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Original Article

Seed-dispersing bird assemblages in riparian environments of a partially urbanized river basin, Southeastern Brazil

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Abstract

Birds play a key role in ecosystem dynamics, including urban and rural areas, bringing environmental quality improvements and ecological stability. Species contribute directly to natural regeneration of vegetation and succession processes, by offering ecosystem services as seed dispersal, an important role in human-modified areas. We studied the assemblages of fruit-eating birds in riparian environments of Monjolinho basin, central São Paulo state, southeastern Brazil. Birds were recorded in 41 points distributed in riparian ecosystems alongside waterbodies, in landscapes with five types of surrounding matrices: urban, periurban, farmland, and native vegetation. We described how assemblages are structured aiming to evaluate the possible influence of seasonality and landscape type. We recorded 39 bird species that can play a role as seed dispersers, 32 in wet season and 32 in dry season. There were no significant differences in the diversity and dominance of species between seasons considering the entire area, indicating stability of basic assemblage structure. However, total number of individuals of all species recorded in different landscapes were influenced by seasonality. Also, the composition and abundance of species significantly changed between seasons, leading to a high dissimilarity with almost 50% of the species contributing with almost 90% of the observed variation. A higher taxonomic diversity and distinctness pointed to a wider array of possible seed-dispersal services in natural areas, while the lowest values of indexes were found in human-modified areas. The higher number of non-related bird species during dry season contrasted with the higher number of individuals during wet season, indicating that there is more possible ecosystem services offered by frugivorous birds in driest period of the year, while in the rainy period the carrying capacity of the riparian environments was increased.

Keywords: diversity, ecosystem services, frugivorous birds, human-modified areas, taxonomic distinctness.

Assembleias de aves dispersoras de sementes em ambientes ripários de uma bacia hidrográfica parcialmente urbanizada, no sudoeste brasileiro

Resumo

As aves desempenham um papel chave na dinâmica dos ecossistemas, incluindo áreas urbanas e rurais, e trazem melhorias na qualidade ambiental e estabilidade ecológica. As espécies contribuem diretamente com a regeneração natural da vegetação e processos de sucessão por oferecerem serviços ecossistêmicos como a dispersão de sementes, um papel fundamental em áreas alteradas. Nós estudamos a assembleia de espécies de aves que se alimentam de frutos em ambientes ripários da bacia do rio Monjolinho, região central do estado de São Paulo, sudeste do Brasil. As aves foram registradas em 41 pontos distribuídos em ecossistemas ripários ao longo dos corpos d'água, em paisagens com quatro tipos de matrizes em seu entorno: urbana, periurbana, rural e vegetação nativa. Nós descrevemos como as assembleias estão estruturadas, objetivando avaliar a possível influência da sazonalidade e do tipo de paisagem do entorno. Foram registradas 39 espécies de aves que podem desempenhar o papel de dispersoras de sementes, sendo 32 espécies no período chuvoso e 32 no período seco. Não foi detectada diferença significativa na diversidade e dominância de espécies entre estações em toda área de estudo, indicando estabilidade da estrutura básica das assembleias. Entretanto, o número total de indivíduos de todas as espécies registrados nas diferentes paisagens foi influenciado pela sazonalidade. Além disso, a composição e abundância de espécies mudou significativamente entre as estações, levando a uma alta dissimilaridade com quase 50% das espécies contribuindo com quase 90% da variação observada. A diversidade e distinção taxonômicas mais altas apontam para maior variedade de serviços ecossistêmicos possíveis relacionados à dispersão de sementes em áreas naturais, enquanto os menores valores desses índices foram encontrados em áreas antropizadas. Um maior número de espécies distintas com menor proximidade taxonômica durante a estação seca, em contraste com um alto número de indivíduos observados na estação chuvosa, indica que existe uma maior gama de possíveis serviços ecossistêmicos oferecidos pelas aves frugívoras no período mais seco do ano, enquanto no período de maior pluviosidade os ecossistemas apresentaram maior capacidade suporte.

Palavras-chave: diversidade, serviços ecossistêmicos, aves frugívoras, áreas alteradas, distinção taxonômica.

