay as hypothetical/possible, while del Castillo & Clay (2004) considered it as requiring documentation.

Esteban (1953) reports a previous specimen record of a female (6662) in the Miguel Lillo Collection, Tucumán from Isla Apipé Grande, Corrientes, Argentina, taken on 24 October 1950 which is geographically close to the Contreras (1992) record and immediately adjacent to the Paraguayan border. However, given the propensity for the extralimital occurrence of terns and the fact that there are potential confusion species which are not excluded by the description provided, it seems best to maintain the Contreras (1992) record as pending documentation.

*Larus dominicanus*: A specimen (RMNH.AVES.46019) of the Kelp Gull with locality "Paraguay" in the Naturalis Biodiversity Center (Leiden, Holland) lacks any collection data. Schlegel (1863) states that the specimen was "acquired from Mr Pardzudacky in 1862". De Azara's (1805) "la mayor" was attributed to this species by Hartlaub (1847), but de Azara specifically stated that the species does not occur in Paraguay. The Kelp Gull is widely distributed in the southern hemisphere breeding in South America (Burger & Gochfeld 1996) and although nowadays expanding into continental ecosystems (including freshwater lagoons) in northern Patagonia (Frixione *et al.* 2012) we treat this historical record as hypothetical in Paraguay and consider the provenance of the specimen to be likely an error.

## DISCUSSION

Though it is a landlocked country, several mayor rivers that bisect Paraguay connect it to important South American wetlands and ultimately to the Atlantic Ocean coast. Large river systems like the Paraguay, Paraná and Pilcomayo Rivers are likely the main source of the wandering species of the suborder Lari recorded in Paraguay to date.

Of the 10 species documented to date, five species are terns, four are gulls and the other is the Black Skimmer. Of the species considered pending documentation, the Snowy-crowned Tern would seem the most likely be subsequently documented in Paraguay given the proximity of recent records in northern Argentina.

The increased number of reports of gulls and terns in Paraguay is likely a result of an increasing interest in waterbirds and birding in general in Paraguay. Since 2001 the Neotropical Waterbird Census, a waterbird monitoring program implemented by a network of volunteers twice a year, has attracted an increasing number of participants. Furthermore, more local people are becoming involved in birding at a time when ecotourism is beginning to attract considerable national and international attention. It would seem that additional records of interest may be expected in the near future, perhaps even including new records of the long absent Brown-hooded Gull.

## ACKNOWLEDGEMENTS

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SHORT-COMMUNICATION

# A new location in Peru for the poorly-known Acre Antshrike *Thamnophilus divisorius* endemic of Serra do Divisor

**Oscar Gonzalez[1,2,3,4] & Magaly Acuy[3]**

[1] Tropical Ecology and Conservation Lab, Department of Wildlife Ecology and Conservation, University of Florida. Gainesville, FL 32611, USA.
[2] Department of Natural Sciences, Emmanuel College. Franklin Springs, GA 30332, USA.
[3] Grupo Aves del Peru. Gomez del Carpio 135, Lima 34, Peru.
[4] Corresponding author: pajarologo@ufl.edu

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**ABSTRACT:** We provide a documented record for the Acre Antshrike *Thamnophilus divisorius*, an endemic species of Serra do Divisor, in the Amazon Forest of Peru. Four birds responded to playback and a female was captured in mist-nets. This is the fourth documented record of this species in the world, 28 km north of the nearest previous record. We comment on the current distribution of this species between Peru and Brazil and the possible threats that it might face in the near future.

**KEY-WORDS:** Amazon Forest, conservation, distribution, endemic species, new records, Thamnophilidae.

The Acre Antshrike *Thamnophilus divisorius* is a passeriform bird of the antbird family (Thamnophilidae). It is endemic of Serra do Divisor, a mountain chain in the western Amazon located in the border between Peru (south of department of Loreto and north of department of Ucayali) and Brazil (west of state of Acre). This mountain chain (200–600 m a.s.l) is protected in both Peru and Brazil, as National Parks in each country (Fig. 1) because of its high biodiversity and endemism (Vriesendorp *et al.* 2006). The Acre Antshrike was first discovered in Brazil in 1996 (Whitney *et al.* 2004) in the southeast part of the mountain chain and in Peru in 2005, almost 100 km west of its discovery location (Tovar *et al.* 2009). A third record was located in the Contaya Mountains, also in Peru, which is 80 km west of this other place. These three locations were the only records for this species until now. BirdLife International (2017) categorizes Acre Antshrike as "Least Concern" (LC).

