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# Bird-plant interactions on the edge of a forest fragment in southwestern Brazilian Amazonia

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**ABSTRACT.** Seed dispersal is one of the principal ecological processes that determine the richness and distribution of plants in tropical forests. Birds play an important role in the zoochoric dispersal of seeds in these forests. The present study investigated the bird-plant interactions involving the ingestion and dispersal of seeds by the birds found in the edge habitat of an isolated forest fragment on the Catuaba Experimental Farm in eastern Acre, in southwestern Brazilian Amazonia. The birds were captured using mist nets, and the seeds were collected from fecal samples obtained during the handling of the animals. These seeds were sorted and identified. The bird and the plant species identified during the study were used to calculate the connectivity and nestedness of the bird-plant interactions. We captured 82 species of birds, with a total sampling effort of 203,180 h.m<sup>2</sup>. Fecal samples obtained from 19 of the bird species contained a total of 2,086 seeds, representing 23 plant species. The interaction network had an intermediate connectance, and significant nestedness. *Ramphocelus carbo* had the highest importance index and was the bird with the largest number of plant interactions, while *Cecropia latiloba* was the plant with the highest importance index, followed by *Schefflera morototoni*. Most of the seed-dispersing birds identified in the present study are generalists found in both the forest core and its edge. The results of the study indicated that the community of generalist-frugivore birds interacts extensively with the plant community of the fragment, providing seed dispersal services that include the deforested areas adjacent to the fragment.

**Keywords:** Acre state; landscape; network interaction; ornithochory; seeds; seed dispersal.

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## Introduction

The Amazon rainforest is one of the most biodiverse terrestrial ecosystems on the planet (Mittermeier et al., 2003; Antonelli et al., 2018). Despite this, many species are becoming extinct as the result of deforestation and the resulting loss and isolation of habitats (Ochoa-Quintero, Gardner, Rosa, Ferraz, & Sutherland, 2015). The accelerated deforestation of some parts of the Amazon region has transformed the landscape into a mosaic of vegetation remnants set within a matrix of pasture (Silva, Conceição, & Anciães, 2012; Fearnside, 2016; Laurance et al., 2018).

Habitat fragmentation results in a landscape mosaic, characterized by the intensification of edge effects (Terraube et al., 2016). Edge is defined here as an abrupt physical transition between two types of habitat (McCollin, 1998; Fonseca, 2008). This transition is inhabited by animal species that transit naturally between the two environments to satisfy their ecological requirements (Terraube et al., 2016). The edge bird community plays an important role in the maintenance of ecological services in both the forest and the adjacent matrix, through seed dispersal and pest control (Terraube et al., 2016; Pires, Gonçalves, Ferreira, Camelo, & Melo, 2018).

Seed dispersal is one of the ecological interactions most impacted by deforestation. The interruption of normal seed dispersal patterns may result in major alterations of the composition of the plant community and the process of forest regeneration (Cramer, Mesquita, & Williamson, 2007). Seed dispersal is one of the principal processes that determine the species richness and distribution of plants (Pinheiro & Ribeiro, 2001; Peternelli, Della Lucia, & Martins, 2004). Frugivore-plant interactions began to evolve around 300 million years ago (Bascompte & Jordano, 2008), and represent a prime example of a mutualistic interaction, which

