Review Version

BIRD FAUNA AT SECONDARY FOREST STAGES: A STUDY IN A SOUTHERN BRAZILIAN PROTECTED AREA

Running title: *Birds on a secondary forest in southern Brazil*

Abstract.

Environmental changes resulting from the succession process may lead to changes in the abundance and composition of species. In each successional stage, the fauna composition will depend on the structure of the habitats and the ecological requirements of each species. In the small sized in isolated forest fragments the effects seems to be more evident. Our main goal was recording the bird fauna composition at different stages of secondary forest in a protected area located in a highly-fragmented region in southern Brazil. In this study, we predicted that the bird fauna composition changes according the secondary forest stage and influenced by the ecological requirements of species. The study was carried out in the Municipal Park Mata do Rio Uruguai Teixeira Soares (Teixeira Soares Park - TSP), northern of the State of Rio Grande do Sul, Brazil. The park is the bigger protected area in the region, with 423 ha. Representative areas of the three successional stages of the secondary forest within the TSP were selected and we record the bird species in each area by counting point sampling method. A total of 145 bird species were recorded in the three areas. There was difference in species composition among areas, indicate that the structure of the bird community is directly linked to successional stages. This relationship is improved by the differences in the occurrence of birds of certain ecological traits between the areas. The size, connectivity of the fragments and the availability of habitats directly influence the distribution of the avifauna in the Park. Changes in the landscape promote a restructuring of these communities, where species with certain ecological traits can be favored or excluded. The TSP, although relatively small, is important to maintenance of bird populations because it represents a rare well preserved fragmented of the Decidual Seasonal Forest in the region.

Keywords: avifauna; conservation; diet; habitat use.

**INTRODUCTION**

Due to the intense deforestation and fragmentation the Atlantic Forest biome became predominantly composed of forest remnants of small size (< 50 ha) (Rodrigues *et al.* 2009, Almeida 2016). Most of these fragments are isolated or composed of secondary forest in early and intermediate stages of secondary forest succession (Metzger *et al.* 2009). This type of vegetation cover has increased in extent and importance, as primary forests are being exploited, fragmented, and converted to agricultural use (Joly *et al.* 2014).

Vegetation structure and environmental conditions in the early stages of succession are different from mature or advanced-stage forests (Bazzaz & Pickett 1980, Dent & Wright 2009). Environmental changes resulting from the succession process, due to the alteration of the structure of the plant community, may lead to changes in the abundance and composition of species that occupy the different stages of succession (Inger & Colwell 1977, Chazdon *et al.* 2003, Veddeler *et al.* 2005). In each successional stage, the fauna composition will depend on the new structure of the habitats and the ecological requirements of each species (Gimenes & Anjos 2003). Changes in forest structure imply a restructuring of these communities, demanding species that require specific ecological attributes to survive might disappear (Donatelli *et al.* 2004) while generalist species may become dominant in relation to specialists (Van Langevelde 2000, Beier *et al.* 2002).

Bird responses range from those benefited from habitat alterations and increase their populations to those excluded from the environments (Marini & Garcia, 2005). Changes in forest structure directly interfere with the abundance and richness of bird species (Willis 1979, Stoufer & Bierregaard 1995, Marsden *et al.* 2001, Antunes 2005). The main environmental influencing factors are forest area, isolation degree, habitat diversity, vegetation heterogeneity, and edge effect (Gimenes & Anjos 2003, Silva *et al.* 2017). The effects are more evident in small sized and isolated forest fragments (Ribon *et al.* 2003, Anjos 2006, Piratelli *et al.* 2008, Ribeiro *et al.* 2009).

Some specific groups of birds, mainly the forest dwelling ones, suffer more with landscape changes. Species considered more sensitive generally have characteristics such as medium and large size, restricted mobility, high specialization, foraging and nesting in the soil, low tolerance to the matrix habitat, low density, and low survival rate (Loiselle & Blake 1992, Sieving & Karr 1997, Şekercioğlu *et al.* 2002). On the other hand, continuous forests submitted to selective forest exploitation may show increased richness and abundance. Particularly generalist species tend to occupy forest areas exploited for economic purposes (Aleixo 1999, Protomastro 2001).

The Atlantic Forest presents one of the highest bird species richness of the planet (MMA 2000), with a high degree of endemism (about 20%). The main threat to Brazilian birds is the loss and fragmentation of habitats (Marini & Garcia 2005). In this sense, understanding how birds are distributed through the different stages of succession may provide important data to definition of conservation strategies for the group, or indicate how areas in secondary stages can contribute to the maintenance of bird communities.

The Teixeira Soares Park (TSP) is a protected area located in the southern Brazil, within the morphoclimatic domain of the Atlantic Forest. Original vegetation in the region was Deciduous Seasonal Forest, which covered most of the Uruguay River valley (Leite & Klein 1990). This formation is currently highly fragmented, and it is one of the most endangered plant formations from Atlantic Forest Domain (Cordeiro & Hasenack 2009). TSP area is composed of different stages of forest succession and is appropriate for studies on forest fragmentation, edge effect, ecological succession, and its effects on conservation. Our main goal was recording the bird fauna composition at different stages of secondary forest in a protected area located in a highly-fragmented region in southern Brazil. In this study, we predicted that the bird fauna composition changes according the secondary forest stage and influenced by the ecological requirements of species.