Vriesendorp *et al.* (2006) and Tovar *et al.* (2009) stated that most of Acre Antshrike's population is to be found in Peru because it was found in two locations. Therefore, it was expected that this species would be also located in North Sierra do Divisor. In 2009, during a biodiversity evaluation in the province of Requena in Loreto department, Peru, we recorded a new location for Acre Antshrike in a mountain ridge at the headwaters of Rio Blanco, inside Sierra del Divisor National Park (73°52'0.48"W; 6°57'29.02"S; 393 m a.s.l.; Fig. 1). This was a remote and unexplored place only accessible by helicopter. The mountain summit is covered by stunted forest with steep slopes, similar to the location where this species was first discovered (Whitney *et al.* 2004, Vriesendorp *et al.* 2006). This place showed little perturbation in comparison with the lowlands, where we found areas that suffered the impact of illegal logging activities. The vegetation composition of this stunted forest was made of small trees (less than 10 m) and the common species were *Anaueria brasiliensis* (Lecythidaceae), *Parkia nitida* (Fabaceae), *Cecropia membranaceae* (Cecropiaceae) and *Anaxagorea brachicarpa* (Anonaceae). There were also several bushes that mostly belong to the families Ericaceae, Piperaceae and Rubiaceae, as well as epiphytes covering their trunks - mainly Bromeliaceae and Orchidaceae.

We carried out our bird evaluation through five point counts, setting 14 mist nets of different sizes, and playback. We achieved a total of 189 net-h from 17–18 March 2009 in a 4 km-transect area; from dawn to dusk. The nets were closed ~3 h each day due to rain. The song of the Acre Antshrike was taken from the Xeno-canto database (Rojas 2005). In 17 March 2009 we detected four individuals of this species responding to the playback. We captured an adult female in one of the mist nets (Fig. 2). There was a singing male close-by, however it was undistinguishable by sight from *Thamnophilus*