1. Introduction

The conservation of biodiversity keeping their natural array of ecological functions can reduce environmental impacts, mitigate the outcomes of climate change, and provide to human societies several benefits. That benefits are generated by a flow of ecosystem services, which are maintained by ecosystem functions (La Notte et al., 2017). Most of ecosystems services are directly related to the land use and land cover, increasing the importance of landscape planning aiming for a high-quality environment (Zulian et al., 2017).

Birds play a key role in the dynamics of all types of environment (e.g., vegetated areas, farmlands, urban ecosystems) by offering several ecosystems services through their ecological functions (Savard et al., 2000; Morante-Filho and Faria, 2017). They can perform many ecological functions such as seed dispersal, controlling of insect populations, pollination, scavenging, ecosystem engineering, and others (Morante-Filho and Faria, 2017; Şekercioğlu et al., 2016). Thus, birds promoted ecosystems services such as natural restoration, transport and cycling of nutrients, insect and disease control, seed dispersal and pollination for many plant species, weed control, environmental stability and resilience, cultural services, recreation opportunities, and much more (Morante-Filho and Faria, 2017; Şekercioğlu et al., 2016; Whelan et al., 2008; MacGregor-Fors et al., 2010; Savard et al., 2000).

In this study, we focused on the seed-dispersal function, a bioindicator for the potential of natural restoration service and the presence of suitable habitats. Seed dispersal is a regulating ecosystem service (Millennium Ecosystem Assessment, 2005) performed mainly by frugivorous bird species in human-modified landscapes. It can affect the vegetation structure, the dynamics of plant populations, habitat displacement of diaspores, colonization of new areas, and natural regeneration, directly influencing food chain, especially in tropical ecosystems (Sekercioglu, 2006; Galetti et al., 2013; Morante-Filho and Faria, 2017).

In a scenery of deforestation and fragmentation, riparian vegetation alongside rivers may serve as connectors between vegetation fragments, linking natural areas to cities and green areas inside them, such as parks, plazas, and urban forests, promoting an ecological network with different landscape units (Mander et al., 1988). Ecological corridors can provide not only habitats for the biodiversity and its locomotion, but also can be the main areas offering ecosystem services for human demand, especially in human-modified landscapes. Therefore, well managed areas alongside rivers can significantly improve the urban ecosystem quality, offering habitats, opportunities for mobility, shelter, food resources, and water for the maintenance of local biodiversity and their ecosystem functions (Flink and Searns, 1993; Scolozzi and Geneletti, 2012).

We aimed to describe the seed-dispersing bird assemblages in riparian environments throughout a midsize river, located in southeastern Brazil. We compared assemblage structure and taxonomic diversity, a surrogate for variation in seed-dispersal services, in dry and wet seasons, within different surrounding landscape matrices along the river.

2. Material and Methods

2.1. Study area

The study area comprises the riparian environments of Monjolinho river basin, in São Carlos municipality, São Paulo state, Brazil (Figure 1). The climate is subtropical humid mesothermal, or Cwa according to the Köppen classification, characterized by cold and dry winters and humid summers (EMBRAPA, 2018). The climate presents clear distinction between the rainy or wet season (October to March), and the dry season (April to September) (Lorandi et al., 2001). The average annual rainfall is about 1470 mm (Soares et al., 2003).

The basin has approximately 275 km^2 covering the municipality of São Carlos and Ibaté and its main waterbody, Monjolinho river, has a length of approximately 43.25 km. The Monjolinho water spring is located in the plateau of São Carlos, at about 900 m of altitude, crossing the city from east to the west (Espíndola, 2000), throughout landscapes such as urban, periurban, farmland, and native vegetation, with different degrees of degradation. Almost the entire urban area of São Carlos is inserted in the Monjolinho basin.

The original vegetation that covered São Carlos municipality, including Monjolinho basin, was characterized by the presence of the Cerrado vegetation physiognomies (from open savannas to forests), mesophilic forest (semideciduous and small patches of forest with *Araucaria angustifolia*) and green wetlands (riparian and swamp forests) (Soares et al., 2003).