**MATERIAL AND METHODS**

*Study area*

The Municipal Park Mata do Rio Uruguai Teixeira Soares (Teixeira Soares Park – TSP) has an area of 423 ha and it is located in the municipality of Marcelino Ramos in the north of Rio Grande do Sul State, (27º28’17” and 27º30’58” S, 51º55’15” and 51º57’42” W). TSP was created in June 2008 as a compensatory measure to the area flooded by the Itá Hydroelectric Plant reservoir (Park Management Plan 2012). Landscape in the study area is primarily occupied by Seasonal Deciduous Forest (Leite & Klein 1990). This forest follows the banks of the Uruguay River, with widths varying originally from 30 to 50 km. Its ramification extends through valleys of the tributaries of river Uruguay, where they contact with the Mixed Ombrophilous Forest. According to Köeppen’s Cfa, the climate is sub‐tropical humid, with an average annual temperature of 17.7°C and precipitation of 1700 mm. The elevation in the study area ranges from 472–572 m a.s.l. The relief varies to the hills next to margins of Uruguay River to cliffs in the highest places (Park Management Plan 2012). Due to the past use forms, the region landscape presents itself as a mosaic of different successional stages, ranging from remnants of primary forest to secondary forest in the initial stage of succession.

 In TSP, these stages present the following characteristics. Secondary forest in initial stage of succession (Figure 1A), characterized by the high number of herbaceous/shrub heliophyte species, small sized vegetation cover (less than four meters high), and slightly shaded understory. Secondary forest in intermediate stage (Figure 1B), where predominate pioneer species, typical of open environments, that still dominate the tree stratum, but with the occurrence of emergent tree species. Trees are 12 m average height, with arboreal species richness superior to that found in the initial stage. Secondary forest in advanced stage (Figure 1C), located in areas of difficult access or of high slope. It forms a closed and relatively uniform canopy, with emergent trees occurring with different degrees of intensity, and upper canopy horizontally broad. There was total deforestation in the initial and intermediate stages, and the estimate age of successional stages was about 14 years to initial and 25 years to intermediary stage. Only trees of commercial value were removed in the advanced stage, without total deforestation, and the use has finished about 30 years ago (Park Management Plan 2012).

Figure 1

*Data collection*

Three sample areas were selected representing the three successional stages of secondary forest. Area 1, a Secondary forest in initial succession stage; Area 2, a Secondary forest in intermediary stage; Area 3, Secondary forest in advanced stage. A 500 m minimum distance between the sampling areas was preserved to avoid the transition region between the successional stages. The transects in Area 3 were established 200 meters distance the edge with Area 2, to avoid edge effect. In each area, eight sampling points were established, distant 100 meters apart, and arranged in two transects with four points each (Wunderle 1994, Bibby *et al.* 2000). The distance between each transect was 150 meters. The transects in Area 3 were established 200 meters from the edge with Area 2, to avoid edge effect.

To record species richness and number of birds in each area we used the counting point sampling method. At each point, two observers remained for 15 minutes (Cavarzere *et al.* 2013) and recorded birds sighted and heard within approximately 30 meters. Samplings occurred from October to December 2016, during the reproductive period of most bird species of southern Brazil (Belton 1994; Giovanni *et al*. 2013)

Observations occurred in the morning, between 06:00 and 11:00 hours. Each area was sampled six times (one area per day), totaling 18 sampling days. Birds were observed with binoculars; photograph and vocalization records were performed whenever possible. Photographs and recorded vocalizations served to identify or confirm species identification. Bird guides Belton (2004) and Sigrist (2014) were consulted to help visual identification. The taxonomic order and nomenclature of the species followed Piacentini *et al.* (2015). Bird species sighted or heard outside sampling points, but within the limits of TSP, or only in flight over the areas were recorded as occasional encounters (OE) and were not considered in comparative analyzes between the areas.

*Data analysis*

To compare ecological traits, bird species were categorized according to their eating habits and habitat use. To determine the ecological traits of the birds, we followed the descriptions of Motta-Júnior (1990), Anjos (2001), Sick (2001), Telino-Júnior *et al.* (2005) and Parker *et al*. (1996). Additionally, we use the predominant forage strata categories described in Parker *et al*. (1996) in order to refine the habitat use. The following categories of feeding habits were recorded for TSP birds: carnivores (Car; capture and consumes other animals, mainly vertebrates), detritivores (Det; eat primarily carcasses), frugivores (Fru; fruit‐eating specialists), granivores (Gra; eat primarily grains or seeds), insectivores (Ins; specialized carnivores that feed on insects and other arthropods), nectarivores (Nec; feeds on flowers nectar), omnivores (Oni; have a widely varied diet, is able to consume different food items), and piscivores (Pis; capture and consumes primarily fish). Recorded birds made use of the following habitats: broad (Bro, may occupy different habitats, including anthropic areas), forest (For, typical from inside forest), forest edge (Fe; use primarily forest borders), open area (Oa, use primarily native open area), wetland (Wet, use primarily swamps).