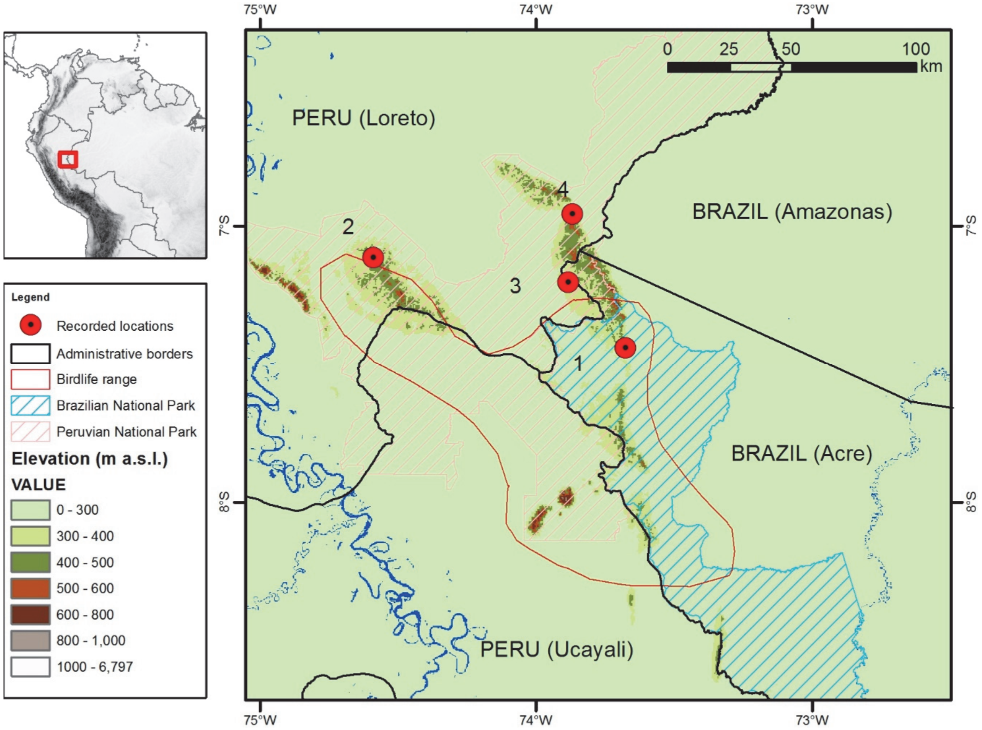

**Figure 1.** Serra do Divisor mountains and recorded locations for the Acre Antshrike *Tamnophilus divisorius*: 1 - Type locality in Brazil; 2 - record at Ojo de Contaya (Vriesendorp *et al.* 2006); 3 - record at Divisor (Vriesendorp *et al.* 2006); 4 - This study.

**Figure 2.** Female Acre Atnshrike *Thamnophilus divisorius* mist-netted at Sierra del Divisor National Park, Loreto, Peru, on 17 March 2009. Photo author: M. Acuy.

*aethiops*, which was also registered in the same location. Individuals observed showed an insectivorous feeding behavior (Fjeldså 2017), foraging on small bees abundant in this forest.

We detected other *Thamnophilus* Antshrikes during our biodiversity evaluation, namely *T. doliatus, T. murinus* and *T. schistaceus*, but all of them were in the lowlands. It is also known that, besides these species, *T. amazonicus* is present in the flooded forest nearby (Tovar *et al.* 2009). However, we did not record it during our fieldtrip. All *Thamnophilus* species we recorded during our trip are known to occur in the Brazilian side (Guilherme 2012).

This report confirms the presence of *T. divisorius* in the north part of the mountain chains of Serra do Divisor, as it was predicted by its discoverers (Whitney *et al.* 2004). The nearest record of this species is 28 km south; from a total of fourth confirmed records. Its range thus extends northward from the map presented by BirdLife International (2017) and provides a biogeographical record that will be useful for conservation planning and future research. This new location gives ornithologists an opportunity to plan research on this species, such as how competition is modeling the distribution of *Thamnophilus* antshrikes (Brunfield & Edwards 2007). Although *T. divisorius* is not considered a threatened species, we assume that any impact on the forest close to the summits would be highly detrimental. Due to its small range and specificity to the summits of the Serra do Divisor Mountains, human perturbations would cause strong negative effects in its populations.

This species, as well as other threatened and endemic species that live in the Serra do Divisor Mountains, justify the existence of National Parks in Peru and Brazil. We strongly recommend to reinforce the protection of the mountain chain of Serra do Divisor by the National Park authorities of both countries, preventing deforestation that would threaten the species.

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ERRATUM

## ERRATUM OF REVISTA BRASILEIRA DE ORNITOLOGIA 25(1): 54–59.

# The invasive species rules: competitive exclusion in forest avian mixed-species flocks in a fragmented landscape

**Marcos Maldonado-Coelho, Miguel Ângelo Marini, Fábio Raposo do Amaral & Rômulo Ribon**

Here we correct a mistake introduced during the publishing process. The Figures A and B in Fig. 3 are out of order and the correct order is presented below.

