HOW CENSUSES IN A HIGHLY FRAGMENTED AND UNDER SAMPLED REGION MIGHT CORROBORATE MASS EXTINCTIONS OF ENDEMIC BIRD SPECIES IN HALF THE STATE OF SÃO PAULO, BRAZIL

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FINAL REPORT

Introduction

The state of São Paulo (248.809 km^2, roughly the size of the United Kingdom) has a peculiar distribution of its phytogeographic domains. The Atlantic forest divides the state into two portions, one to the west and another to the east. These portions are separated by *Cerrado* vegetation. Although the deforestation of the Atlantic Forest in the state is accentuated on its eastern portion (hereafter EAST), to the west (hereafter WEST) of the *Cerrado* this condition is even more worrying. This is due to some reasons. First, the rugged terrain helped to keep two large forest corridors within the EAST, exceeding 1,000,000 ha: Serra do Mar and Serra de Paranapiacaba (Leitão-Filho 1994) (Ribeiro, et al. 2009), in which several protected areas are embedded. They include Serra do Mar State Park, Intervales State Park, Carlos Botelho State Park, Turístico do Alto Ribeira State Park, Nascentes do Paranapanema State Park, Xitué Ecological Station, as well as several Environmental Protection Areas and Natural Heritage Private Reserves, among others. Within the EAST there are also forest blocks deliberately maintained for water supply of large cities in São Paulo. These include Cantareira State Park (~ 8,000 ha), Morro Grande Forest Reserve (> 10,000 ha), and fragments around the Billings and Guarapiranga dams. In addition, the EAST is connected to large continuous Atlantic Forest found in coastal areas of the states of Rio de Janeiro to the north and Paraná to the south.

In contrast, seasonal semi-deciduous forests of the WEST are highly fragmented. Except for Morro do Diabo State Park (34,000 ha), located in the Pontal do Paranapanema, there are few remnants exceeding 2,000 ha, such as two of the four remnants of the Black-lion Tamarin Ecological Station (also situated within the Pontal do Paranapanema), and Caetetus Ecological Station (2,180 ha). Together, protected areas that hold semi-deciduous forests in São Paulo are fragmented and do not exceed 85,000 ha (Ribeiro, et al. 2009).

The historical ornithological knowledge of the WEST is known due to museum specimens collected in the early 20th century, as well as to early surveys, especially those of (Willis e Oniki 2003), conducted during the 1970s. From this information it is acknowledged that Atlantic Forest endemic bird species occurred within this region. Recently, a major source of records (existing since 2009) has been created and is freely available online. Through the Wiki Aves (www.wikiaves.com.br) website users can upload photographs and vocalizations of birds recorded within the country. These records are then indicated on a Brazilin map according to municipal offices or exact locations where they were made. Thus, information on historical and current distribution of bird species are fairly detailed. However, they have never been confronted. By doing this, I noticed a pattern that is present in about 20% of all Atlantic Forest endemic bird species (*sensu* Moreira-Lima 2013) with documentation in the state of São Paulo (Silveira e Uezu 2011): most of the endemic species is not present in much of the interior of São Paulo. This pattern is exemplified below by an Atlantic Forest endemic species, the Swallow-tailed Manakin *Chiroxiphia caudata*. It was recorded in the WEST at the time of Willis & Oniki's inventories, but current records within this portion are now very rare (**Figure 1**).

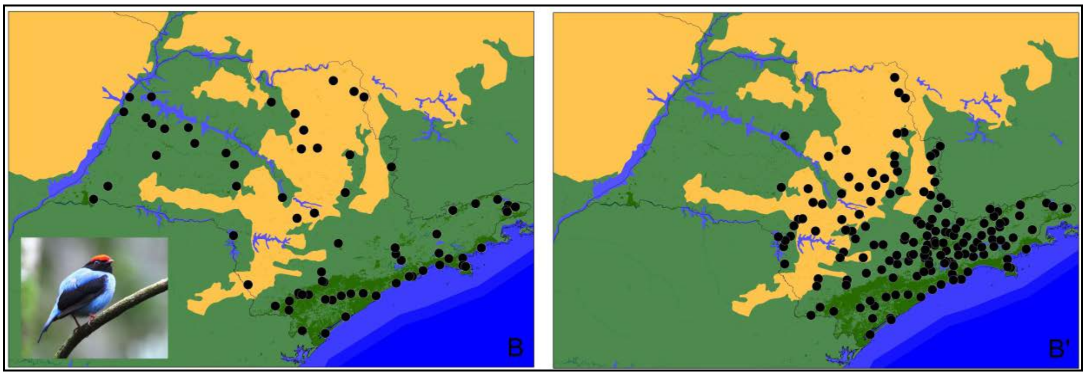

Figure 1: Distribution of historical records (specimens deposited at the Zoology Museum of the University of São Paulo and/or registered by EO Willis and Y. Oniki during the 1970s and 1980s) of the Swallow-tailed Manakin (inset), an Atlantic Forest endemic species. The image to the right indicates locations with current records of this species according to the Wiki Aves website.

The Wiki Aves information is immeasurable. Yet another type of information not desired by the website concerns whether a given species was recorded or not in a given location. Because the presence of endemic species can be incontestable to the EAST, I decided to search the literature for recent bird surveys conducted within the *Cerrado* of São Paulo and to the WEST. I was able to find 32 studies carried out in 54 locations from the 1990s-present. These again suggest the absence of Atlantic Forest endemic bird species in part of the state (**Figure 2**). In the WEST the small number of recent inventories throughout the region, especially west of the Tietê River, is remarkable.