For richness estimation, general and by area, we used the Jack 1 estimator (Chao 1984), calculated in the EstimateS 9.0 software. For comparing the similarity between the areas, we used the Jaccard similarity coefficient (SJij). Areas were compared for richness (number of species recorded per area by sampling), number of individuals (number of individuals recorded per area per sample), and for ecological traits (number of species recorded in each category per sampling area) using variance analysis (One-way ANOVA) and Tukey post-hoc test, with the p-value <0.05. The diversity of the three areas was compared using the Shannon H' Index. To test if there is a difference between H' values obtained for each area, we applied the t-Test for specific diversity, with p <0.05, and the aid of Past 3.15 software (Hammer *et al.* 2001).

**RESULTS**

A total of 145 bird species was recorded in TSP, distributed through 18 orders and 42 families (see Appendix). From these, 125 species were recorded in the sample areas and 20 as occasional encounters. The Jack1 estimator indicated that 88.62% of the species richness was recorded, considering the three areas together (N (J1) = 141.05 ± 3.49). For each area, the Jack1 estimator indicated that more than 80% of the richness was recorded (Area 1: 84.89%, N(J1)=104.83±3,51; Area 2: 87.69%, N(J1)=108.33±3.80; and Area 3: 83.61%, N(J1)=101.66±2.47).

The largest species number was recorded in Area 2 (N=95), followed by Area 1 (N=89), and Area 3 (N=85; see Appendix). There was no significant difference in number of species between the areas (F2,15=0.74; p=0.48). Area 2 also had the higher number of registered individuals (N=1100), followed by Area 3 (N=982), and Area 1 (N=940). There was no significant difference in number of individuals recorded between the areas (F2, 15=0.99; p=0.39).

Only 53 species were registered in all areas. The greatest overlap occurred between Areas 1 and 2 (N=72), followed by Areas 2 and 3 (N=70), and Areas 1 and 3 (N=55). The similarity was greater between the areas in nearest succession stages (Areas 1 and 2, SJij=0.64, and Areas 2 and 3, SJij=0.63), and lower among areas more distant (Areas 1 and 3, SJij=0.46). Area 1 showed higher number of exclusive species (N=15), followed by Area 3 (N=13), and Area 2 (N=6). The greatest diversity was in Area 1 (H'=4.04), followed by Area 2 (H'=4.03) and Area 3 (H'=3.74). Area 3 differed from the other two (p<0.01), between Areas 1 and 2 there was no difference (p=0.77).

There was a predominance of omnivores (N=60) and insectivores (N=52) species in TSP (frugivores N=12, granivores N=8, carnivores N=5, nectarivores N=4, detritivores N=2 and piscivores N=2; see Appendix). There was difference in species number from a determined ecological trait between the areas. Frugivores species were less recorded in the initial stage than in the advanced stage. Granivores species were more found in the initial stage than in the advanced stage. Insectivores species were less recorded at the initial stage of succession. Omnivores were more recorded at the intermediary stage than in the advanced stage. Detritivores and piscivores species were recorded only at the initial stage of succession. Nectarivores species showed no differences between areas (Table 1, Figure 2).

Species of broad habitat were more found at the initial stage and less found at the advanced stage. Forest species were less recorded in areas of initial succession. Forest edge species were less recorded in the advanced stage than in the initial stage. Open area species were most frequently recorded in areas of early succession (Table 1, Figure 3).

Table 1

Figure 2 and 3

**DISCUSSION**

The total richness of 145 bird species corroborates the proposition that forests composed of different secondary successional stages are important for the maintenance of diversity in the Atlantic Forest (*e.g*., Vianna *et al.* 1997, Kaminski *et al.* 2016). The pattern of continuous and heterogeneous forest, formed by mosaics of successional stages, seems to contribute to the maintenance of bird populations in the Atlantic Forest (Casas *et al.* 2016), due to its high floristic recovery capacity (Protomastro 2001, Guariguata & Ostertag 2001, Dewalt *et al.* 2003). Forest restructuring processes make it possible to occupy the area by species with different ecological requirements and influence the community composition and the bird richness of a determined region (Aleixo 1999, Lehman & Tilman 2000). In this sense, the heterogeneity of forest environments found in TSP, due to the stages of forest succession, may explain the occurrence of a large number of bird species in the area. Furthermore, even though almost 90% of the richness has been recorded, it is probable that increasing sampling time, new species will be added, increasing the total bird richness for the TSP.