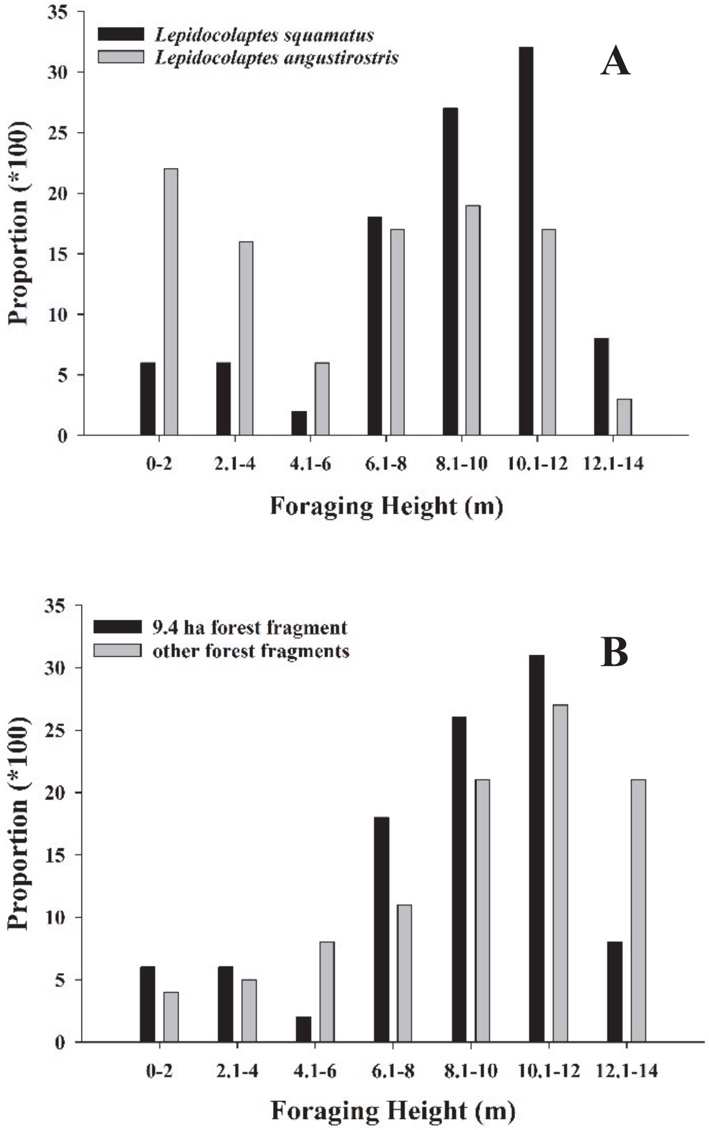

**Figure 3.** Proportion of foraging height distribution use for the two *Lepidocolaptes* species when associated with mixed-species flocks in the 9.4 ha forest fragment (**A**). Proportion of foraging height distribution use for the native woodcreeper (*L. squamatus*) individuals when associated with mixed-species flocks in the 9.4 ha forest fragment and for individuals of this species when associated with mixed-species flocks in the other eight forest fragments (**B**).

# Instructions to Authors

The ***Revista Brasileira de Ornitologia*** will accept original contributions related to any aspect of the biology of birds, with emphasis on the documentation, analysis, and interpretation of field and laboratory studies, presentation of new methodologies, theories or reviews of ideas or previously known information. Studies using animals in captivity, zoos or rehabilitation centers should have a clear focus on applicability to wild birds; otherwise will be rejected without review. The ***Revista Brasileira de Ornitologia*** is interested in publishing ornithological studies on behavior, behavioral ecology, biogeography, breeding biology, community ecology, conservation biology, distribution, evolution and genetics, landscape ecology, methods and statistics, migration, nomenclature, paleontology, parasites and disease, phylogeography, physiology, population biology, systematics, and taxonomy. Significant range extensions and novel geopolitical (*e.g.* first country) records of vagrants are also welcome, but not mere lists of the avifauna of a specific locality, nor limited extensions in distribution. Monographs may be considered for publication upon consultation with the editor. **Research papers** are usually over 3000 words, including Abstract and References), with over 3 figures and/or tables. **Short-communications** (lower than 3000 words and up to 3 figures and/or tables) are also acceptable. We encourage submissions of thorough **Review Papers**, on methods or on a particular theoretical subject, which will receive priority during the review process. **Obituaries** and **Book Reviews** are also acceptable.

Manuscripts submitted to the ***Revista Brasileira de Ornitologia*** must not have been published previously or be under consideration for publication, in whole or in part, in another journal or book. Manuscripts may be written only in American English and must be typed in Microsoft Word, using Times New Roman 12, spacing 1.5 and left justified, throughout the MS, including references and tables. Authors for whom English is not their native language are strongly recommended to have their manuscript professionally edited before submission to improve the English. Two of these independent suppliers of editing services in Brazil can be found through maryandriani@yahoo.com or the web site www.idstudio.art.br. All services are paid for and arranged by the author, and use of one of these services does not guarantee acceptance or preference for publication.