Riparian ecosystems of the studied area have been under threat by the removal of native vegetation, unplanned occupation, alteration of lowland areas, waterways erosion, siltation of waterways, illegal sewage dumping, untreated industrial wastewater, and degradation of water sources (Campanelli, 2012).

2.2. Field methods

We distributed 41 points along Monjolinho river and its main tributaries, nearby the water course, covering all types of riparian environments. The amount of points was proportional to the extension of surrounding matrix, categorized in four landscape matrices types: urban matrix, periurban, farmlands (rural zone with crops or livestock), and native vegetation (Figure 1). Spatial independence was guaranteed by the distance of a minimum 200 m between points (Von Matter et al., 2010).

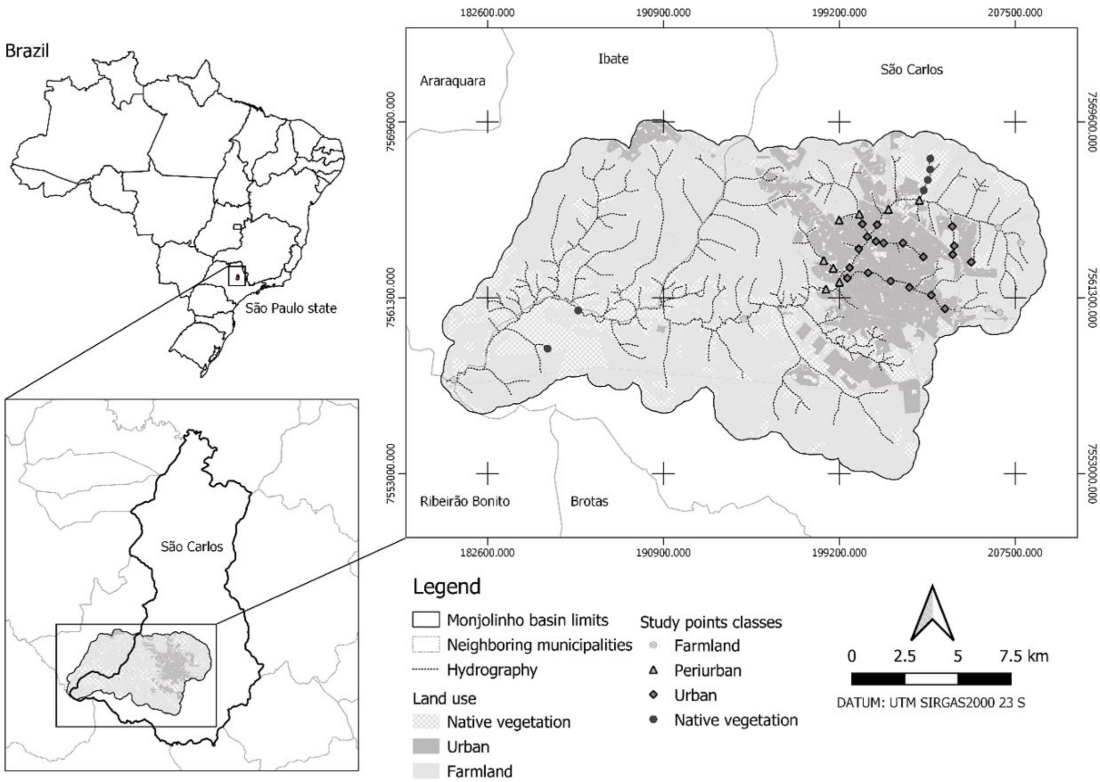

Figure 1. Study area with indication of sampling points distributed along riparian environments of Monjolinho river watershed in São Carlos municipality, São Paulo state, Brazil.

The main characteristics of each landscape matrix are: (i) urban zone, where the environment is predominantly composed by construction and streets, with some scattered trees, parks or gardens; (ii) periurban areas, located in the city edge, presenting elements of urbanization and farmland, with or without small fragments of vegetation; (iii) farmlands, where the surrounding matrix is composed of agricultural (predominantly sugarcane) or livestock activities, with or without patches of native vegetation; and (iv) native areas, where the surrounding environments are mainly composed by native vegetation (riparian and non-riparian).