In regions with different stages of succession, intermediate stages are expected to harbor the greatest bird abundance, since they have more heterogeneous habitats that can be used by several bird species which have behavior flexibility and broad environmental tolerance (Sick 2001, Casas *et al.* 2016). In addition, intermediate stages of succession, especially when physically connected to the early and advanced stages, tend to have transitional landscape features (Garcia *et al.* 2011). This characteristic allows species typical of other successional stages to occupy the area, even if sporadically. The greater species overlap and similarity with the other areas and the smaller number of exclusive species in Area 2 corroborate this hypothesis.

The species number from forest fragments appears to be associated with total area size, conservation degree, and isolation (Galli *et al.* 1976, Terborgh *et al.* 1997). Forest fragments surrounded by a matrix habitat different and isolated from other forests, usually present isolation effects similar to those observed in islands (Pires *et al.* 2006). The factors that determine the dynamics of species movements between landscapes do not depend only on habitat and isolation characteristics, but also on the biological traits of each species, such as vagility, habitat preferences, and behavioral factors (Macarthur & Macarthur 1961). Bird species from the forest nucleus (*e.g.,* *Corythopis delalandi*, *Habia rubica*, *Sclerurus scansor* and *Mionectes rufiventris*), tend to be sensitive to the edges of the forest, being restricted to the most conserved areas (Zuckerberg *et al.* 2016).

If more conserved areas are continually reduced, birds that are more demanding in relation to the environmental quality tend to disappear over time (Leck 1979). Besides the distinct matrix, forest clearings around the fragment may represent a barrier to many bird species adapted to live inside the forests, which prevents the flow of individuals between the fragments (Goerck 1997, Gimenes & Anjos 2003). In this sense, different successional stages can function as a selective filter for dispersion of individuals, determining which species will be able to cross it and how often. So, even different successional stages might be considered matrix habitat for certain groups of birds. Consequently, richness in advanced stages seems to be associated not only with the fragment total size but also with the size of the most conserved area.

TSP is one of the few forest fragments with more than 400 hectares (considering all successional stages) in the region. The advanced stage represents about 40% of the park area. However, areas at advanced stage of succession are rare and usually small around the TSP, while areas in the initial and intermediate stages are relatively common (Park Management Plan 2012). The lower species number and diversity recorded in the more advanced stage may reflect the size and isolation of the TSP more conserved areas from others in the environment.

In primary and secondary forest in advanced stage, it is expected to find species that are more sensitive to habitat modification (Boçon 2010). This, in turn, highlights the potential importance of preserved areas, even small ones (Anjos *et al.* 2009, Anjos *et al.* 2011). In fact, small forest fragments were considered important for the persistence of more demanding birds in relation to the habitat in Neotropical fragmented landscapes (Whitmore 1997). In fragmented areas, the main contribution to birds of the more advanced stages of succession is the maintenance of more sensitive populations (Loures-Ribeiro *et al.* 2011). The occurrence of species that may be considered more sensitive indicates the importance of more conserved areas, which is the case of *Tinamus solitarius* (Vieillot 1819), which was found only in the advanced succession stage.

There was a predominance of omnivores and insectivores species in TSP. According to Willis (1979), omnivory is a common and opportunistic trophic category in open areas and under the anthropic influence, since it represents a buffer effect against fluctuations in food supply. Environmental changes may lead to an increase in omnivores and possibly less specialized insectivores birds and a decrease in more specialized frugivores and insectivores birds (Willis 1979). The number of omnivores species found in this study is a feature of smaller forest fragments, as well as areas of secondary vegetation because the omnivores species adjust more easily into these types of environments. The high percentage of insectivores bird species is a pattern for the tropical region (Sick 2001).

Even though there was no significant difference in number of species and individuals recorded between the areas, there was a difference in species composition between areas. Insectivores species were most recorded in the intermediate and advanced stages of succession. This result reinforces the proposal that insectivores are sensitive to human impacts (Lohr *et al.* 2002, Roshan *et al.* 2017) since they were less frequent in the most impacted area (Area 1). The granivores birds were more common in the initial stage of succession, possibly due to the presence of large open areas with grass cover, which provide a high amount of seeds (Roshan *et al.* 2017). The detritivores species occurred only in area 1, represented by *Coragyps atratus* and *Cathartes aura*, due to their wide occurrence, not requiring exclusively the forest to survive (Belton 2004).

The presence of frugivores birds in secondary successional stages positively influences the forest recovery process, since they contribute to the dispersion of seeds from more advanced stages (Metzger *et al.* 2009). Frugivores species were less recorded in the initial stage and apparently are among those susceptible to habitat reduction and mischaracterization (Aleixo 1999). On the other hand, omnivores species were more associated with the intermediary stage, indicating that can occupy less preserved areas.

Species of forest habit were the most common in TSP. Due to the predominantly forest origin of the Atlantic Forest, it is expected that, even in fragmented environments, the occurrence of a greater number of forest species. The predominance of forest species in the advanced stage is due to the complexity of the vegetation and the high density of individuals of arboreal species in comparison with the other areas. The open-area species were recorded in area 1, because the conditions of this area allowed the occupation by species of field habits such as *Sporophila caerulescens*, *Volatina jacarina*, *Sicalis flaveola* , *Zonotrichia capensis* which occupy open and shrub areas (Sick 2001, Belton 2004, Ridgely & Tudor 2009).

