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Habitat features predicting the abundance of thrushes (*Turdus* spp.) in urban and forested Restinga sites in Paraná, Brazil

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ABSTRACT: Changes in habitat structure, mainly vegetation, can influence how animals use the environment. Therefore, understanding the basic ecological requirements of fauna offers significant insights into the habitat`s patterns of use, an important piece of knowledge for environmental preservation and management. Thus, this study assessed how the habitat structure influences the abundance of thrushes on the northern coast of Paraná, Brazil. It was feasible to apply generic linearized models using the data set from individual counting and the quantification of environmental factors, gathered between 2017 and 2018. As a result, it was discovered that although there is a negative correlation, the depth of the leaf litter is a reliable indicator of *Turdus rufiventris* abundance. Nonetheless, we must consider the very low significance of this estimate and the impact of additional factors that were also categorized by the models (such as DAP, the percentage of soil discovered, and organic matter). The number of thin trees positively affected the abundance of *T. amaurochalinus*, and the percentage of soil discovered negatively affected the abundance *T. albicollis*. Thrushes are important dispersers in Restinga forests in southern Brazil, and the variation in their regional abundance provides relevant indicators for understanding patterns of use about forests, islands and nearby urban habitats.
Palavras-chave: Atlantic rainforest; habitat structure; habitat changes; vegetation changes; Ilha do Mel.

Características de habitat preveem a abundância de sabiás (*Turdus* spp.) em hábitats de Restingas urbanas e florestadas no Paraná, Brasil

RESUMO: Mudanças na estrutura do habitat principalmente na vegetação influenciam no modo com que animais utilizam o ambiente. Portanto, compreender os requisitos ecológicos básicos da fauna fornece importantes interpretações dos padrões de uso do habitat, informações úteis na conservação e gestão do ambiente. Portanto, este estudo avaliou como a estrutura do habitat influencia a abundância de sabiás no litoral norte do Paraná, Brasil. Por meio de dados de contagem de indivíduos e da quantificação de variáveis ambientais, dados obtidos entre 2017/2018, tornou possível a utilização de modelos gerais linearizados. Deste modo, afere-se que a profundidade da serapilheira é um bom preditor para a abundância de *Turdus rufiventris*, contudo, negativamente correlacionada. Entretanto, deve-se considerar a importância relativamente pequena desta estimativa e a influência de outras variáveis também classificadas pelos modelos (incluindo DAP, percentagem de solo descoberto e matéria orgânica). Positivamente, houve efeito do número de árvores finas na abundância de *T. amaurochalinus* enquanto a percentagem de solo descoberto afeta negativamente a abundância de *T. albicollis*. Sabiás são importantes dispersores em florestas de restinga no sul do Brasil, e a variação em sua abundância regional fornece indicativos relevantes na compreensão da maneira com que utilizam habitats florestais, insulares e locais próximos de áreas urbanas.
Palavras-chave: Mata Atlântica; estrutura de habitat; mudanças de habitat; mudanças de vegetação; Ilha do Mel.

1. INTRODUCTION

Birds select places to forage, reproduce, and rest non-randomly (MORRIS, 2003; FULLER, 2012). The selection of habitats can be influenced by many factors, such as habitat structure, vegetation type, shelter availability, quality and quantity of food resources, breeding areas, and the population density of predators (KRAUSMAN, 1999; MURPHY et al., 2001). Some sites are of higher quality than others, placed in favorable environmental conditions that guarantee organisms' survival, growth, and reproduction (PULLIAM; DANIELSON, 1991; BATTIN, 2004). Consequently, the changes in habitat structure may affect the quality of these sites by altering the quantity and quality of food resources, shelter, and nesting places (TUBELIS et al., VON POST et al., 2012; POWELL et al., 2015).

Life history and intensity of habitat changes are essential determinants of individual responses to alteration of habitat structure. Some species are more sensitive to habitat modifications than others. Thus, alterations in their habitat can lead to population decline and even local extinction (BATTIN, 2004; HOLLANDER et al., 2011; MARIANO-NETO; SANTOS, 2023). In contrast, some species are more resistant, being able to adapt to the new environmental characteristics (ARONSON et al., 2014). As a result, alterations in habitat features can influence the survival of bird species, reflecting on their abundance and community composition (FCULLER, 2012; SCHÜTZ; SCHULZE, 2015). Different land use patterns and occupations may lead to differences in birds' diversity and abundance (HOLLANDER et al., 2011; MARIANO-NETO; SANTOS, 2023). Therefore, studies comparing different places with different patterns of land use are essential to evaluate how bird species respond to changes in habitat structure.