Scientific names must be shown in *italic*, and authors are encouraged to follow the latest systematic sequence, spelling and taxon authors of the Brazilian (Piacentini *et al.* 2015. *Rev. Bras. Ornitol.* 23: 91–298) or South American (www.museum.lsu.edu/~Remsen/SACCBaseline.html) bird lists, when pertinent and at their discretion. When using one of each of those sources, please be explicit about which one is being used, following it consistently throughout the manuscript. Common names should also follow those recommended by Brazilian or South American lists). Common names should be capitalized (*e.g.*, Kaempfer's Woodpecker, Common Tern).

## SUBMISSION

Originals must be submitted by the online submission system at http://www.museu-goeldi.br/rbo and as a single Microsoft Word file (tables and figures must be at the end of the manuscript). Upon manuscript acceptance, high quality image files (extensions JPG, TIF, PSD, PDF, AI, EPS, WMF or XLS; minimum resolution of 300 dpi) of the original figures will be requested. The *title* must be concise and clearly define the topic of the manuscript. Generic expressions such as "contribution to the knowledge..." or "notes on..." must be avoided. The name of each author must be written in full, followed by the full mailing address, identified by superscript numerals, and author for correspondence, in the case of multiple authors.

The parts of the **Research papers** must be organized as follows:

- **Title** of the manuscript and author names, in lowercase – not capitals – and in bold, followed by addresses of all authors. Titles longer than 100 characters with spaces should be accompanied by a running-head, or short title, no longer than 100 characters in total, also provided in the first page of the manuscript.
- **ABSTRACT/KEY-WORDS** (with title and up to 300 words; five to eight key-words related to the main topics of the manuscript and *not already mentioned in the title* must be provided in alphabetical order and separated by comma). For **Short-communications** an abstract of up to 150 words is required, in addition to key-words.
- **INTRODUCTION** (starting on a new page).
- **METHODS** (this and subsequent parts continue without page breaks).
- **RESULTS** (only the results, succinctly).
- **DISCUSSION** (avoid repetition of results and speculations, keeping Discussion as short as possible).
- **ACKNOWLEDGEMENTS**
- **REFERENCES** (check and follow format carefully).
- **Tables**
- **Figure Legends**
- **Figures**

For **Short-communications**, only the subheadings ABSTRACT, KEY-WORDS, ACKNOWLEDGEMENTS, and REFERENCES are required.

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

Figure legends, occupying one or more pages following the tables, should be numbered successively, also in Arabic numerals. Figures will follow, one to each page, and clearly numbered in agreement with the legends. Figures should be pooled as composition (Fig. 1A, B, C) always as possible.

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

The following *abbreviations* should be used: h (hour), min (minute), s (second), km (kilometer), m (meter), cm (centimeter), mm (millimeter), ha (hectare), kg (kilogram), g (gram), mg (milligram), all of them in lowercase (not capitals) and with no "periods" ("."). Use the following *statistical notations: P, n, t, r, F, G, U, df* (degrees of freedom), $\chi^2$, ns (non-significant), CV (coefficient of variation), SD (standard deviation), SE (standard error). With the exception of temperature and percentage symbols (*e.g.*, 15°C, 45%), leave a space between the number and the unit or symbol (*e.g.*, $n = 12$, $P < 0.05$, 25 min), also in figures and tables.

Latin words or expressions should be written in italics (*e.g.*, *i.e.*, *c.*, *et al.*, *in vitro*, *in vivo*, *sensu*, *a priori*). The same rule applies to words in a language distinct from the manuscript language, *i.e.*, English, but does not apply to references, which follow distinct format rules, as indicated below. Numbers one to ten should be written out, unless a measurement (*e.g.*, four birds, 6 mm, 2 min); from 11 onwards use numbers.