 Broader and forest edges habitats species were more frequent in the initial stage, because this area is the most mischaracterized, what possibly allowing occupation by generalist species, such as *Coragyps atratus*, *Molothrus bonariensis*, *Troglodytes musculus* (Sick 2001, Cavarzere *et al.* 2009), as enables the occurrence of omnivorous species that use a relatively broad range of resources or habitats (Colles *et al.* 2009).

The coexistence of bird species typical of more conserved forests and secondary stages of succession, recorded in this study, is associated with the TSP forest matrix, formed by a mosaic of closely related environments that favors the circulation of species (Aleixo 1999, Barlow *et al.* 2007). The differences found between the areas regarding the ecological traits reinforce that the species occupy the habitats associated with their ecological limits. This fact stresses the importance of maintaining areas at an advanced stage of succession, especially because these forested areas are proportionally smaller in size and quantity (Loures-Ribeiro *et al.* 2011).

Differences in species composition and diversity between areas indicate that bird community structure seems linked to the successional stages (Lehman & Tilman 2000, Antongiovanni & Metzger 2005). This relation is reinforced by the differences in the occurrence of birds of determined ecological traits between the areas, and by the number of exclusive species of the initial and final stages of succession. Past changes in the landscape promoted a restructuring of the community when species with particular ecological traits were favored or excluded from the successional stages (Beier *et al.* 2002, Gimenes & Anjos 2003, Silva *et al.* 2017).

The high diversity found in this study highlight the importance of TSP for bird conservation. Located in a region with a highly fragmented landscape, and composed of different stages of forest succession, the TSP can be considered as one of the few remnants of the Decidual Seasonal Forest (Uruguay River Forest) in the study region. Therefore, even areas that have undergone deforestation in the past and today have different stages of forest succession may represent conservation possibilities for birds typical of subtropical forest.

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**Table 1.** Analysis of variance between the tree sampling areas (Area 1 - secondary forest in initial succession stage, Area 2 - secondary forest in intermediary stage, Area 3 - secondary forest in advanced stage) to ecological traits of birds, tested by One‐way ANOVA and Tukey post-hoc test, with the P value <0.05. Teixeira Soares Park (TSP), southern Brazil.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Feeding habit** | **Three areas** | **Area 1 and 2** | **Area 1 and 3** | **Area 2 and 3** |
| Carnivores | F=3,35, p=0,06 | - | - | - |
| Frugivores | F=3,92, p=0,04 | - | p<0,05 | - |
| Granivores | F=5,49, p=0,01 | - | p<0,05 | - |
| Insectivores | F=4,14, p=0,03 | p<0,05 | p<0,05 | - |
| Nectarivores | F=1,23, p=0,31 | - | - | - |
| Omnivores | F=4,90, p=0,02 | - | - | p<0,05 |
| **Habitat use** |  |  |  |
| Broad | F=26,38, p<0.01 | p<0,05 | p<0,05 | p<0,05 |
| Forest | F=18,88, p<0.01 | p<0,05 | p<0,05 | - |
| Forest edge | F=5,21, p=0.01 | - | p<0,05 | - |
| Open area | F=12,07, p<0.01 | p<0,05 | p<0,05 | - |
| Wetlands | F=1,09, p=0,36 | - | - | - |

Figure legends

**Figure 1**. Secondary forest in initial succession stage (a), secondary forest in intermediary stage (b), and secondary forest in advanced stage (c). Teixeira Soares Park (TSP), southern Brazil, October 2016.

**Figure 2**. Number of bird species recorded by sampling area and by feeding habit that there was a significant difference between areas. Middle point (mean), boxes (mean ± standard errors), and vertical bars (mean ± conf. interval). Area 1 - secondary forest in initial succession stage, Area 2 - secondary forest in intermediary stage, Area 3 - secondary forest in advanced stage. Teixeira Soares Park (TSP), southern Brazil.

**Figure 3**. Number of bird species recorded by sampling area and by habitat use that there was a significant difference between areas. Middle point (mean), boxes (mean ± standard errors), and vertical bars (mean ± conf. interval). Area 1 - secondary forest in initial succession stage, Area 2 - secondary forest in intermediary stage, Area 3 - secondary forest in advanced stage. Teixeira Soares Park (TSP), southern Brazil.