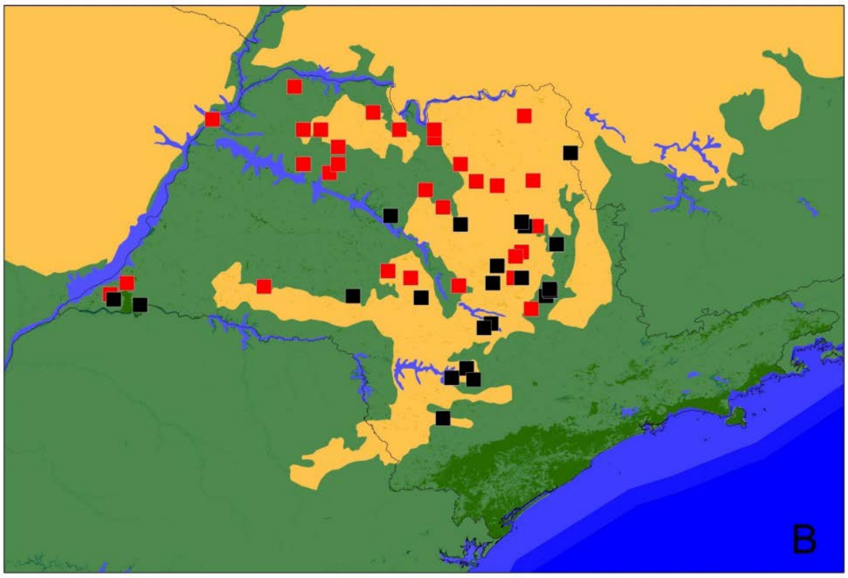

Figure 2: Distribution of records accumulated from 32 studies from the 1990s-present in São Paulo. Black squares indicate locations where the Atlantic Forest endemic Swallow-tailed Manakin was recorded, whereas red squares indicate inventoried locations where the manakin failed to be recorded.

The confrontation of all data presented can be seen in **Figure 3**. It is noteworthy that almost no location with historical records in the WEST has been revisited.

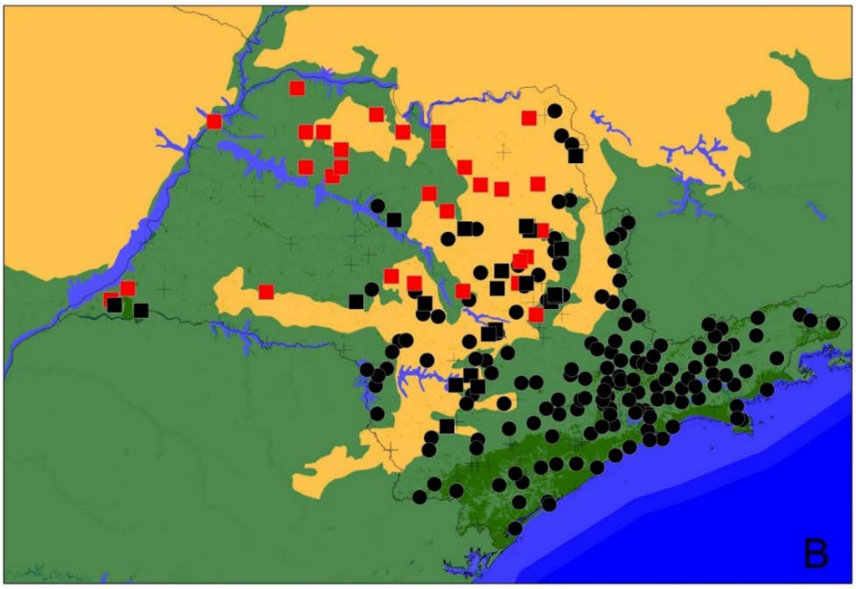

Figure 3: Confrontation of historical and current records of the Atlantic Forest endemic Swallow-tailed Manakin. Crosses represent historical records. Circles are locations from Wiki Aves and squares represent recent literature. Black indicates recent records, while red indicates the absence of the species in a given locality.

Until 06 September 2016 the inspection case by case of Atlantic Forest endemic bird species on the Wiki Aves website (as well as many other forest wide-ranged species) whose range is expected in the interior of São Paulo (Erize, Rumboll e Mata 2006) (Ridgely e Tudor 2009) demonstrates the recurrence of the aforementioned pattern. At first glance, the absence of records in the WEST suggests a corresponding gap of users in this citizen science website. However, most counties in the state are represented with bird records (**Figure 4**).

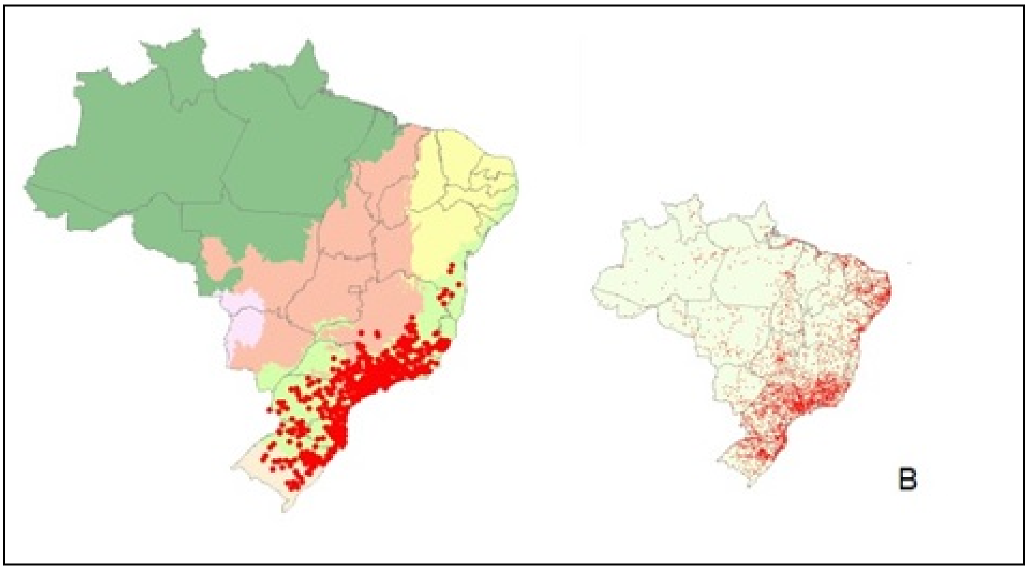

Figure 4: Records (red dots) of Wiki Aves users that indicate the presence of (A) Atlantic Forest endemic Swallow-tailed Manakin to the EAST of the *Cerrado* domain in São Paulo state. Note the absence of the species WEST of the *Cerrado*, although the representation of records of birds in the state encompass virtually all of São Paulo municipalities (B).