Thrushes are a common species in most Brazilian sites. The species of the *Turdus* genus are some of the most frequent birds in coastal habitats in many Atlantic Forest sites, examples are rufous-bellied thrush, creamy-bellied thrush, pale-breasted thrush and yellow-legged thrush (CAVARZERE et al., 2012; VALLS et al., 2016; CAVARZERE et al., 2019; MESTRE, 2021). Despite most of the thrushes being residents in Brazil, some species of the family are migratory, and their abundances can vary between seasons and habitats (VOGEL et al., 2012; SOMENZARI et al., 2018). They are widely distributed throughout Brazil and adapted to different degrees of environmental disruption, so they are considered good models for ecological studies (GASPERIN; PIZO, 2009; LOMÁSCOLO et al., 2010; VOGEL, 2012).

Thrushes have a relatively well-known biology and the study of the Turdidae family is growing in several areas of biology (VOGEL et al., 2013). However, many gaps remain to be filled, ranging from reproductive aspects (RUIZ et al., 2017) to how these birds use the landscape (SILVEIRA, 2015). Thrushes perform many ecological functions, known as important seed dispersal in fragmented landscapes, therefore understanding how changes in the landscape affect the abundance and persistence of thrushes is essential to determining how human activities can direct population fluctuations (CIACH; MROWIEC, 2013; BAILEY; KING, 2019; MALMORIA, 2021).

In this way, we looked for relationships between thrushes abundance and measurable habitat features in three areas on the coast of Paraná, Brazil. Since the habitat structure (e.g., land use pattern) differs among the sampled sites, we hypothesize that the abundance of these three species would differ between the sampled areas, with some measurable habitat features explaining such variations. Consequently, we aim to propose which features of the habitat may be linked to the abundance of each thrush species, bringing up some clues of habitat selection of these common Atlantic Forest birds.

2. MATERIAL AND METHODS

2.1. Study area

This study was carried out in three areas on the north coast of Paraná State in of southern Brazil. The soil is of the dystrophic Podzol type, originating from marine sediments deposited in the Quaternary period, where non-hydrophilic restinga forests predominate (BRITEZ et al. 1997). According to De Mello (2017), the study area has average annual of precipitation around 2,130mm, pattern that characterizes the tropical rainy, always humid climate type (Cfa), with summer being the wettest period (38.9%) and the average annual temperature of 21.4°C, while February is the hottest month (25.4°C) and July the coldest month (17.3°C) and predominant wind direction is south (23.6%).

This study was conducted at two sites at the Ilha do Mel island and one at Pontal do Sul (Figure 1). This region belongs to the domain of the Atlantic Forest biome, has a high diversity of fauna and flora, and is a vital area for tourism on the Paraná coast (RODERJAN et al., 2005; KERSTEN; SILVA, 2005). Human activities led to different land use and occupation patterns in the sampled areas, reflecting differences in natural vegetation availability and altered environment among the three sites.

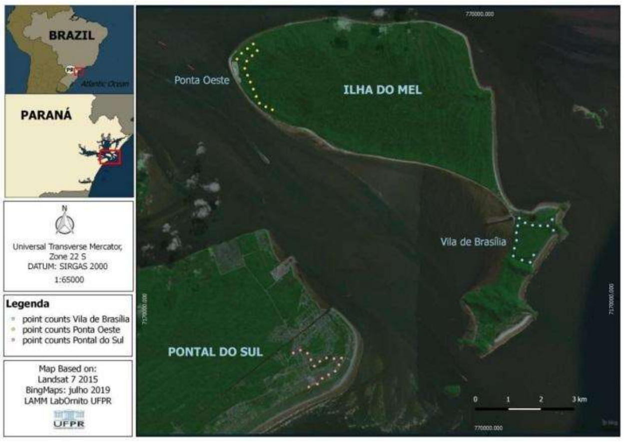

Figure 1. Study area with three sites: Pontal do Sul and two villages on Ilha do Mel (Brasília and Ponta Oeste), North coast of Paraná, Brazil.

Figura 1. Área de estudo com três sítios: Pontal do Sul e duas aldeias na Ilha do Mel (Brasília e Ponta Oeste), Litoral Norte do Paraná, Brasil.

At Ilha do Mel, samples were taken in Brasília and Ponta Oeste villages. Brasília is one of the most populated villages on the island and has many facilities such as hotels, lodges, restaurants, and trails. On the other hand, Ponta Oeste is a small fishing village, whose habitation has been discouraged due to the creation of a State Park. This village does not have electrical energy and has few houses (SILVA et al., 2019). Pontal do Sul, considered the most disturbed area, is a balneary that belongs to the municipality of Pontal do Paraná. At this site, an industrial pool was set up, attracting people from different regions of Brazil. As a result, there was an increase in the urbanized area (ONOFRE et al., 2022). At this site, the sample was taken in the urban area, along streets and woody sites near houses.