Appendix. Bird species recorded in Teixeira Soares Park, southern Brazil. Feeding habits: Carnivores (Car), detritivores (Det), frugivores (Fru), granivores (Gra), insectivores (Ins), nectarivores (Nec), omnivores (Oni), Piscivores (Pis); Habitat use: broad (Bro), forest (For), forest edge (Fe), open area (Oa), wetland (Wet). Succession stage: Secondary forest in initial succession stage (A1), secondary forest in intermediary stage (A2), secondary forest in advanced stage (A3). Occasional encounters (OE).

| **Taxa** | **Feeding habit** | **Habitat use** | **A1** | **A2** | **A3** | **OE** |
| --- | --- | --- | --- | --- | --- | --- |
| **TINAMIFORMES** |  |  |  |  |  |  |
| **Tinamidae** |  |  |  |  |  |  |
| *Crypturellus obsoletus*  | Gra | For |  | X | X |  |
| *Tinamus solitarius*  | Oni | For |  |  | X |  |
| **GALLIFORMES** |  |  |  |  |  |  |
| **Cracidae** |  |  |  |  |  |  |
| *Penelope obscura* | Oni | For |  |  |  | X |
| **PELECANIFORMES** |  |  |  |  |  |  |
| **Ardeidae** |  |  |  |  |  |  |
| *Bubulcus ibis*  | Ins | Oa |  |  |  | X |
| *Egretta thula*  | Pis | Wet |  |  |  | X |
| *Syrigma sibilatrix*  | Oni | Oa | X |  |  |  |
| *Threskiornithidae* |  |  |  |  |  |  |
| *Mesembrinibis cayennensis*  | Oni | Wet | X | X | X |  |
| *Plegadis chihi*  | Oni | Wet |  |  |  | X |
| *Phimosus infuscatus*  | Oni | Wet |  |  |  | X |
| *Theristicus caudatus*  | Ins | Oa | X | X | X |  |
| **CATHARTIFORMES** |  |  |  |  |  |  |
| **Cathartidae** |  |  |  |  |  |  |
| *Cathartes aura*  | Det | Bro | X |  |  |  |
| *Coragyps atratus*  | Det | Bro | X |  |  |  |
| **ACCIPITRIFORMES** |  |  |  |  |  |  |
| **Accipitridae** |  |  |  |  |  |  |
| *Ictinia plumbea* | Ins | Fe | X |  | X |  |
| *Elanoides forficatus* | Car | Bro |  |  |  | X |
| *Rupornis magnirostris*  | Car | Bro | X | X | X |  |
| **GRUIFORMES** |  |  |  |  |  |  |
| **Rallidae** |  |  |  |  |  |  |
| *Aramides saracura*  | Oni | For | X | X | X |  |
| **CHARADRIIFORMES** |  |  |  |  |  |  |
| **Charadriidae** |  |  |  |  |  |  |
| *Vanellus chilensis*  | Oni | Oa | X | X |  |  |
| **COLUMBIFORMES** |  |  |  |  |  |  |
| **Columbidae** |  |  |  |  |  |  |
| *Columbina talpacoti*  | Gra | Oa | X | X | X |  |
| *Leptotila rufaxilla*  | Oni | For | X | X | X |  |
| *Leptotila verreauxi*  | Gra | For | X | X | X |  |
| *Patagioenas picazuro*  | Gra | Bro | X | X | X |  |
| *Zenaida auriculata*  | Oni | Bro | X | X |  |  |
| **CUCULIFORMES** |  |  |  |  |  |  |
| **Cuculidae** |  |  |  |  |  |  |
| *Crotophaga ani*  | Ins | Oa |  |  |  | X |
| *Crotophaga major*  | Ins | For |  |  |  | X |
| *Guira guira*  | Ins | Oa | X |  |  |  |
| *Piaya cayana*  | Ins | Fe | X | X |  |  |
| *Tapera naevia*  | Ins | Oa | X |  |  |  |
| **CAPRIMULGIFORMES** |  |  |  |  |  |  |
| **Caprimulgidae** |  |  |  |  |  |  |
| *Hydropsalis forcipata*  | Ins | For | X |  |  |  |
| *Hydropsalis torquata*  | Ins | Oa | X |  |  |  |
| *Nyctidromus albicollis*  | Ins | Fe |  |  |  | X |
| **APODIFORMES** |  |  |  |  |  |  |
| **Apodidae** |  |  |  |  |  |  |
| *Chaetura meridionalis* | Ins | Fe | X | X |  |  |
| **Trochilidae** |  |  |  |  |  |  |
| *Chlorostilbon lucidus*  | Nec | Bro | X | X |  |  |
| *Leucochloris albicollis* | Nec | Fe | X | X |  |  |
| *Phaethornis pretrei*  | Nec | Fe |  |  | X |  |
| *Stephanoxis loddigesii* | Nec | Fe | X | X | X |  |
| **TROGONIFORMES** |  |  |  |  |  |  |
| **Trogonidae** |  |  |  |  |  |  |
| *Trogon surrucura*  | Oni | For | X | X | X |  |
| **CORACIIFORMES** |  |  |  |  |  |  |