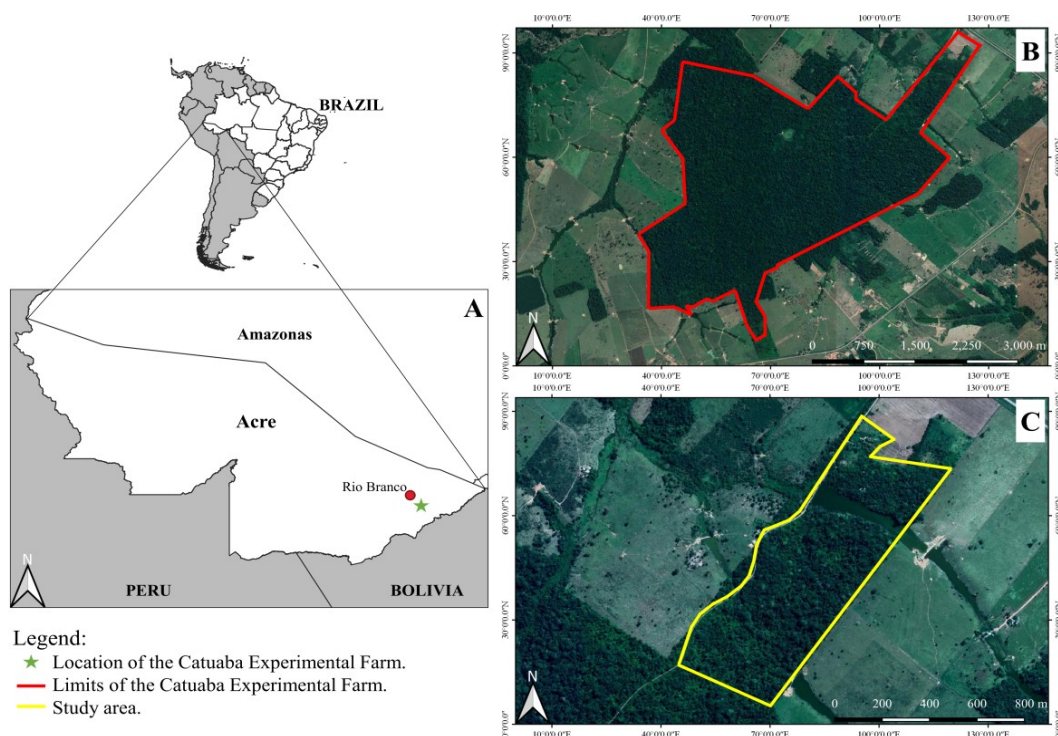
entails benefits for both the organisms involved in the interaction (Primack & Rodrigues, 2001; Ricklefs, 2010; García, 2016).

In Neotropical forests, approximately 30% of the bird species are frugivores or generalists, and almost 90% of these species have adaptations for zoochoric seed dispersal (Pizo & Galetti, 2010). These values indicate that frugivorous birds have an important seed dispersal function, and influence the distribution and survival of the forest's flora (Fadini & De Marco Jr., 2004; Christianini & Martins, 2015). Birds offer a number of advantages for the plant in comparison with other frugivores, including their species diversity, their mobility, and their varied diet. Given this, birds make an essential contribution to the maintenance of ecosystems, with key roles in food webs (Scherer, Silva, & Baptista, 2007; García, 2016).

The Neotropical region has the greatest known diversity of specialized frugivore birds, although studies focusing on the relationships between Neotropical plants and their dispersers are still incipient (Dugger et al., 2019). This situation is most evident in the Amazon region where the mutualistic relationships between frugivorous birds and plants are relatively poorly studied, considering the vast size of this biome (Parrini, Raposo, Del Hoyo, & Silva, 2013; Purificação, Pascotto, Pedroni, Pereira, & Lima, 2014; Dugger et al., 2019). Given these shortcomings, the present study investigated bird-plant interactions in an area of forest edge habitat in the southwestern Brazilian Amazon region, based on the analysis of the seeds found in fecal samples obtained from local birds captured in mist nets.

## Material and methods

We conducted the study on the Catuaba Experimental Farm - CEF (10°04' S, 67°37' W). This property is located in the municipality of Senador Guiomard, in the eastern extreme of the state of Acre, Brazil (Figure 1A) and has a total area of 1,200 ha (Medeiros, Castro, Salimon, Silva, & Silveira, 2013; Figure 1B). The CEF is surrounded by a pasture matrix composed of exotic grasses (e.g. *Urochloa* sp.) with sparse trees such as palms and Brazil nut, *Bertholletia excelsa* (Araújo & Lani, 2012). The tract of forest on the CEF selected for the present survey has an area of approximately 0.54 km<sup>2</sup>, with a perimeter of 3.56 km (Figure 1C). It is a relatively elongated area, approximately 80 m wide, located within a matrix of pasture (Figure 1C). The vegetation of the study area is a mosaic of dense *terra firme* forest with patches of bamboo and secondary forest at varying stages of succession, surrounded by pasture (Rasmussen, Rehg, & Guilherme, 2005; Silveira, 2005).



**Figure 1.** Study site. (A) Location of the CEF (green star) within the Brazilian state of Acre and in relation to the state capital, Rio Branco (red circle); (B) Total perimeter of the Catuaba Experimental Farm, including the study area, in the northeastern extreme, and (C) Study area.