2.2. Target species

The three species of thrushes studied were: White-necked Thrush *Turdus albicollis* (VIEILLOT, 1818), Rufous-bellied Thrush *T. rufiventris* (VIEILLOT, 1818) and Creamy-bellied Thrush *T. amaurochalinus* (CABANIS, 1850). The species coexist in the sampling sites and are expected to find at least two species in the same area (GASPERIN; PIZO, 2009; VOGEL, 2012). They are generalists, feeding on fruits, seeds, and various invertebrates (BOSENBECKER; BUGONI, 2020). In altered habitats, they are considered one of the main species contributing to seed dispersal (MALMORIA, 2021).

Turdus albicollis is the most sensitive to environmental changes and is more restricted to forest interiors (CLEMENT; HATHWAY, 2000). In contrast, *T. rufiventris* and *T. amaurochalinus* are more resistant to environmental alteration and use open areas such as forest edges, clearings, parks, gardens, and urban places (SICK, 1997; COLLAR, 2005). Beyond open areas, they also use forest fragments to seek shelter, protection against predators, nesting sites, and food resources (SICK, 1997; CAPLLONCH et al., 2008). Only *T. amaurochalinus* is partially migrating between the species from May until August (CLEMENT; HATHWAY, 2000; VOGEL et al., 2011).

2.3. Data sample

We sampled 45 points between June 2017 and January 2018 for two groups of data: (1) structure of habitat and (2) abundance of *Turdus* spp. We set the points at the existing trails in Ilha do Mel (15 in Ponta Oeste and 15 in Brasília) and Pontal do Sul (15, Figure 1). These points were located among the natural vegetation and houses and restaurants. In Ponta Oeste, we used an abandoned trail within the forest and established a new trail. These points were all located in the natural vegetation. In Pontal do Sul, points were located in the streets, among houses and remaining vegetation. Points were set at least 200 meters away from each other to ensure independence between samples (SUTHERLAND, 2006). All sampling was performed under the authorization of Instituto Água e Terra (project #42.16).

2.4. Abundance

We used count points to estimate species abundance and sampled each for 10 minutes in the morning, from sunrise until 10:30h am. The sampling was divided into three-, two-, and five-minute intervals (RALPH et al., 1995) to avoid re-registering the same individual. This method considers that birds registered in the first interval will be removed from the sampled population in the next interval (FARNSWORTH et al., 2002, 2005). The sample was taken between May 2017 and January 2018, with all points in all areas sampled mainly in the rainy season. To optimize bird encounters, each point was sampled five times (with one day-to-month intervals), and we considered the maximum number of birds counted at each sampling point.

2.5. Habitat structure

We measured habitat in each of the 45-point counts (from bird samples). We choose habitat features that are easily obtained and known to be linked to thrush's feeding ecology. We measured: (1) soil cover, (2) litter depth, and (3) tree vegetation structure. Based on the fact that the studied thrush species live in the understory and constantly use the floor and resources therein, we measured soil cover and depth of litter as estimates of available habitat for arthropods, or tree vegetation structure, as available habitat for feeding and nesting (SICK, 1997, CLEMENT; HATHWAY, 2000, COLLAR, 2005).

To measure soil cover, we used percentages of eight soil variables in 10x10m quadrants where variables were: 1) bare ground (BG), as the amount of exposed soil without organic matter cover, generally sandy or rocky; 2) litter (Lit), as the area with fallen leaves; 3) anthropic (Ant) or artificial structures, which considered the presence of rubbish, rubble and asphalt; 4) organic matter (OrgMa), which considered the presence of branches or vegetable matter different from fallen leaves or litter. Finally, we considered different types of understory vegetation: the percentage covered by ferns (Fern), grass (Gr), herbaceous vegetation (Herb), and moss (Mos). For Herb, we considered plants without secondary growth that did not fit into Gr or Fern. These percentages were summed to 100%, and estimations were repeated four times within each quadrant; the data were transformed into an average for statistical purposes. We measured the litter depth four times in each 1x1 m quadrant using a 300 mm ruler to acquire an average for each quadrant for statistical purposes. At the center of each point count, we also established a 10x10 m plot (following Lopes et al. 2006) for measuring the diameter at breast height (DBH) of all trees and classified them into five DBH classes (Meireles et al. 2008), < 10 cm; 10 – 20 cm; 20 – 30 cm; 30 – 40 cm; and > 40 cm. We also sampled soil cover and litter depth by randomly establishing a 1x1 m quadrant at four locations, just once in the quadrant (adapted from LEE; MARSDEN, 2008).

2.6. Data analysis

We used the maximum number of individuals recorded at each point count to analyze the species abundance and their potential relation to habitat features. This number reflects the maximum number of birds that can live in a given area using resources in that given habitat, considering these species are residents. Despite sampling being done in less than eight months, we consider the possible translocation of some individuals during this time.