Over the climatic zones of the state of São Paulo one can observe differentiation of forest formations with interior semi-deciduous forests and Atlantic rain forests along the coasts. This environmental change is abrupt; vegetation of the Serra do Mar, under the direct influence of the ocean moisture, receives around 3,600 mm per year of rainfall, while the weather has evident seasonality as one distances from the coast, with rainfall between 1,300 and 1,600 mm^{-year} (Oliveira-Filho e Fontes 2000). Similarly, the interior of the state of Paraná is composed of seasonal semi-deciduous forests as rainforests are limited to the coastal strip (Veloso 1962). Surprisingly, the Wiki Aves records indicate that Atlantic Forest endemic bird species (as well as all others examined) are still currently present in the interior of Paraná, although the fragmentation of vegetation is just as, if not more, alarming in relation to the WEST. In São Paulo, the deforestation of the forests of north-eastern São Paulo plateau was quite advanced already in the 1910s due to coffee monocultures. During early 1960s large forest fragments existed only in the Pontal do Paranapanema, west of the state (Victor, et al. 2005). One of the most devastated regions of Paraná is the northern region, which suffered an accelerated process of colonization already from the decade of 1930. This resulted in the almost complete replacement of forests by coffee growing areas (Maak 1963), so that in 1990 only 5% of the state was covered by forest, mostly present in the southern portion (Gubert Filho 2010). Today a remnant of about 830 ha is the largest forest fragment of the northeast region of the state (Tomé, et al. 1999).

The distribution of birds suggests, in addition to insufficient inventories of inland birds, the presence of another type of vegetation in the WEST. Several congeners show close relationship with different vegetation types, suggesting geographic segregation. In **Figure 5**, the Little Woodpecker *Veniliornis passerinus*, typically found in *Cerrado*, is replaced by the White-spotted Woodpecker *V. spilogaster*, common in Atlantic Forests (Sick 1997). The presence of large *Cerrado* enclaves, instead of seasonal forests of the Atlantic Forest domain, in the WEST has been already suggested by (Borgonovi e Chiarini 1965) based on photo-interpretation of satellite images. (Eiten 1972) drew attention to the inadequacy of the *Cerrado* vegetation maps and especially for São Paulo, suggested that all maps show less *Cerrado* than there actually is; he mentions the vast *cerrado* areas in the west of the state. (Durigan, et al. 2003) performed intensive surveys of the tree flora of São Paulo and neighbouring states, concluding that in the central and north-northeast of Sao Paulo grassland physiognomies dominated, with flora more similar to *Cerrado* in the states of Minas Gerais, Paraná and Mato Grosso do Sul. (Siqueira e Durigan 2007) suggested environmental suitability for potential distribution of *Cerrado* in much of the WEST based on hundreds of niche models of 17 woody *Cerrado* species.

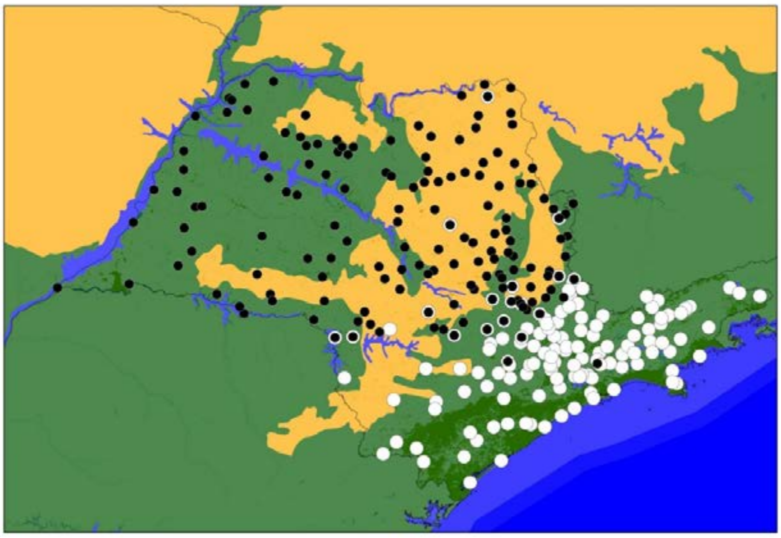

Figure 5: Geographic segregation of two species of *Venilionis* woodpeckers, *V. passerinus* (black circles), typical of *Cerrado*, and *V. spilogaster* (white circles), typical of the Atlantic Forest.

In order to try to understand this unprecedentedly described pattern of distribution, I intended to survey several sites in the states of Sao Paulo and Paraná. My special interest was the record of Atlantic Forest endemic bird species. I expected to estimate parameters of interest generated by statistical models and to securely suggest the presence or absence of selected bird species. Based on species ranges, the suggestion that the vegetation of the state of São Paulo does not conform to the seasonal forests of the Atlantic Forest phytogeographic domain can serve as an additional incentive for botanical studies to further investigate the types of biomes of this region.