Field survey occurred in the two major seasons of the region, wet and dry. During wet season, we proceed with the point counts in the summer (December to March 2016) to reduce spatial bias due to nest-site defense, which is very intense in early spring (Sick, 1997). During dry season, we limited point counts to the autumn (April to June 2016), because some bird species begin the nest-site selection in late winter (end of dry season), right before spring. Thus, in selected survey periods, birds are more prone to execute movements throughout the habitats as a response of food availability. So, our field sampling design may represent an adequate approach to investigate the effects of seasonality on the seed-dispersing assemblages, considering the bird presence as an occupation of available trophic niches in the studied area.

We collected data using the traditional "point count" method, described by Von Matter et al. (2010). We established 10 min count session per point, and two visits in each season, but not in consecutive days. All birds in a radius of about 50 m from the point were counted. If the record was auditive, it was counted as one individual, unless it was possible to correctly identify more individuals (e.g., duets, individuals in opposite direction).

From the entire bird community, we selected all species that commonly include fruits in their diets or is mainly a frugivorous bird and can be considered as seed dispersers. Besides our field experience (pers. obs.), we also used the literature to confirm the (i) main frugivorous, and the (ii) partially frugivorous birds (omnivorous, insectivore-frugivorous, nectarivore-frugivorous) (Moojen et al., 1941; Motta-Junior, 1990; Sick, 1997; Sigrist, 2006, 2009; Athiê, 2014; WIKIAVES, 2019). We excluded frugivorous birds of Psittacidae family, and the seedeaters, which consume mainly or exclusively seeds of herbaceous plants (e.g., grasses), such as species of Columbidae family and some passerine birds (genus *Sporophila*, *Volatinia*, *Ammodramus* and *Zonotrichia*). Both groups can be seed dispersers, but also play an important role as seed predators, the reason why we did not consider them in this study.

2.3. Statistical analysis

2.3.1. Assemblage structure

Basic community structure of birds was described by the diversity index of Shannon (H') and Simpson's Dominance (D). We used t test for diversity, as described by Magurran (2013), to compare the structure of bird assemblages of the entire study area between seasons. The number of recorded species (richness) and counted individuals (abundance) at points grouped into four categories according to surrounding landscape matrix were compared between seasons using the chi-squared test (Zar, 1999; Ayres et al., 2007).

2.3.2. Species composition

We performed the multivariate Analysis of Similarity – ANOSIM, based on Bray-Curtis similarity measure, adequate for abundance data of species, to identify possible seasonal influence on species. The ANOSIM permutation test was used to test the null hypothesis that there are no differences between species in the two seasons (Clarke, 1993).

We applied the Similarity Percentage analysis – SIMPER to assess which taxa were primarily responsible for the observed differences between groups of samples (Clarke, 1993). This procedure also uses the multivariate analysis of similarity, based on Bray-Curtis similarity measure, but here we used to calculate the overall average dissimilarity (significance of the difference) between the samples (seasons), which can be decomposed among the species, indicating taxon-specific contributions to overall dissimilarity (Hammer, 2019).

2.3.3. Diversity of seed-dispersal services

Variations in seed-dispersal services promoted by birds are related to species characteristics, such as the preference for consumption of certain types of fruits, differential feeding rates, potential of the digestive system to facilitate breaking dormancy of seeds, capacity to fly long distances, maximum size of fruits the species can ingest, and other characteristics related to behavior and morphology. These traits allow a single guild of fruit eaters to be represented by species that can offer certain variations of seed dispersal.