### Mist netting and bird captures

We captured birds at 15-day intervals between June 2016 and March 2017, a period that covers part of the late dry season and the early rainy season. We used 20 mist nets (12 m × 2.5 m; 36 mm mesh), installed in continuous lines along the edge and within the forest, throughout the whole area of the study tract. Each capture cycle lasted an average of three days, with a total sampling effort of 4,838 h.m<sup>2</sup> per cycle. All the birds were identified to species (Schulenberg, Stotz, Lane, O'Neill, & Parker, 2007; Piacentini et al., 2015), and marked with metal rings supplied by CEMAVE (*Centro Nacional de Pesquisa e Conservação de Aves Silvestres*), within the scope of project 1099/7, coordinated by Edson Guilherme (Senior Bird Bander, Registration Number: 324654). Each captured bird was placed in a cloth bag containing absorbent paper, where it was maintained for 15 minutes to collect fecal samples. The birds were subsequently released near the capture site. The scientific nomenclature was based on that of the Brazilian Committee of Ornithological Records (Piacentini et al., 2015).

### Collection, sorting, and identification of the seeds encountered in the fecal samples

The seeds were obtained from the fecal material collected from each bird. Once collected, the seeds were packed individually and labeled with the name of the bird species that produced the sample and the habitat in which the individual was captured. The seeds were cleaned manually *in natura* to remove the excess fecal material and other debris (such as insect parts), sorted, and grouped by their size and morphological similarities. The seeds were then counted, photographed, packed individually by morphospecies, and labeled with information on the amount of seeds, and the habitat in which the sample was collected, the date, and the bird species. We established a reference collection of the seeds collected in the CEF using a portion of the seeds of each morphospecies (70%). The other portion (30%) was reserved for planting, to enable the identification of the plant species from seedlings. The seeds or seedlings obtained from the fecal samples were identified to the lowest possible taxonomic level with the assistance of local botanists and specific references for the study region (Daly & Silveira, 2008; Cornejo & Janovec, 2010).

### Guilds

The birds were assigned to one of the feeding guilds defined by Wilman et al. (2014), based on the analysis of the content of the fecal samples collected during this study.

### Data analysis: bird-plant interactions

Based on the identification of the plant species ingested by the different bird species captured during the present study, we established a bipartite network of interspecific interactions. To compile this network, we organized the data into a binary matrix of presence/absence data in which plant species were represented in the lines and the birds in the columns. In this matrix, the element  $a_{ij}$  is equal to 1 if plant  $i$  interacts with the frugivorous bird  $j$  or to 0 if there was no interaction (Bascompte, Jordano, Melián, & Olesen, 2003). The analysis of the bird-plant interaction network was run in the R software (R Core Team, 2018). To reinforce the analysis of the bird-plant interactions, we calculated the importance index (I), and the connectance (C) and nestedness (N) of the data. We considered a  $p < 0.05$  significance level in all analyses.

### Importance index (I)

This index was proposed by Murray (2000), and determines the relative contribution of each bird and plant species to the interaction. The value of this index approaches 1 either when larger numbers of bird and plant species interact or when there is a larger number of exclusive interactions. This index is calculated by  $I_j = \sum_{i=1}^S [C_{ij}/T_i]/S$ , where:  $C_{ij} = 1$ , if bird species  $j$  consumes the fruits of the plant species  $i$ , or 0 if there was no interaction,  $T_i$  = the total number of bird species that feed on the fruit/seeds of plant  $i$ , and  $S$  = the total number of plant species recorded.

### Connectance (C)

This index estimates the percentage of interactions recorded between birds and plants in relation to all possible interactions (Jordano, 1987). Connectance is calculated by the equation:  $C(\%) = I \times 100/(F \times P)$ ,

where:  $I$  = the number of recorded interactions,  $F$  = the number of frugivore species,  $P$  = the number of plant species, and  $(F \times P)$  = the total number of possible interactions.

### Nestedness (N)

Nestedness is a concept commonly applied in the analysis of networks of mutualistic interaction. The patterns nested in the interaction matrices between the emerging and specialist species that interact with other species will form well-defined subsets (Bascompte et al., 2003; Jordano, Bascompte, & Olesen, 2003; Guimarães Jr., Rico-Gray, Reis, & Thompson, 2006). We measured the nestedness in the data based on the equation defined by Bascompte et al. (2003):  $N = (100 - T)/100$ , where:  $N$  is the nestedness, with values ranging from 0 (minimum) to 1 (maximum), and  $T$  is the network temperature that estimates the deviation of the presence or absence was not predicted, with values ranging from  $0^\circ$  to  $100^\circ$  (Atmar & Patterson, 1993). We ran this analysis in the Nested software (Guimarães Jr. & Guimarães, 2006; Almeida-Neto, Guimarães, Guimarães Jr., Loyola, & Ulrich, 2008).