Material and Methods

Study area. Northern and western Paraná as well as in the valleys of the rivers forming the Paraná river basin, below 800 m above sea level, lie semi-deciduous forests of the Atlantic Forest domain. They are named semi-deciduous because most trees partially lose their leaves during the drier winter. Predominant tree species are *Aspidosperma* sp., *Peltophorum* sp., *Enterolobium* sp., *Parapiptadenia* sp., *Cordia* sp., *Gallesia* sp., *Balfourodendron* sp., *Holocalyx* sp. and *Cedrela* sp. In addition to the possible occurrence of frost, the flora is subject to a period of low rainfall. In response to the significant reduction of precipitation and relative humidity during winter months, epiphytes are extremely modest and *Philodendron bipinnatifidum* Schott ex Endl. (Araceae) is the most characteristic species. The presence of lianas is expressive, being Bignoniaceae, Sapindaceae, Cucurbitaceae and Asteraceae the most common families. This formation takes place under different soil units, with the most common Latosols, Argissols, Nitossols, Cambisols, Litholic and Quartizic Neosols (Roderjan, et al. 2002).

In São Paulo the semi-deciduous forest occurs in the depression of the Paraíba Valley, and on the 3rd São Paulo plateau covering the basins of the Peixe, Aguapeí, Medium and High Tietê, São José dos Dourados and Turvo Rivers. In these regions, soils are mild, sandy and have low water retention (Eiten, 1970) (Victor, et al. 2005).

Design. Based on a shape file of the remaining Atlantic Forest and *Cerrado* vegetation I selected sites > 50 ha simply to reduce the number of remnants to be selected to survey. With this filtering and satellite imagery aid, I selected fragments according to accessibility as well as area heterogeneity. In some cases, I could not visit pre-selected fragments, which resulted in the choice of nearby sites or exclusion of some sites. Whenever possible I visited sites one day in advance and which already counted with existing trails.

Methods. Occupancy models are often used in data sampling with point counts and repeated at least three times within a short period, or transects with determined mileage and route, repeated three or more times (Mattson e Marshall 2008). Here I proposed each site be surveyed for three consecutive mornings. I alternated the starting time of censuses between nearby sites whenever possible. I used 10 species lists (MacKinnon e Phillips 1993) along transects within fragments. This method is based on writing down the first 10 species, without repeating species. When starting a subsequent list, a species already recorded in the previous list may appear again, but never in the same list of 10 species. This procedure is applied until the transect end, and the sample unit is the number of 10-species lists. During surveys I recorded all species, observed with binoculars, and heard. To maximize the chances of bird records, I surveyed during early mornings, starting about 15 minutes before sunrise, when birds vocalize more intensely in this region.

Occupancy models, covariates and model selection. I used one species and one season occupancy model (MacKenzie, Nichols e Lachman, et al. 2002) (MacKenzie, Nichols e Royle, et al. 2005) implemented by the unmarked package (Fiske, et al. 2015) within the R environment (R Development Core Team 2014). I considered presence and absence data of species in accordance with models that estimate their occupancy while accounting for heterogeneity of the probability of detection, or imperfect detection (Royle 2006) (Yamaura, et al. 2011). I surveyed forest fragments both from different regions of São Paulo and northeast Paraná. Thus I generated presence information of the species in locations where their occurrence is known, avoiding inflation of zeros, which can also interfere with the convergence of model adjustment (Dénes, Silveira e Beissinger 2015).

I considered four covariates, listed below with their respective assumptions related to detection and occupancy probabilities. To estimate occupancy parameters, covariate I was centred on the average:

I. <u>Size of fragments in hectares</u>. I hypothesised that occupancy can be influenced by fragment size, since the largest the fragment the more species must persist in it.

II. <u>Presence of Atlantic Forest endemic bird species</u>. If the type of vegetation influences the occupancy of Atlantic Forest endemic species it is expected that the biome in which no endemic species are recorded must not be seasonal forests of the Atlantic Forest domain.

III. (III a) <u>latitude</u> and (III b) <u>longitude</u>. There was correlation between the number of Atlantic Forest endemic species and latitude (-0.49) and longitude (0.85, Pearson correlation). Thus, I speculated that the smaller the values of latitude or longitude, the greater the species richness of Atlantic Forest endemic species. This somehow reflects the distribution of rainforests within São Paulo, which are located to the east and northeast of the state.

I ranked models according to Akaike Information Criterion values corrected for small samples (AICc). I chose the combination of covariates with ΔAICc < 2 (Akaike 1974) (Burnham e Anderson 2004).

Results and discussion

I selected 40 sites of which I visited 35 in the states of São Paulo (n = 21; 60%) and Paraná (n = 14). Their locations can be seen in **Figure 6.** Information about the number of times each site was visited, as well as their brief descriptions are shown in **Table 1**. Inherent particularities of each site limited three successive mornings on some occasions (average 2.7 ± 0.68 visits^{-site}). However, 71% of the sites could be sampled according to the proposed design.