Thus, we used a taxonomic approach to describe bird assemblages according to their potentiality to offer variation of ecosystem services of seed dispersal inside the guild, in both seasons and each of the four types of surrounding matrices. Considering that the relatedness between two birds can indicate how close their niches might be (Ricklefs, 2009), we used taxonomic diversity and taxonomic distinctness as a measure of the amount of possible niches (Clarke and Warwick, 1998) or, in this case, the variation of ecosystem services inside the seed-dispersal spectrum. Taxonomic diversity can be considered analogous to Simpson's index of diversity, with the addition of taxonomic or phylogenetic information, so it is under the influence of evenness of the species abundance data. Taxonomic distinctness measures only the relatedness within species, independently of species abundance data in samples. Both indexes are not dependent on the sampling effort, thus results from different samples can be compared (Clarke and Warwick, 1998). All statistical analyses were performed in PAST Program (Hammer et al., 2001, vers. 3.26 released in August 2019).

3.Results

3.1. Assemblage structure

We recorded 39 bird species that can play a role as seed dispersers along riparian environments of the Monjolinho basin. The two seasons have the same richness, 32 species. However, the total number of counted individuals was higher in the wet season. Diversity index in the driest period of the year (H'=2.703) was slightly higher than in the wet season (H'=2.601), but this difference was not statistically significant (t=-1.432, p=0.15). The dominance index also indicated no differences between seasons (t=1.007, p=0.31), despite little higher in wet (D=0.121), than in the dry season (D=0.109), as shown in Table 1.

Comparing the richness recorded in each of the four landscape types between seasons, no differences were found (χ^2=0.61, df=3, p=0.89). However, seasonality influenced the number of individuals counted in each landscape type (χ^2=28.46, df=3, p<0.001). Those results indicated the structure of seed-dispersing assemblages was not significantly distinct between seasons, even considering a higher number of individuals using riparian environments in the wet season.

3.2. Species composition

Considering the multivariate data of species composition and abundance, we found significant differences between seasons (ANOSIM, R=0.056, p=0.001). The overall average dissimilarity between seasons was moderate to high (SIMPER, 71.46), indicating that species turnover and changes in specific abundance between seasons occurred, even with a stable diversity structure. Decomposing the overall value, the taxon-specific dissimilarities revealed that 48.7% of species (n=19) was responsible for 89.9% of the observed dissimilarity (Table 2). Seven bird species (17.94% of all species) were recorded only in the dry season, and other seven species only in wet season, what

Table 1. Diversity descriptors in wet and dry seasons, with results of t-test to detect differences in diversity and dominance, and the total values for the assemblage of seed-dispersing birds in riparian environments of Monjolinho basin, southeastern Brazil.

Diversity descriptors	Wet	Dry	t test	Total
Richness	32	32	-	39
Individuals	630	450	-	1080
Diversity (H')	2.601	2.703	t=-1.432, p=0.15	2.762
Dominance (D)	0.121	0.109	t=1.007, p=0.31	0.098

Table 2. Seed-dispersing birds recorded in riparian environments of Monjolinho River. The overall average dissimilarity between two seasons (SIMPER, 71.46) is decomposed in taxon-specific average dissimilarities (Average dissim.). The relative (Relat.%) and cumulative (Cumul.%) contributions are specific percentages of the overall dissimilarity. The abundances in last two columns are the mean number of individuals recorded in 41 points during the wet and dry seasons.