## Results

We captured 475 individual birds representing 82 species in 26 families, with a total sampling effort of 203,180 h.m<sup>2</sup>. The species captured were each assigned to one of five feeding guilds: insectivore ( $n = 57$  species), omnivore ( $n = 16$ ), frugivore ( $n = 14$ ), nectarivore ( $n = 4$ ), and carnivore ( $n = 1$ ). Birds of the family Thraupidae dispersed the largest quantity of seeds, followed by those of the Pipridae and Tyrannidae (Table 1). Plants of the families Urticaceae and Melastomataceae were the most abundant in the fecal samples (Table 1), and thus potentially the most dispersed by the birds. A total of 263 fecal samples were collected from these individuals, of which, 81 contained whole seeds with no signs of predation. We collected 2,086 seeds from the fecal samples collected from 19 bird species, and identified 23 plant species (Table 2).

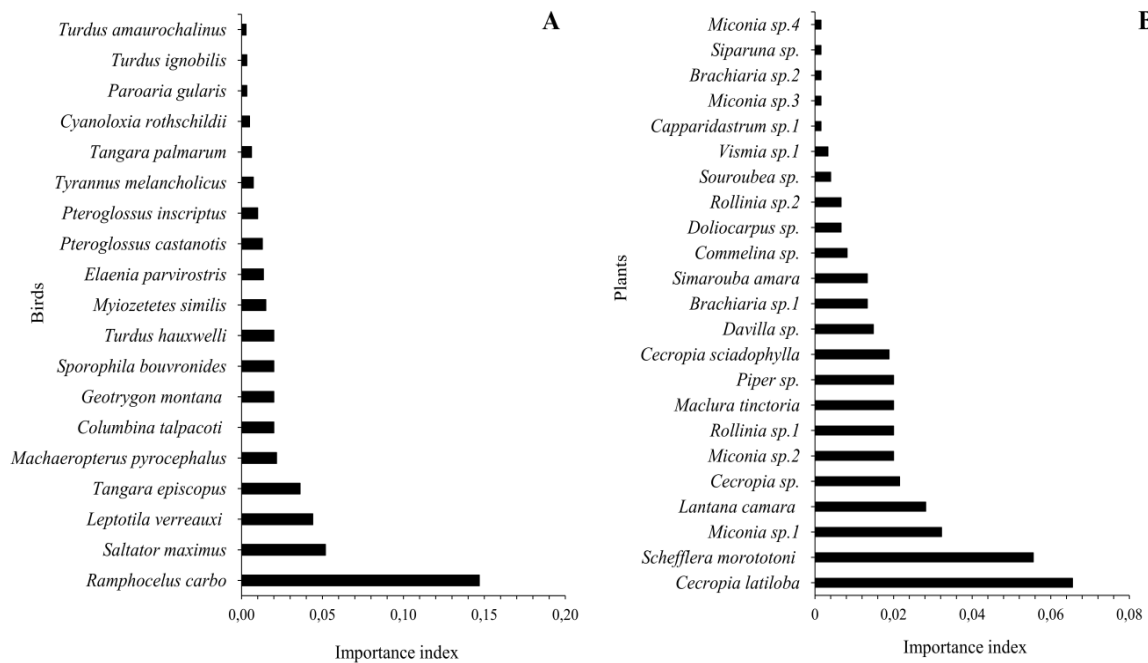
*Ramphocelus carbo*, *Saltator maximus*, *Leptotila verreauxi*, *Tangara episcopus*, and *Machaeropterus pyrocephalus* were the bird species with the highest importance indices (Figure 2A). *Ramphocelus carbo* presented the highest index of importance ( $I = 0.147$ ; Figure 2A), being responsible for 70.1% of the seeds dispersed during the study. The most abundant seeds found in the fecal samples of *R. carbo* were those from the genera *Cecropia* and *Miconia* (Table 2). *Cecropia latiloba* had the highest importance index ( $I = 0.066$ ; Figure 2B) of the plant species dispersed by the birds captured in the present study, followed by *Schefflera morototoni* ( $I = 0.056$ ), *Miconia* sp.1, *Lantana camara*, and *Cecropia* sp. The principal dispersers of *Cecropia latiloba* were *R. carbo* and *T. episcopus*.