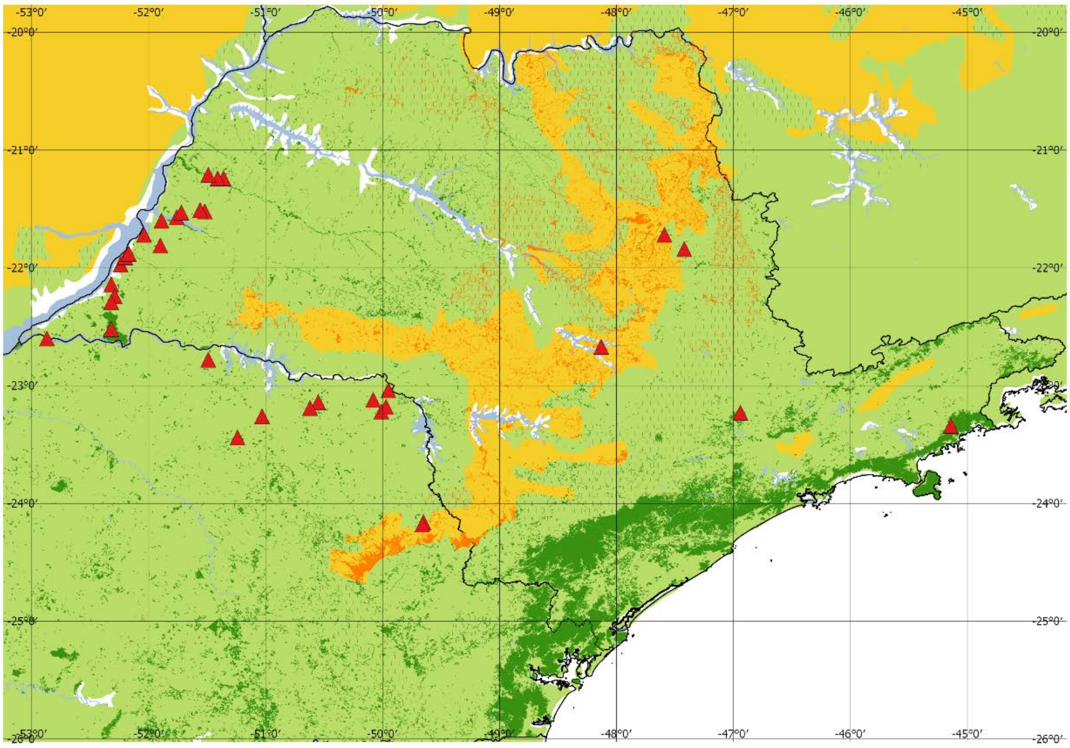

Figure 6: Location of the 35 sites where I surveyed birds in the states of São Paulo and Paraná.

I recorded 338 species of birds in 678 10-species lists. Of this total, 50 (14.7%) species are considered endemic of the Atlantic Forest (Appendix I). The site with the highest number of endemic species (n = 30) was 32-SP19, in the municipality of São Luiz do Paraitinga, in Serra do Mar, São Paulo state. In contrast, only one endemic species, the Eared Pygmy-Tyrant *Myiornis auricularis* was recorded in 15-PR12 and 15-SP16, in the municipalities of Diamante do Norte, PR and President Epitácio, SP, respectively. Due to logistics, I was not always able to arrive at each site before sunrise. Therefore, I did not survey nocturnal species.

Table 1: Descriptions of sites where bird surveys were performed. Columns 1, 2 and 3 correspond to the detection data on each occasion.

Site	1	2	3	Area (ha)	Visit	Richness	Endemic	Lists
07-SP13	0	0	0	221.5	3	50	0	13
07-SP14	0	0	0	<50	3	34	0	5
07-SP15	0	0	0	<50	3	44	0	6
08-SP01	0	0	0	682.5	3	79	0	23
08-SP02	0	0	0	<50	3	69	0	21
08-SP03	0	-	0	<50	2	41	0	6
08-SP04	0	0	0	83.72	3	82	0	27
08-SP05	0	0	0	<50	3	44	0	8
08-SP06	0	0	0	<50	3	41	0	7
08-SP07	-	0	0	<50	2	51	0	7
08-SP08	0	0	0	899.9	3	93	0	33
08-SP09	0	0	0	<50	3	54	0	9
08-SP10	0	-	-	<50	1	13	0	1
08-SP11	-	0	0	<50	2	40	0	5
12SP-22	1	1	0	317.6	3	77	9	29
12SP-23	-	1	-	613	1	62	11	18
15-PR12	1	1	1	1435	3	71	1	14
15-PR12	0	0	0	309	3	81	0	31
15-SP16	1	1	1	516.6	3	65	1	19
15-SP17	0	-	-	1184	1	13	0	1
15-SP18	1	1	1	33000	4	90	2	26
16-PR11	0	0	0	168.2	3	38	0	11
19-SP20	1	1	1	1400	3	93	14	46
26-PR09	1	0	1	783.9	3	90	14	44
26-PR10	1	1	1	71.7	3	51	4	22
27-PR01	0	0	0	76.81	3	54	4	19
27-PR02	0	0	-	40	2	61	3	16
27-PR07	1	1	1	247.2	3	86	7	33
27-PR08	0	1	0	256.8	3	67	9	21
28-PR03	1	0	0	<50	3	54	5	17
28-PR04	1	0	1	147.5	3	56	4	19
31-SP21	0	1	-	8144	2	80	13	37
32-SP19	0	0	0	80636	3	83	30	34
35-PR05	0	-	0	200	2	74	4	22
35-PR06	0	0	0	220	3	93	4	28

The mean values of total species richness, number of Atlantic Forest endemic species and number of lists obtained on sites can be seen in **Table 2**.

Table 2: Mean values (x) of total species richness, number of Atlantic Forest endemic species and number of lists accumulated are indicated separately for the 35 sites located in the states of São Paulo and Paraná. Surveys occurred between September 2015 and May 2016. Standard deviation (SD), maximum (max) and minimum (min) values.

	Species richness	Endemic species	Lists
x	62.1	4.0	19.4
SD	21.8	6.3	11.9
max	93	30	46
min	13	0	1

For now, only one Atlantic Forest endemic species accumulated enough records (> 60) for analyses: Eared Pygmy-Tyrant (Appendix II). Of the 35 study sites, I detected this species in 13 (37%, **Figure 7**). The models I tested for occupancy probabilities of the Eared Pygmy-Tyrant are shown in **Table 3**. The model which obtained ΔAICc < 2 was the one which describes constant detection probability of the species, while occupancy probability varies according to the presence of other Atlantic Forest endemic species. According to this model, estimated parameters are: detection probability (*p*) = 75.8%, and occupancy probability (Ψ) = 97.7%.