| **Alcedinidae** |  |  |  |  |  |  |
| *Chloroceryle americana*  | Car | Wet |  |  |  | X |
| *Megaceryle torquata*  | Pis | Wet | X |  |  |  |
| **PICIFORMES** |  |  |  |  |  |  |
| **Ramphastidae** |  |  |  |  |  |  |
| *Ramphastos dicolorus*  | Oni | For | X | X | X |  |
| **Picidae** |  |  |  |  |  |  |
| *Colaptes campestris*  | Ins | Oa | X | X |  |  |
| *Colaptes melanochloros*  | Oni | Oa | X | X | X |  |
| *Melanerpes candidus* | Oni | Bro | X |  |  |  |
| *Piculus aurulentus*  | Ins | For |  | X | X |  |
| *Picumnus temminckii* | Ins | For |  | X |  |  |
| *Veniliornis spilogaster* | Ins | For | X | X | X |  |
| **CARIAMIFORMES** |  |  |  |  |  |  |
| **Cariamidae** |  |  |  |  |  |  |
| *Cariama cristata* | Oni | Oa |  |  |  | X |
| **FALCONIFORMES**  |  |  |  |  |  |  |
| **Falconidae** |  |  |  |  |  |  |
| *Micrastur semitorquatus*  | Car  | For |  |  |  | X |
| *Micrastur ruficollis*  | Car | For |  |  | X |  |
| *Milvago chimachima*  | Oni | Bro |  | X |  |  |
| **PSITTACIFORMES** |  |  |  |  |  |  |
| **Psittacidae** |  |  |  |  |  |  |
| *Pionopsitta pileata*  | Fru | For |  | X | X |  |
| *Pionus maximiliani*  | Fru | For | X | X | X |  |
| *Pyrrhura frontalis*  | Fru | For | X | X | X |  |
| **PASSERIFORMES** |  |  |  |  |  |  |
| **Thamnophilidae** |  |  |  |  |  |  |
| *Dysithamnus mentalis*  | Ins | For |  | X | X |  |
| *Thamnophilus caerulescens* | Ins | For | X | X | X |  |
| *Thamnophilus ruficapillus* | Oni | Oa |  | X |  |  |
| **Formicariidae** |  |  |  |  |  |  |
| *Chamaeza campanisona*  | Ins | For |  | X | X |  |
| **Scleruridae** |  |  |  |  |  |  |
| *Sclerurus scansor*  | Ins | For |  |  | X |  |
| **Dendrocolaptidae** |  |  |  |  |  |  |
| *Dendrocolaptes platyrostris*  | Ins | For |  | X | X |  |
| *Lepidocolaptes falcinellus*  | Ins | For | X | X | X |  |
| *Sittasomus griseicapillus*  | Ins | For | X | X |  |  |
| *Xiphorhynchus fuscus*  | Ins | For |  | X | X |  |
| **Furnariidae** |  |  |  |  |  |  |
| *Lochmias nematura*  | Ins | For | X | X | X |  |
| *Philydor rufum*  | Ins | For |  | X | X |  |
| *Synallaxis cinerascens*  | Ins | For |  | X | X |  |
| *Synallaxis ruficapilla*  | Ins | For |  | X | X |  |
| *Synallaxis spixi*  | Ins | Oa | X | X |  |  |
| *Syndactyla rufosuperciliata*  | Ins | For |  | X | X |  |
| **Pipridae** |  |  |  |  |  |  |
| *Chiroxiphia caudata*  | Fru | For |  | X | X |  |
| **Tityridae** |  |  |  |  |  |  |
| *Pachyramphus polychopterus*  | Oni | Fe | X | X | X |  |
| *Pachyramphus validus*  | Ins | For |  |  | X |  |
| *Schiffornis virescens*  | Oni | For |  |  | X |  |
| *Tityra cayana*  | Oni | Fe | X | X | X |  |
| *Tityra inquisitor*  | Fru | Fe |  |  |  | X |
| **Platyrinchidae** |  |  |  |  |  |  |
| *Platyrinchus mystaceus*  | Ins | For |  |  | X |  |
| **Rhynchocyclidae** |  |  |  |  |  |  |
| *Corythopis delalandi*  | Ins | For |  |  | X |  |
| *Leptopogon amaurocephalus*  | Ins | For | X | X | X |  |
| *Mionectes rufiventris* | Oni | For |  |  | X |  |
| *Phylloscartes ventralis*  | Ins | For | X | X | X |  |
| *Poecilotriccus plumbeiceps*  | Ins | For | X | X | X |  |
| *Tolmomyias sulphurescens*  | Ins | For | X | X | X |  |
| **Tyrannidae** |  |  |  |  |  |  |
| *Camptostoma obsoletum*  | Ins | Bro | X | X |  |  |
| *Elaenia flavogaster*  | Oni | Fe |  | X |  |  |
| *Elaenia mesoleuca*  | Oni | Fe | X | X | X |  |
| *Elaenia parvirostris*  | Oni | Fe | X | X |  |  |
| *Elaenia spectabilis*  | Oni | Fe |  |  |  | X |
| *Empidonomus varius*  | Ins | Fe | X | X | X |  |
| *Legatus leucophaius*  | Oni | Fe | X | X | X |  |