**Table 1.** The number of seeds dispersed per family of bird and plant.

Bird family (number of plant species dispersed)	Number of seeds dispersed	Plant family (number of bird species dispersing seeds)	Number of seeds dispersed
Thraupidae (18)	1826	Urticaceae (8)	1326
Pipridae (3)	143	Melastomataceae (5)	507
Tyrannidae (6)	73	Marcgraviaceae (1)	70
Ramphastidae (3)	15	Dilleniaceae (3)	60
Turdidae (3)	13	Capparaceae (2)	13
Columbidae (5)	11	Araliaceae (8)	35
Cardinalidae (1)	5	Verbenaceae (5)	20
-	-	Poaceae (3)	16
-	-	Simaroubaceae (2)	15
-	-	Moraceae (1)	9
-	-	Annonaceae (2)	8
-	-	Commelinaceae (2)	3
-	-	Piperaceae (1)	2
-	-	Hypericaceae (1)	1
-	-	Siparunaceae (1)	1

**Table 2.** Potential seed-dispersing bird species and the respective plant species dispersed (i.e., seeds found in the fecal samples obtained from the bird).

Bird order / family / species	Plant family	Plant species	Total number of seeds
Columbiformes			
Columbidae			
<i>Columbina talpacoti</i>	Melastomataceae	<i>Miconia</i> sp.2 Ruiz & Pav.	2
<i>Geotrygon montana</i>	Annonaceae	<i>Rollinia</i> sp.1 A. St.-Hil.	2
<i>Leptotila verreauxi</i>	Dilleniaceae	<i>Dolioscarpus</i> sp. Rol.	1
	Annonaceae	<i>Rollinia</i> sp.2 A. St.-Hil.	2
	Verbenaceae	<i>Lantana camara</i> L.	4
Piciformes			
Ramphastidae			
<i>Pteroglossus inscriptus</i>	Urticaceae	<i>Cecropia</i> sp. Loeffl.	1
<i>Pteroglossus castanotis</i>	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	5
	Poaceae	<i>Urochloa</i> sp.1 P.Beauv.	9
Passeriformes			
Pipridae			
<i>Machaeropterus pyrocephalus</i>	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	1
	Melastomataceae	<i>Miconia</i> sp.1 Ruiz & Pav.	141
	Commelinaceae	<i>Commelina</i> sp. L.	1
Tyrannidae			
<i>Elaenia parvirostris</i>	Dilleniaceae	<i>Davilla</i> sp. Vand.	7
	Verbenaceae	<i>Lantana camara</i> L.	11
	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	6
<i>Myiozetetes similis</i>	Urticaceae	<i>Cecropia sciadophylla</i> Mart.	4
	Simaroubaceae	<i>Simarouba amara</i> Aubl.	4
<i>Tyrannus melancholicus</i>	Verbenaceae	<i>Lantana camara</i> L.	3
	Urticaceae	<i>Cecropia latiloba</i> Miq.	29
Turdidae			
<i>Turdus hawxwelli</i>	Moraceae	<i>Maclura tinctoria</i> (L.) D.Don ex Steud.	9
<i>Turdus amaurochalinus</i>	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	1
<i>Turdus ignobilis</i>	Urticaceae	<i>Cecropia latiloba</i> Miq.	3
Thraupidae			
<i>Paroaria gularis</i>	Melastomataceae	<i>Miconia</i> sp.1 Ruiz & Pav.	9
<i>Tangara episcopus</i>	Melastomataceae	<i>Miconia</i> sp.1 Ruiz & Pav.	151
	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	9
	Marcgraviaceae	<i>Souroubea</i> sp. Aubl.	70
	Urticaceae	<i>Cecropia latiloba</i> Miq.	19
	Urticaceae	<i>Cecropia sciadophylla</i> Mart.	3
<i>Tangara palmarum</i>	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	5
	Urticaceae	<i>Cecropia latiloba</i> Miq.	33
<i>Ramphocelus carbo</i>	Urticaceae	<i>Cecropia latiloba</i> Miq.	515
	Melastomataceae	<i>Miconia</i> sp.1 Ruiz & Pav.	316
	Verbenaceae	<i>Lantana camara</i> L.	2
	Urticaceae	<i>Cecropia sciadophylla</i> Mart.	57
	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	1
	Dilleniaceae	<i>Davilla</i> sp. Vand.	32
	Urticaceae	<i>Cecropia</i> sp. Loeffl.	500
	Melastomataceae	<i>Miconia</i> sp.6 Ruiz & Pav.	1
	Capparaceae	<i>Capparidastrium</i> sp. (DC.) Hutch.	13
	Siparunaceae	<i>Siparuna</i> sp. Aubl.	4
	Melastomataceae	<i>Miconia</i> sp.5 Ruiz & Pav.	14
	Commelinaceae	<i>Commelina</i> sp. L.	2
	Poaceae	<i>Urochloa</i> sp.2 P.Beauv.	13
<i>Sporophila bouvronides</i>	Commelinaceae	<i>Commelina</i> sp. L.	2
<i>Saltator maximus</i>	Piperaceae	<i>Piper</i> sp. L.	1
	Verbenaceae	<i>Lantana camara</i> L.	4
	Urticaceae	<i>Cecropia sciadophylla</i> Mart.	37
	Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire et al.	7
	Hypericaceae	<i>Vismia</i> sp. Vand.	1
	Poaceae	<i>Urochloa</i> sp.1 P.Beauv.	3
	Simaroubaceae	<i>Simarouba amara</i> Aubl.	11
Cardinalidae			
<i>Cyanoloxia rothschildii</i>	Melastomataceae	<i>Miconia</i> sp.1 Ruiz & Pav.	5