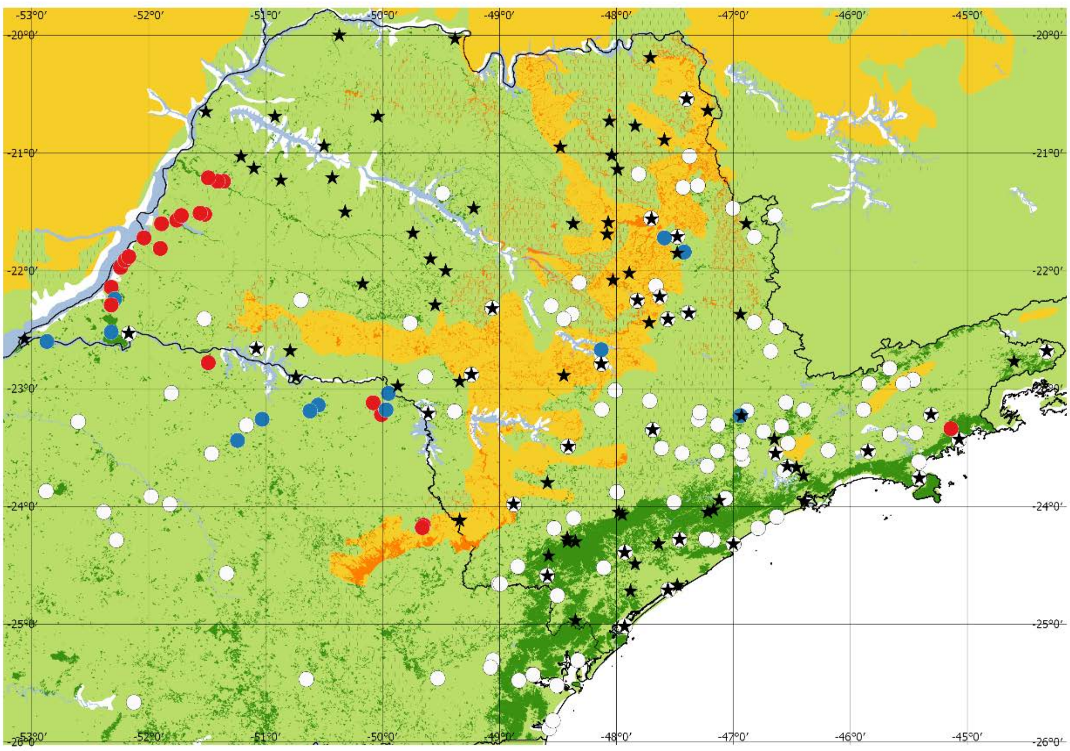

Figure 7: Locations where I recently surveyed birds and where Eared Pygmy-Tyrant I recorded (blue) or failed to record (red) the species. Black Stars correspond to historical records of the species whereas white circles indicate localities where this species has been documented according to the Wiki Aves website.

Table 3: Best models tested for occupancy probabilities of the Eared Pygmy-Tyrant.

Models	**# parameters**	**AICc**	**ΔAICc**	**AICc weight ωi**
p(.)Ψ(presence endemics)	3	72.45	0.00	0.76
p(.)Ψ(#endemics)	3	92.41	19.96	0.22
p(occasion)Ψ(# endemics)	5	79.96	7.51	0.02
p(.)Ψ(.)	2	87.61	15.16	0.00
p(occasion)Ψ(latitude)	5	90.43	17.98	0.00
p(.)Ψ(area)	3	90.00	17.55	0.00
p(occasion)Ψ(longitude+latitude)	6	92.41	19.96	0.00
p(occasion)Ψ(longitude)	5	92.00	19.55	0.00
p(occasion)Ψ(.)	4	92.27	19.82	0.00
p(occasion)Ψ(area)	5	95.00	22.55	0.00

parameters = number of estimated parameters by each model; AICc = Akaike Information Criterion value corrected for small samples; ΔAICc = difference between each model and the best model; weight AICc weight = Akaike weight (ωi) (conditional probability for each model). The dot between brackets represents a constant covariate.

The best model suggests that the Eared Pygmy-Tyrant has a constant detection probability, *i.e.* it is the same for all days surveyed throughout the campaign. Regarding detection, the Eared Pygmy-Tyrant can be considered very conspicuous. Features that may affect its detectability, such as weather condition or vegetation type were uniform across locations. The average occupancy probability of the species is relatively high (0.61 ± 0.28). Comparatively, the São Paulo Marsh Antwren *Formicivora acutirostris*, a globally critically endangered species and with a detection probability > 90%, has an average Ψ = 0.25 (Del-Rio, Rêgo e Silveira 2015). Thus, non-detection of the Eared Pygmy-Tyrant in part of the sites while taking into account detection (75.8%) and occupancy (97.7%) probabilities strongly suggests that (A) fragmentation does not affect its occurrence and (B) its non-detection may correspond to true absences.

The findings, for now, are limited, since it is necessary to collect more information to increase the number of surveyed sites. This preliminary analysis suggests that the vegetation of the interior of São Paulo has conditions to support the Eared Pygmy-Tyrant. In some sites, however, the species seems truly absent, given its *p* and Ψ values.

Account of expenditure

Item	**Quantity**	**Unitary Value (R$/£)**		**Total (R$/£)**	
Accommodation	130	50	11.11	6500	1444.44
Food	390	20	4.44	7800	1733.33
Gasoline	1030	3.9	0.87	4017	892.67
Toll	99	5	1.11	495	110.00
TOTAL					**4180.44**

R$ refers to the Brazilian currency: real.

Accommodation refers to hotels I stayed in while visiting fragments in several municipalities in São Paulo and Paraná states.