Taxon	Average dissim.	Species contribution		Mean abundance	
		Relat.%	Cumul.%	Wet	Dry
Pitangus sulphuratus (Linnaeus, 1766)	9.607	13.44	13.44	2.27	2.83
Molothrus bonariensis (Gmelin, 1789)	7.244	10.14	23.58	4.05	0.415
Tangara sayaca (Linnaeus, 1766)	6.588	9.219	32.8	1.51	0.951
Coereba flaveola (Linnaeus, 1758)	5.702	7.978	40.78	1.27	1.32
Turdus leucomelas Vieillot, 1818	4.764	6.667	47.44	0.659	1.02
Tyrannus melancholicus Vieillot, 1819	4.589	6.422	53.87	1.17	0.097
Tangara cayana (Linnaeus, 1766)	3.513	4.916	58.78	0.585	0.39
Euphonia chlorotica (Linnaeus, 1766)	3.313	4.636	63.42	0.561	0.341
Cyclarhis gujanensis (Gmelin, 1789)	2.657	3.718	67.14	0.341	0.341
Ramphocelus carbo (Pallas, 1764)	2.379	3.329	70.47	0.244	0.39
Myiozetetes similis (Spix, 1825)	2.326	3.255	73.72	0.244	0.512
Mimus saturninus (Lichtenstein, 1823)	1.833	2.565	76.29	0.317	0.171
Cyanocorax chrysops (Vieillot, 1818)	1.651	2.31	78.6	0.097	0.366
Serpophaga subcristata (Vieillot, 1817)	1.616	2.261	80.86	0.366	0.122
Myiarchus ferox (Gmelin, 1789)	1.572	2.2	83.06	0.195	0.22
Dacnis cayana (Linnaeus, 1766)	1.521	2.128	85.19	0.073	0.341
Turdus amaurochalinus Cabanis, 1850	1.208	1.69	86.88	0.097	0.244
Elaenia flavogaster (Thunberg, 1822)	1.096	1.533	88.41	0.146	0.195
Camptostoma obsoletum (Temminck, 1824)	1.059	1.482	89.89	0.097	0.171
Icterus pyrrhopterus (Vieillot, 1819)	1.008	1.411	91.3	0.171	0.024
Empidonomus varius (Vieillot, 1818)	0.857	1.2	92.5	0.244	0
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	0.635	0.889	93.39	0.073	0.049
Megarynchus pitangua (Linnaeus, 1766)	0.581	0.812	94.2	0.073	0.049
Conirostrum speciosum (Temminck, 1824)	0.559	0.783	94.99	0.049	0.073
Antilophia galeata (Lichtenstein, 1823)	0.526	0.737	95.72	0.073	0
Cyanocorax cristatellus (Temminck, 1823)	0.42	0.588	96.31	0.073	0
Ramphastos toco Statius Muller, 1776	0.376	0.526	96.84	0	0.073
Tersina viridis (Illiger, 1811)	0.34	0.476	97.31	0.122	0
Tangara palmarum (Wied, 1821)	0.312	0.437	97.75	0.049	0.049
Myiarchus swainsoni Cabanis & Heine, 1859	0.248	0.347	98.1	0	0.049
Myiodynastes maculatus (Statius Muller, 1776)	0.226	0.316	98.41	0.049	0
Tachyphonus coronatus (Vieillot, 1822)	0.199	0.279	98.69	0.024	0.024
Nemosia pileata (Boddaert, 1783)	0.19	0.266	98.96	0	0.049
Eucometis penicillata (Spix, 1825)	0.165	0.231	99.19	0.024	0
Myiarchus tyrannulus (Statius Muller, 1776)	0.159	0.223	99.41	0	0.024
Crypturellus parvirostris (Wagler, 1827)	0.138	0.193	99.61	0	0.024
Turdus rufiventris Vieillot, 1818	0.123	0.172	99.78	0	0.024
Tyrannus savana Daudin, 1802	0.085	0.119	99.9	0.049	0
Turdus flavipes Vieillot, 1818	0.074	0.104	100	0	0.024

keeps the same richness for both seasons. It means that 35.9% of birds only occurred in one season, what makes species turnover an important feature of bird assemblages.

3.3. Diversity of seed-dispersal services

The taxonomic diversity and distinctness of bird species in different landscapes indicated a wider array of possible seed-dispersal functions in dry season, with minor exceptions in taxonomic diversity in urban environments, and distinctness in farmlands (Figure 2). Sampling points at riparian environments surrounded by native vegetation matrix hold the broader taxonomic diversity and distinctness.

4. Discussion

4.1. Assemblage structure

The 39 species that can be considered as seed dispersers in riparian environments of Mojolinho basin are representative of typical bird assemblages in human-modified landscapes with different cover areas of urban structures, farmland, natural remnants, reforestation and anthropogenic or ruderal vegetation. However, it is important to state that there are more fruit-eater birds in the study area not recorded (e.g., *Penelope superciliaris*, *Tityra cayana*) or not considered in this study (e.g., species of Psittacidae family).