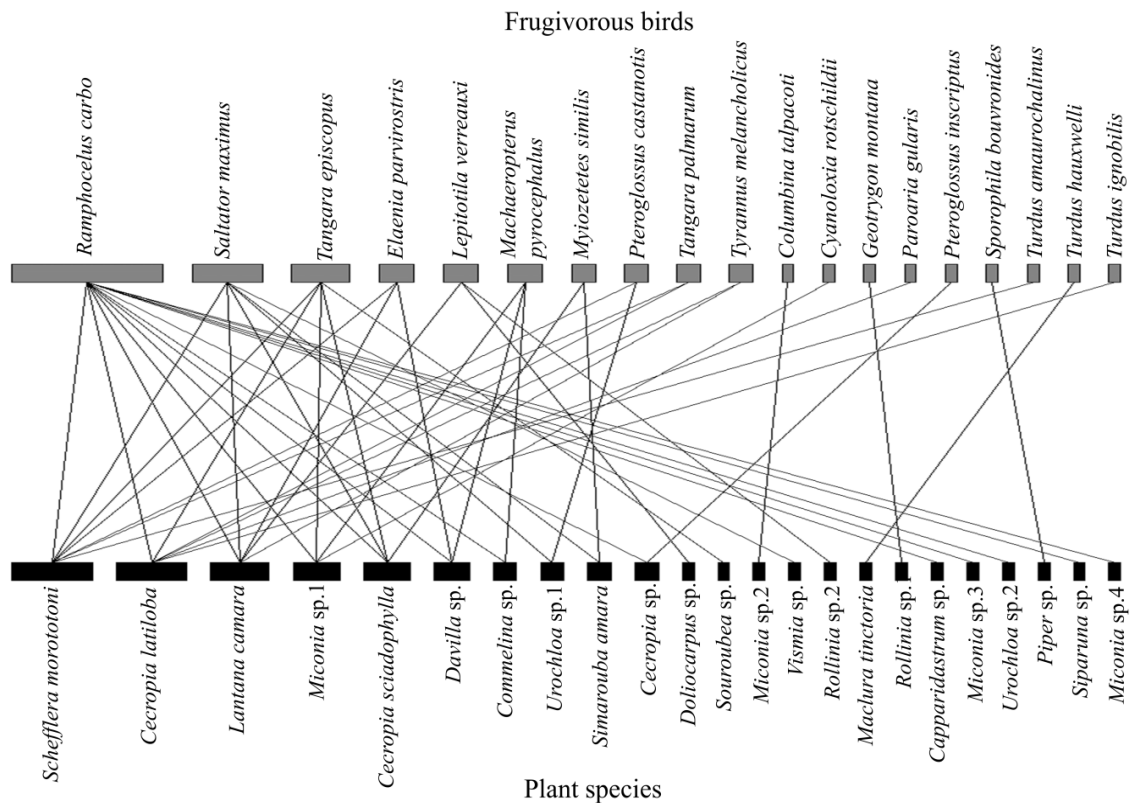
**Figure 2.** Importance indices of the bird (A) and plant (B) species involved in the plant-bird interactions recorded in the present study area on the Catuaba Experimental Farm in Acre, Brazil.