I considered **food** as three meals a day, which includes breakfast, lunch and dinner.

Transport includes displacement between my hometown (city of São Paulo) to every municipality I visited in São Paulo and Paraná states as well as movements between hotels I stayed in and visited remnants. These include gasoline (litres) and highway tolls.

Appendix

Appendix I.
List of species of birds recorded during recent surveys conducted from September 2015 to May 2016 in the states of São Paulo and Paraná, Brazil.

Species	Endemism
Tinamus solitarius	E
Crypturellus obsoletus	
Crypturellus parvirostris	
Crypturellus tataupa	
Rhynchotus rufescens	
Nothura maculosa	
Anhima cornuta	
Dendrocygna autumnalis	
Cairina moschata	
Penelope superciliaris	
Penelope obscura	
Odontophorus capueira	E
Jabiru mycteria	
Mycteria americana	
Phalacrocorax brasilianus	
Tigrisoma lineatum	
Butorides striata	
Bubulcus ibis	
Ardea cocoi	
Syrigma sibilatrix	
Mesembrinibis cayennensis	
Theristicus caudatus	
Cathartes aura	
Cathartes burrovianus	
Coragyps atratus	
Sarcoramphus papa	
Leptodon cayanensis	
Accipiter striatus	
Ictinia plumbea	
Busarellus nigricollis	
Rostrhamus sociabilis	
Heterospizias meridionalis	
Rupornis magnirostris	
Geranoaetus albicaudatus	
Buteo brachyurus	
Spizaetus tyrannus	
Aramus guarauna	
Aramides cajaneus	
Aramides saracura	E

Species	Endemism
Amaurolimnas concolor	
Laterallus viridis	
Laterallus melanophaius	
Porzana albicollis	
Pardirallus nigricans	
Gallinula galeata	
Vanellus chilensis	
Jacana	
Columbina talpacoti	
Columbina squammata	
Columbina picui	
Patagioenas picazuro	
Patagioenas cayennensis	
Patagioenas plumbea	
Zenaida auriculata	
Leptotila verreauxi	
Leptotila rufaxilla	
Geotrygon violacea	
Geotrygon montana	
Piaya cayana	
Coccyzus melacoryphus	
Crotophaga ani	
Guira	
Tapera naevia	
Dromococcyx pavoninus	
Megascops choliba	
Glaucidium brasilianum	
Athene cunicularia	
Nyctibius griseus	
Antrostomus rufus	
Lurocalis semitorquatus	
Hydropsalis albicollis	
Hydropsalis parvula	
Hydropsalis torquata	
Cypseloides senex	
Streptoprocne zonaris	
Streptoprocne biscutata	
Chaetura cinereiventris	
Chaetura meridionalis	
Phaethornis pretrei	
Phaethornis eurynome	E
Eupetomena macroura	
Florisuga fusca	
Anthracothorax nigricollis	

Species	**Endemism**
Chlorostilbon lucidus	
Thalurania glaucopis	E
Hylocharis chrysura	
Leucochloris albicollis	
Amazilia versicolor	
Clytolaema rubricauda	E
Calliphlox amethystina	
Trogon surrucura	
Trogon rufus	
Megaceryle torquata	
Chloroceryle amazona	
Baryphthengus ruficapillus	
Momotus momota	
Galbula ruficauda	
Nystalus chacuru	
Malacoptila striata	
Nonnula rubecula	
Monasa nigrifrons	
Chelidoptera tenebrosa	
Ramphastos toco	
Ramphastos dicolorus	E
Selenidera maculirostris	E
Pteroglossus bailloni	E
Pteroglossus castanotis	
Picumnus cirratus	
Picumnus temminckii	E
Picumnus albosquamatus	
Melanerpes candidus	
Melanerpes flavifrons	
Veniliornis passerinus	
Veniliornis spilogaster	
Piculus flavigula	
Colaptes melanochloros	
Colaptes campestris	
Celeus flavescens	
Dryocopus lineatus	
Campephilus robustus	E
Cariama cristata	
Caracara plancus	
Milvago chimachima	
Herpetotheres cachinnans	
Micrastur ruficollis	
Micrastur semitorquatus	
Falco sparverius	

Species	Endemism
Falco femoralis	
Ara ararauna	
Ara chloropterus	
Primolius maracana	
Psittacara leucophthalmus	
Aratinga auricapillus	
Eupsittula aurea	
Pyrrhura frontalis	
Forpus xanthopterygius	
Brotogeris tirica	E
Brotogeris chiriri	
Pionopsitta pileata	E
Pionus maximiliani	
Amazona amazonica	
Amazona aestiva	
Terenura maculata	E
Formicivora rufa	
Rhopias gularis	E
Dysithamnus mentalis	
Herpsilochmus atricapillus	
Herpsilochmus longirostris	
Herpsilochmus rufimarginatus	
Thamnophilus doliatus	
Thamnophilus ruficapillus	
Thamnophilus pelzelni	
Thamnophilus caerulescens	
Taraba major	
Hypoedaleus guttatus	E
Batara cinerea	
Mackenziaena leachii	E
Mackenziaena severa	E
Myrmoderus squamosus	E
Pyriglena leucoptera	
Drymophila ferruginea	E
Drymophila ochropyga	E
Drymophila malura	E
Conopophaga lineata	
Conopophaga melanops	E
Grallaria varia	
Hylopezus nattereri	E
Eleoscytalopus indigoticus	E
Chamaeza meruloides	E
Sclerurus scansor	E
Dendrocincla turdina	E