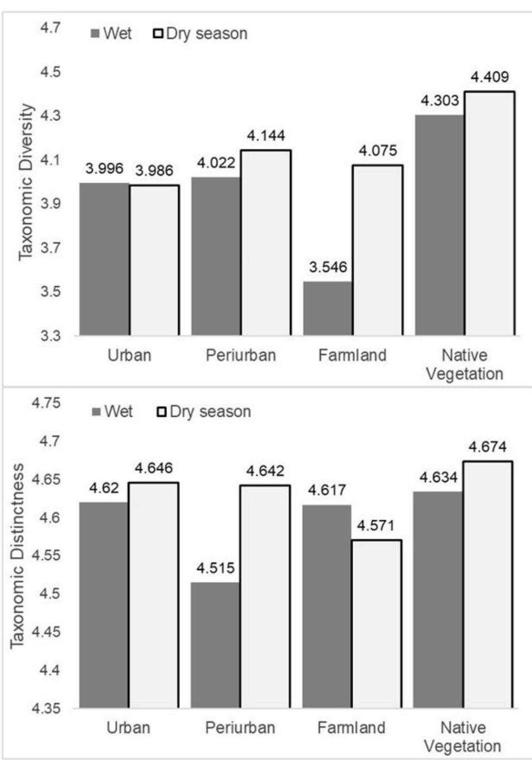

Figure 2. Taxonomic diversity (above) and taxonomic distinctness (below) within seed-dispersal assemblages of birds recorded in riparian environments of Monjolinho basin, according to landscape matrix.

Studies focused on frugivorous guild of birds carried out in the same region showed similar assemblage structure. Athiê and Dias (2012) recorded 38 species in a mosaic composed by a Semideciduous Atlantic Forest remnant (4 ha) and reforestation (27 ha), with riparian environments. In a State Park about 70 km distant from Monjolinho river, Athiê (2014) recorded 56 seed-dispersing birds in a large area of contiguous vegetation composed by 168.7 ha of Cerrado (Brazilian savanna), 378.2 ha of Semideciduous Atlantic Forest, 35.9 ha of well-connected riparian environments, and small areas of reforestation, exotic or altered vegetation. All species recorded in Monjolinho basin were also listed in those studies or in the major citizen repository of bird records in Brazil (Wikiaves, 2019), except for *Turdus flavipes*, an uncommon species in São Carlos municipality.

The richness of birds that feed on fruits in all study area was the same for both seasons, but the total number of individuals recorded was higher in wet season. Diversity and dominance of species did not vary between seasons, indicating a stability of basic structure of seed-dispersing assemblages in riparian environments of Monjolinho basin. It is possible that the resilience of basic aspects of assemblage structure between seasons may have been favored by the availability of resources and niches for the frugivorous guild at larger spatial scale (the entire watershed) in both seasons, and by the possibility of species interchange with surrounding ecosystems, as a response for changes in resource types and possible niches at small scale (surveyed points) between seasons. As the results indicated, there was a species turnover between seasons that did not change the patterns of richness, nor diversity and dominance indexes.

Richness of species recorded in each type of surrounding matrix at landscape scale (urban, periurban, farmland, native vegetation) showed no differences between seasons. However, the number of individuals counted in those areas varied between seasons, indicating the seasonality influenced the carrying capacity of riparian ecosystems, which was enhanced during the wet season.

4.2. Species composition

We found differences between seasons promoted by specific changes in abundance, and by the seasonal absence of some species, according to multivariate analysis of similarity, indicating that bird species can respond differently to seasonality. That difference between seasons was corroborated by a moderate to high dissimilarity between the two assemblages. Specific contribution of each taxon to the overall average dissimilarity pointed to a high proportion of bird species (almost a 50%) contributing with most of the observed variation. Because of variations in abundance occurred differently among species, and the species turnover that kept the same richness in two seasons, the statistical results indicated no significant difference in basic diversity structure of assemblages.