| *Megarynchus pitangua*  | Oni | Fe | X | X | X |  |
| *Myiarchus swainsoni*  | Oni | For | X | X | X |  |
| *Myiodynastes maculatus*  | Oni | For | X | X | X |  |
| *Myiopagis viridicata*  | Ins | For | X | X | X |  |
| *Phyllomyias virescens*  | Ins | For | X | X |  |  |
| *Pitangus sulphuratus*  | Oni | Bro | X | X | X |  |
| *Serpophaga subcristata*  | Ins | Oa |  | X |  |  |
| *Sirystes sibilator*  | Oni | For |  | X |  |  |
| *Tyrannus savana*  | Ins | Oa |  |  |  | X |
| *Tyrannus melancholicus*  | Ins | Fe | X | X |  |  |
| **Vireonidae** |  |  |  |  |  |  |
| *Cyclarhis gujanensis*  | Oni | Fe | X | X | X |  |
| *Hylophilus poicilotis*  | Oni | For |  | X | X |  |
| *Vireo chivi*  | Oni | For | X | X | X |  |
| **Corvidae** |  |  |  |  |  |  |
| *Cyanocorax chrysops*  | Oni | For | X | X | X |  |
| **Hirundinidae** |  |  |  |  |  |  |
| *Progne chalybea*  | Ins | Bro |  |  |  | X |
| **Troglodytidae** |  |  |  |  |  |  |
| *Troglodytes musculus*  | Ins | Bro | X |  |  |  |
| **Turdidae** |  |  |  |  |  |  |
| *Turdus albicollis*  | Oni | For | X | X | X |  |
| *Turdus amaurochalinus* | Oni | Bro | X | X | X |  |
| *Turdus leucomelas*  | Oni | Bro | X | X | X |  |
| *Turdus rufiventris*  | Oni | Bro | X | X | X |  |
| *Turdus subalaris*  | Oni | For | X | X | X |  |
| **Mimidae** |  |  |  |  |  |  |
| *Mimus saturninus*  | Oni | Oa |  |  |  | X |
| **Passerellidae** |  |  |  |  |  |  |
| *Geothlypis aequinoctialis*  | Ins | Oa | X |  |  |  |
| *Zonotrichia capensis*  | Oni | Bro | X | X |  |  |
| **Parulidae** |  |  |  |  |  |  |
| *Basileuterus culicivorus*  | Ins | For | X | X | X |  |
| *Myiothlypis leucoblephara*  | Ins | For | X | X | X |  |
| *Setophaga pitiayumi*  | Ins | For | X | X | X |  |
| **Icteridae** |  |  |  |  |  |  |
| *Agelaioides badius*  | Oni | Oa |  |  |  | X |
| *Cacicus chrysopterus*  | Oni | For | X | X | X |  |
| *Cacicus haemorrhous*  | Oni | For | X | X | X |  |
| *Icterus pyrrhopterus*  | Oni | For |  |  | X |  |
| *Molothrus bonariensis*  | Oni | Bro | X |  |  |  |
| **Thraupidae** |  |  |  |  |  |  |
| *Conirostrum speciosum*  | Ins | For |  | X | X |  |
| *Coryphospingus cucullatus*  | Oni | Fe | X | X |  |  |
| *Embernagra platensis*  | Oni | Oa |  |  |  | X |
| *Haplospiza unicolor*  | Oni | For | X | X | X |  |
| *Hemithraupis guira*  | Fru | For |  | X | X |  |
| *Microspingus cabanisi*  | Oni | Fe | X | X |  |  |
| *Pipraeidea bonariensis*  | Fru | Bro | X |  |  |  |
| *Poospiza nigrorufa*  | Oni | Wet | X | X |  |  |
| *Pyrrhocoma ruficeps*  | Ins | For | X | X | X |  |
| *Saltator similis*  | Oni | For | X | X | X |  |
| *Sicalis flaveola*  | Gra | Bro | X |  |  |  |
| *Sporophila caerulescens*  | Gra | Oa | X |  |  |  |
| *Stephanophorus diadematus*  | Fru | Fe | X | X |  |  |
| *Tachyphonus coronatus*  | Oni | For | X | X | X |  |
| *Tangara preciosa*  | Fru | For | X | X | X |  |
| *Tangara sayaca*  | Oni | Bro | X | X | X |  |
| *Tersina viridis*  | Oni | Fe |  |  |  | X |
| *Trichothraupis melanops* | Oni | For |  | X | X |  |
| *Volatinia jacarina*  | Gra | Oa | X |  |  |  |
| **Cardinalidae** |  |  |  |  |  |  |
| *Cyanoloxia brissonii*  | Oni | Fe | X | X |  |  |
| *Habia rubica*  | Oni | For |  |  | X |  |
| *Piranga flava*  | Oni | Bro |  | X |  |  |
| **Fringillidae** |  |  |  |  |  |  |
| *Chlorophonia cyanea*  | Fru | For |  |  | X |  |
| *Euphonia chalybea*  | Fru | For | X | X | X |  |
| *Euphonia chlorotica*  | Fru | Bro |  |  | X |  |
| *Spinus magellanicus*  | Gra | Oa | X | X | X |  |