Author *citations* in the text must follow the pattern: (Pinto 1964) or Pinto (1964); two publications of the same author must be cited as (Sick 1985, 1993) or (Ribeiro 1920a, b); Two authors are cited in text with "&" (*e.g.* Aleixo & Pacheco 2006). Three or more authors must be presented as the first author followed by *et al.* (*e.g.* Aleixo *et al.* 2013). Avoid multiple citations in text, such as more than 3 references to support an idea or information. Multiple references should be listed in chronological order (*e.g.* Sick 1997; Narosky & Yzurieta 2003; BirdLife International 2015).Unpublished information by third parties must be credited to the source by citing the initials and the last name of the informer followed by the appropriate abbreviation of the form of communication: (H. Sick, pers. comm.) or V. Loskot (*in litt.*); unpublished observations by the authors can be indicated by the abbreviation: (pers. obs.); when only one of the authors deserves credit for the unpublished observation or another aspect cited or pointed out in the text, this must be indicated by the name initials: "... in 1989 A.S. returned to the area...". *Unpublished manuscripts* (*e.g.*, technical reports, Undergraduate Monographs, M.Sc. Dissertations and Doctoral Thesis) and *meeting abstracts* should be cited only exceptionally, in cases they are absolutely essential and no alternative source exists. The *reference* list must include all and only the cited publications (titles written in full, not abbreviated), in alphabetical order by the authors' last name:

**Articles**

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

Santos M.P.D. & Vasconcelos M.F. 2007. Range extension for Kaempfer's Woodpecker *Celeus obrieni* in Brazil, with the first male specimen. *Bulletin of the British Ornithologists' Club* 127: 249–252.

Worthington A.H. 1989. Adaptations for avian frugivory: assimilation efficiency and gut transit time of *Manacus vitellinus* and *Pipra mentalis. Oecologia* 80: 381–389.

**Books and Monographs**

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

**Book Chapters**

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

**Theses and Dissertations**

Novaes F.C. 1970. *Estudo ecológico das aves em uma área de vegetação secundária no Baixo Amazonas, Estado do Pará*. Ph.D. Thesis. Rio Claro: Faculdade de Filosofia, Ciencias e Letras de Rio Claro.

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

**Web-based References**

IUCN. 1987. A posição da IUCN sobre a migração de organismos vivos: introduções, reintroduções e reforços. http://iucn.org/themes/ssc/pubs/policy/index.htm (access on 25 August 2005).

Dornas T. 2009a. [XC95575, *Celeus obrieni*]. http://www.xeno-canto.org/95575 (access on 25 February 2012).

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

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

*Illustrations* and *tables.* The illustrations (photographs, drawings, graphics and maps), which will be called figures, must be numbered with Arabic numerals in the order in which they are cited and will be inserted into the text. Upon manuscript acceptance, high quality image files (extensions JPG, TIF, PSD, AI, EPS, WMF or XLS; minimum resolution of 300 dpi) of the original figures will be requested. Tables and figures will receive independent numbering. In the text, mentioning figures and tables must follow the pattern: "(Fig. 2)" or "... in Fig. 2." Table headings must provide a complete title, and be self-explanatory, without needing to refer to the text. All figure legends must be grouped in numerical order on a separate sheet from the figures.

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All materials must be submitted through the *Revista Brasileira de Ornitologia* web site: www.museu-goeldi.br/rbo

Only submissions through the web site will be considered. A letter of submission must accompany the manuscript. Notification of receipt of the submission will be sent automatically to the corresponding author. Please follow instructions strictly for preparation of manuscripts, otherwise they will be rejected without revision. Once the manuscript is finally accepted and a final version consolidated, PDF proofs will be sent by email to the corresponding author for revision. The correction of the final version sent for publication is entirely the authors' responsibility. The first author of each published paper will receive via e-mail, free of charge, a PDF file of the published paper. In the case of doubts as to the rules of format, please contact the editor prior to submission:

**Leandro Bugoni**
Universidade Federal do Rio Grande - FURG
Instituto de Ciências Biológicas, Caixa Postal 474, CEP 96203-900, Rio Grande, RS, Brazil.
Phone: (55) 53 3293 5059
E-mail: editoriarbo@gmail.com

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