With the exception of *Turdus flavipes*, no recorded species can be considered rare in regional context. However, there are two species listed in the Red List of São Paulo state, *Eucometis penicillata* (endangered) and *Antilophia galeata* (near threatened) (São Paulo, 2014). The last one is also endemic to riparian environments of Cerrado and its border with Atlantic Forest (Silva, 1997). One corvid, *Cyanocorax cristatellus*, is endemic to the Cerrado (Silva, 1997), but is now expanding its distribution to the Atlantic Forest (Maciel et al., 2009), following "savannization" and loss of dense forests (Lopes, 2008). Other species are regular migrants, as *Turdus flavipes*, *Tyrannus savanna*, *T. melancholicus*, *Myiarchus swainsoni*, and *Empidonomus varius* (Sick, 1997; Sigrist, 2009; Wikiaves, 2019).

4.3. Diversity of seed-dispersal services

The space and time distribution of possible seed-dispersal services offered by birds is an outcome of the taxonomic differences in species composition between seasons in each type of landscape, considering the surrounding matrix of surveyed points. In fact, the relatedness among birds can influence the niches occupied by species and the niche width of the entire bird guild. For example, there are 3 species belonging to the genus *Tangara* (*T. sayaca*, *T. palmarum*,*T. cayana*), 4 species of the genus *Turdus* (*T. leucomelas, T. amaurochalinus, T. rufiventris*, *T. flavipes*), 3 species of genus *Myiarchus* (*M. ferox, M. swainsoni, M. tyrannulus*). Behavior and food preferences within each of these genera are very similar or at least much more similar when compared to species of other genera. Therefore, it is expected more variation in seed-dispersal services when promoted by two non-related birds than by two close-related birds.

The assessment of taxonomic diversity and taxonomic distinctness within seasons and landscape matrix types to compare the potential of seed-dispersal services offered by birds indicated that riparian habitats surrounded by a matrix of native vegetation can hold a wider variety of services offered by birds, where species are more probable to be distant related. In other words, there are more distinct birds living in natural areas, than in anthropic environments, where there are more birds occupying similar niches. It is known that the presence of urban and farmland habitats makes the taxonomic diversity be low (MacGregor-Fors and Schondube, 2011; Ortega-Álvarez and MacGregor-Fors, 2011).

Stretches of Monjolinho river in the farmland matrix, mainly composed by sugar-cane plantations, exhibited low values of taxonomic diversity and distinctness, indicating a comparatively higher relatedness among birds, what may favor niche overlap. The noteworthy difference between taxonomic diversity and distinctness during wet season in farmland areas can be explained by the effect of a lower evenness in species abundance. When two species is chosen at random in this assemblage with a higher dominance (low evenness), it is more probable that the most abundant species will be selected and compared with a related species or other dominant species, what reduced the taxonomic diversity index, while did not affected the taxonomic relatedness which considers only the presence of each species in area, but not their abundances.

The analysis pointed to a higher number of possible services being offered during the dry season by birds. Despite of this result may led to think that available niches in riparian ecosystems could have attracted more non-related birds in the driest period of the year, it is equally or even more plausible to think that the surrounding environments with less or no influence of constant waterflow and humidity availability along riparian areas had reduced their available niches, forcing more species to move to wetlands and associated vegetation. Other studies indicated that human-modified ecosystems offer a limited amount of food resources, low diversity of zoochoric plant species, and many of them are exotic trees (MacGregor-Fors and Schondube, 2011; MacGregor-Fors and Schondube, 2012).

5. Final considerations

In summary, this study showed that riparian environments of Monjolinho river basin, despite of the state of degradation of riparian zone, harbor a well-structured bird assemblage of seed dispersers, with high stability and resilience between seasons.

The stretches of waterbodies surrounded by different types of environments, from the most to the less modified or degraded, influenced the taxonomic variety of birds that offer seed-dispersal services. More conserved environments harbor more bird species with potentially different habits due to taxonomic distance, so it is possible to find a better scenario for ecosystem services in areas with higher proportion of natural vegetation.

The higher number of non-related bird species during dry season, in contrast to the higher number of individuals during wet season, indicated that there is more possible ecosystem services offered by seed-dispersing birds in driest period of the year, while in the rainy period the carrying capacity of the riparian environments was increased.

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