Species	Endemism
Sittasomus griseicapillus	
Xiphorhynchus fuscus	
Campylorhamphus trochilirostris	
Lepidocolaptes angustirostris	
Dendrocolaptes platyrostris	
Xiphocolaptes albicollis	
Xenops minutus	
Xenops rutilans	
Furnarius rufus	
Lochmias nematura	
Automolus leucophthalmus	
Anabacerthia amaurotis	E
Anabacerthia lichtensteini	E
Heliobletus contaminatus	E
Syndactyla rufosuperciliata	
Certhiaxis cinnamomeus	
Synallaxis ruficapilla	E
Synallaxis cinerascens	
Synallaxis frontalis	
Synallaxis albescens	
Synallaxis spixi	
Cranioleuca vulpina	
Cranioleuca pallida	E
Manacus	
Ilicura militaris	
Chiroxiphia caudata	E
Antilophia galeata	
Onychorhynchus swainsoni	E
Schiffornis virescens	E
Tityra inquisitor	
Tityra cayana	
Pachyramphus castaneus	
Pachyramphus polychopterus	
Pachyramphus validus	
Procnias nudicollis	E
Pyroderus scutatus	
Carpornis cucullata	E
Platyrinchus mystaceus	
Mionectes rufiventris	
Leptopogon amaurocephalus	
Corythopis delalandi	
Phylloscartes ventralis	
Tolmomyias sulphurescens	
Todirostrum poliocephalum	E

Species	**Endemism**
Todirostrum cinereum	
Poecilotriccus plumbeiceps	
Poecilotriccus latirostris	
Myiornis auricularis	E
Hemitriccus diops	E
Hemitriccus orbitatus	E
Hemitriccus margaritaceiventer	
Euscarthmus meloryphus	
Camptostoma obsoletum	
Elaenia flavogaster	
Elaenia spectabilis	
Elaenia parvirostris	
Elaenia mesoleuca	
Elaenia chiriquensis	
Myiopagis caniceps	
Myiopagis viridicata	
Capsiempis flaveola	
Phaeomyias murina	
Phyllomyias fasciatus	
Serpophaga subcristata	
Attila rufus	E
Legatus leucophaius	
Myiarchus swainsoni	
Myiarchus ferox	
Myiarchus tyrannulus	
Sirystes sibilator	
Casiornis rufus	
Pitangus sulphuratus	
Machetornis rixosa	
Myiodynastes maculatus	
Megarynchus pitangua	
Myiozetetes similis	
Tyrannus melancholicus	
Tyrannus savana	
Empidonomus varius	
Colonia colonus	
Myiophobus fasciatus	
Gubernetes yetapa	
Cnemotriccus fuscatus	
Lathrotriccus euleri	
Knipolegus cyanirostris	
Knipolegus lophotes	
Xolmis cinereus	
Xolmis velatus	

Species	Endemism
Cyclarhis gujanensis	
Vireo chivi	
Hylophilus poicilotis	E
Hylophilus amaurocephalus	
Hylophilus pectoralis	
Cyanocorax cristatellus	
Cyanocorax chrysops	
Pygochelidon cyanoleuca	
Stelgidopteryx ruficollis	
Progne tapera	
Progne chalybea	
Tachycineta leucorrhoa	
Troglodytes musculus	
Cantorchilus leucotis	
Donacobius atricapilla	
Turdus flavipes	
Turdus leucomelas	
Turdus rufiventris	
Turdus amaurochalinus	
Turdus subalaris	
Turdus albicollis	
Mimus saturninus	
Anthus lutescens	
Zonotrichia capensis	
Ammodramus humeralis	
Arremon flavirostris	
Setophaga pitiayumi	
Geothlypis aequinoctialis	
Basileuterus culicivorus	
Myiothlypis flaveola	
Myiothlypis leucoblephara	
Myiothlypis rivularis	E
Cacicus chrysopterus	
Cacicus haemorrhous	
Icterus pyrrhopterus	
Icterus croconotus	
Gnorimopsar chopi	
Chrysomus ruficapillus	
Pseudoleistes guirahuro	
Molothrus bonariensis	
Coereba flaveola	
Saltator similis	
Saltator fuliginosus	E
Nemosia pileata	

Species	**Endemism**
Thlypopsis sordida	
Tachyphonus coronatus	E
Ramphocelus carbo	
Lanio cucullatus	
Lanio penicillatus	
Lanio melanops	
Tangara desmaresti	E
Tangara sayaca	
Tangara ornata	E
Tangara cayana	
Cissopis leverianus	
Schistochlamys ruficapillus	
Paroaria capitata	
Pipraeidea melanonota	
Tersina viridis	
Dacnis cayana	
Hemithraupis guira	
Hemithraupis ruficapilla	E
Conirostrum speciosum	
Haplospiza unicolor	E
Sicalis flaveola	
Sicalis luteola	
Emberizoides herbicola	
Volatinia jacarina	
Sporophila caerulescens	
Sporophila leucoptera	
Sporophila angolensis	
Tiaris fuliginosus	
Habia rubica	
Sporagra magellanica	
Euphonia chlorotica	
Euphonia violacea	
Euphonia pectoralis	E
Chlorophonia cyanea	

Appendix II.

Figure 8: Eared-Pygmy Tyrant, *Myironis auricularis*, an Atlantic Forest endemic species. Credit: Thiago T. Silva (http://www.wikiaves.com/999191).

Figure 9: Morro do Diabo, Teodoro Sampaio, São Paulo.

Figure 10: Santa Rita do Passa Quatro, São Paulo.

Figure 11: Ouro Verde, São Paulo.

Figure 12: Junqueirópolis, São Paulo.

Figure 13: Dracena, São Paulo.

Figure 14: Caiuá, São Paulo.

Figure 15: Presidente Epitácio, São Paulo.

Figure 16: Teodoro Sampaio, São Paulo.

Figure 17: Santo Antônio da Platina, Paraná.

Figure 18: Jaguariaíva, Paraná.

Figure 19: Diamante do Norte, Paraná.

Figure 20: Londrina, Paraná.