We recorded 50 of the 437 possible bird-plant interactions available in the network (Figure 3). These interactions had an intermediate level of connectance ( $C = 11.44\%$ ), and were nested significantly ( $N = 12.74$ ;  $p = 0.02$ ). The bird species that interacted with most plant species was *Ramphocelus carbo*, with 13, of which, five were exclusive interactions (Figure 3), followed by *Saltator maximus* (six interactions), and *Tangara episcopus* (five). The plant species with most interactions with birds was *Schefflera morototoni*, with seven interactions, including an exclusive interaction with *Turdus amaurochalinus*, followed by *Cecropia latiloba* (six) and *Lantana camara* with five interactions (Figure 3).

## Discussion

The bird species captured in mist nets during the present study represent 29.7% of the total species richness (276) recorded in the CEF up to now (Rasmussen et al., 2005; Guilherme, 2016), although this was expected due to the reduced extension of the study area, and the fact that mist nets set at ground level tend to capture predominantly understory birds that fly at heights of below 2.5 m (Pedroza, Verde, & Guilherme, 2019). Most of the species captured in the present study are typical of open environments, secondary forests, and forest edge, and are predominantly insectivores (more than half of the total), as well as omnivores and frugivores. This predominance of insectivores was expected, given that the diversity of this guild tends to increase toward the equator (Kissling, Sekercioglu, & Jetz, 2011). Insectivores are also known to colonize the forest edge, where the enhanced field of view allows them to forage for insects more efficiently, both in the forest and in adjacent areas of more open habitat, such as pasture and plantations (McCollin, 1998; Barbaro, Bockerhoff, Giffard, & Van Halder, 2012; Terraube et al., 2016).

Thraupids were the birds captured most frequently during the present study, and were responsible for more than 87.5% of the seeds found in the fecal samples, representing primarily the genera *Cecropia* and *Miconia*. *Ramphocelus carbo* provided the largest number of seeds found in the fecal samples, and thus had the highest importance index of all the frugivorous/omnivorous birds captured in the present study. Some thraupids are known to disperse the seeds of zoochoric plants between forest fragments and open areas in the Amazon region (Silva, Uhl, & Murray, 1996). Allenspach, Telles, and Dias (2012) observed *R. carbo* consuming the infructescences of *Cecropia* and the fruit of *Miconia* in São Carlos, São Paulo, Brazil, while in Paragominas, Pará, Silva et al. (1996) observed this bird feeding on a number of different plants, including *Cecropia palmata*, which confirms the importance of this bird as a disperser of the seeds of these and other plant genera in the different biomes.



**Figure 3.** Bird-plant interactions determined from the analysis of the fecal samples collected from the birds captured in the present study area on the Catuaba Experimental Farm in Acre, Brazil.

In the case of the tyrannids, we found seeds of *Lantana camara* and *Cecropia* sp. in two of the three fecal samples obtained from the five *Tyrannus melancholicus* captured during the present study, even though Wilman et al. (2014) classified this species as exclusively insectivorous. However, Wütherich, Azócar, García-Núñez, and Silva (2001) identified *T. melancholicus* as the most important disperser of the seeds of *Palicourea rigida* (Rubiaceae) at a site in the llanos of Venezuela. This indicates that *T. melancholicus* may also eat fruit and thus contribute to seed dispersal. In fact, Mobley (2019) also confirmed that *T. melancholicus* feeds on fruit opportunistically, especially when migrating.

Seeds were also found in the fecal samples obtained from two other tyrannids, *Myiozetetes similis* and *Elaenia parvirostris*. Tewksbury, Levey, Huizinga, Haak, and Traveset (2008) considered the *E. parvirostris* to be an excellent disperser of wild chili in Bolivia. This bird is of special interest because it is an austral migrant in southwestern Amazonia (Guilherme, 2016; Hosner, 2019), and the presence of seeds in its fecal material indicates that it may be a long-distance disperser (possibly even between biomes) of the seeds of at least three plants, *Davilla* sp., *Lantana camara*, and *Schefflera morototoni*.

The diversity of the frugivore guild also tends to increase toward the equator, albeit less intensively than in the insectivores (Kissling et al., 2011), with this guild contributing 17.1% of the species collected in the present study. Generalist frugivores provided most of the seeds collected from the fecal samples. These species have a cosmopolitan diet composed basically of fruit and insects, and typically inhabit impacted environments (Andrade, Mota, & Carvalho, 2011; Purificação et al., 2014).

In the present study, seeds of the genera *Cecropia* and *Miconia* were the most abundant in the fecal samples collected. *Cecropia* and *Miconia* are pioneer plants that produce succulent fruits with minuscule seeds throughout the year (Gaglioti, Scabbia, & Romaniuc-Neto, 2016), which would likely account for the large numbers of seeds from the two genera found in the fecal samples collected during the present study. *Cecropia latiloba* presented the highest index of importance due to the large numbers of its seeds in the fecal samples. In addition to birds, bats and monkeys are known to feed on *C. latiloba* fruit (Van Roosmalen, 1985; Horsley, Bicknell, Lim, & Ammerman, 2015). Birds are known to be the principal dispersers of *Miconia* seeds in the Amazon biome (Gomes, Marceliano, & Jardim, 2008; Blendinger, Blake, & Loiselle, 2011). In the present study, *R. carbo* and *Machaeropterus pyrocephalus* were the birds with the most *Miconia* seeds in their fecal material.



*Schefflera morototoni* was the plant with the second highest index of importance in terms of the amount of dispersed seeds. This plant is also classified as a pioneer species (Fontes, 1999) and its fruit is appreciated by many birds (Saracco, Collazo, Groom, & Carlo, 2005; Parrini et al., 2013; Purificação, Pascotto, Mohr, & Lenza, 2015). In the present study, *S. morototoni* interacted with eight birds, while Purificação et al. (2015) recorded interactions with 10 bird species in a savanna-forest environment within the Cerrado biome. However, Parrini et al. (2013) recorded at least 51 bird species feeding on *S. morototoni* in the Amazon, and Purificação et al. (2015) observed 21 birds feeding on this plant in an area of the Cerrado-Amazon Forest transition. While we recorded fewer bird species feeding on this plant in the present study, these birds were clearly important dispersers of this species in the region.

We recorded an intermediate level of connectance in the present study, although it was still higher than that recorded by Jordano (1987) in montane rainforest in Costa Rica ( $C = 0.059$ ) and in a tropical rainforest in Mexico ( $C = 0.053$ ). A large number of bird-plant interactions is expected in megadiverse communities, such as those of tropical forests (Jordano, 1987; Galetti & Pizo, 1996; Galetti et al., 2013; Dugger et al., 2019), although Fadini and De Marco Jr. (2004) concluded that intermediate connectance values are expected in tropical forests that have suffered some degree of disturbance. As the site of the present study was part of a forest fragment mostly surrounded by pasture, the disturbance and isolation of the forest may have influenced the dynamics of the local bird community. This is reflected in the predominance of certain species that are common in disturbed habitats, a situation that influences the ecological dynamics of these environments and the potential interactions between birds and plants in the Neotropical region (Galetti & Pizo, 1996; Pizo, 2007; Andrade et al., 2011).

## Conclusion

Over the past 50 years, much of the forest of eastern Acre has been converted to cattle pasture and, on a smaller scale, cleared for the planting of cash crops. In this scenario, the forested area of the Catuaba Experimental Farm has acted as an environmental filter, preventing the spread of exotic plants such as signalgrass, *Urochloa* sp., further into the forest. The results of the present study indicate that the seeds of many plants are dispersed effectively, even at the edge of the forest. Some of these birds are known to disperse among forests in the fragmented landscape, while others are migratory, and may carry seeds over long distances. These birds deposit the seeds at a certain distance from the mother plant, contributing to the maintenance of plant diversity within the fragment, and in particular, to the formation of a seed bank in adjacent areas that have lost their forest cover. The present study is the first to describe a bird-plant interaction network for the study region. We believe that this and similar studies will be an important step toward the development of effective conservation strategies for the region's forest fragments, including the formation of ecological corridors and the recovery of areas of degraded forest in the southwestern Amazon basin.

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