We used the general linear model (fitted with the R function gum; family Poisson) to test for which habitat structure variables could best explain each of the abundances of *Turdus* species. We constructed an initial global model including all variables and used information criteria to rank the relative importance of those variables in the models. Then, we used the function dredge in the MuMIn package (BARTON, 2015) to select, record, and rank all statistical models using Akaike's Information Criterion corrected for small sample sizes (AIC_C). The models were ranked from the best to the worst goodness of fit (lowest AICc) to find the most parsimonious model out of our set of candidate models that explain the data best using the minor parameters (ANDERSON, 2008). All five models of the three species had AICc smaller than two and were used to evaluate which variables better explain the abundance of each species. We performed our analyses in the R environment (R Core Team c2017).

3. RESULTS

Based on the abundances and variables collected in this study, we performed and selected five main models showing the relative importance of each variable based on their AIC values. According to the most parsimonious model, we found Litter depth predicting *Turdus rufiventris* abundance; this variable was observed in all the five best-fit models (AIC<1.15, Table 1) and was negatively correlated with *T. rufiventris* abundance ($p<0.002$, Table 2). However, we should consider the relatively minor importance of this estimate (-0.018±0.006) and the influence of other variables also ranked by the models (including DBH, percentage of bare ground, and organic matter).

We found the variables "percentage of Bare ground" and "percentage of Litter" as having significant importance in predicting *Turdus albicollis* abundance (AIC<1.12, Table 1). We found a "percentage of Bare ground" with a negative correlation to *T. albicollis* abundance, but in just one model, this correlation was significant but also with relatively small importance (estimate of -0.07, p=0.06). On the other hand, it is crucial to consider the positive correlation with the variable "percentage of Litter" with a higher estimated value (0.309) and also significantly different (p=0.0009, Table 1).

The variables that best explain the abundance of *Turdus amaurochalinus* are the trees with DBH class between 10 and 20cm, based on the most parsimonious models (AIC<1.51). This variable was registered in all five best models with a negatively significant correlation (p<0.001), and relatively greater importance in terms of estimates (from -0.219 to -0.401). We registered significant differences in habitat structure among sites (NMDS, Figure 2; PERMANOVA, F = 30.456, p = 0.001, S1) and different abundances of studied species among sites (*T. rufiventris,* p = 0.001; *T. albicollis,* p < 0.001; and *T. amaurochalinus,* p < 0.001, Figure 2).

Table 1. Five models of the abundance of *T. rufiventris, T. albicollis* and *T. amaurochalinus* in South Brazil. AICc = estimates the best model among all models. ΔAICc = is the difference in the value of AICc about the best model. The models are classified according to the ΔAICc. (df = degree of freedom; AICc = Akaike Information Criterion; ΔAICc = change Akaike Information Criterion; weight = weight of AICc).
Tabela 1. Cinco modelos de abundância de *T. rufiventris*, *T. albicollis* e *T. amaurochalinus* no Sul do Brasil. AICc = estima o melhor modelo entre todos os modelos. ΔAICc = é a diferença do valor do AICc em relação ao melhor modelo. Os modelos são classificados de acordo com o ΔAICc. (gl = grau de liberdade; AICc = Critério de Informação de Akaike; ΔAICc = alteração do Critério de Informação de Akaike; peso = peso de AICc).

Species		Model	df	AICc	ΔAICc	Weight
Turdus rufiventris	1	Litter depth	2	111.58	0.00	0.29
	2	Litter depth + DBH 30cm – 40cm	3	112.41	0.83	0.19
	3	Litter depth + DBH 10cm – 20cm	3	112.56	0.98	0.18
	4	Litter depth + % Bare ground	3	112.69	1.10	0.17
	5	% Organic matter + Litter depth	3	112.73	1.15	0.17
Turdus albicollis	1	% Anthropic + % Bare ground	3	43.00	0.00	0.28
	2	% Anthropic + % Moss + % Bare ground	4	43.45	0.44	0.22
	3	% Fern + % Litter	3	44.02	1.02	0.17
	4	% Litter	2	44.04	1.04	0.17
	5	% Anthropic + % Fern + % Bare ground	4	44.13	1.12	0.16
Turdus amaurochalinus	1	DBH 10cm - 20cm	2	84.27	0.00	0.31
	2	% Bare ground + DBH 10cm - 20cm	3	85.19	0.92	0.20
	3	% Anthropic + DBH 10cm - 20cm	3	85.26	0.99	0.19
	4	% Fern + DBH 10cm – 20cm	3	85.73	1.45	0.15
	5	% Litter + DBH 10cm – 20cm	3	85.79	1.51	0.15

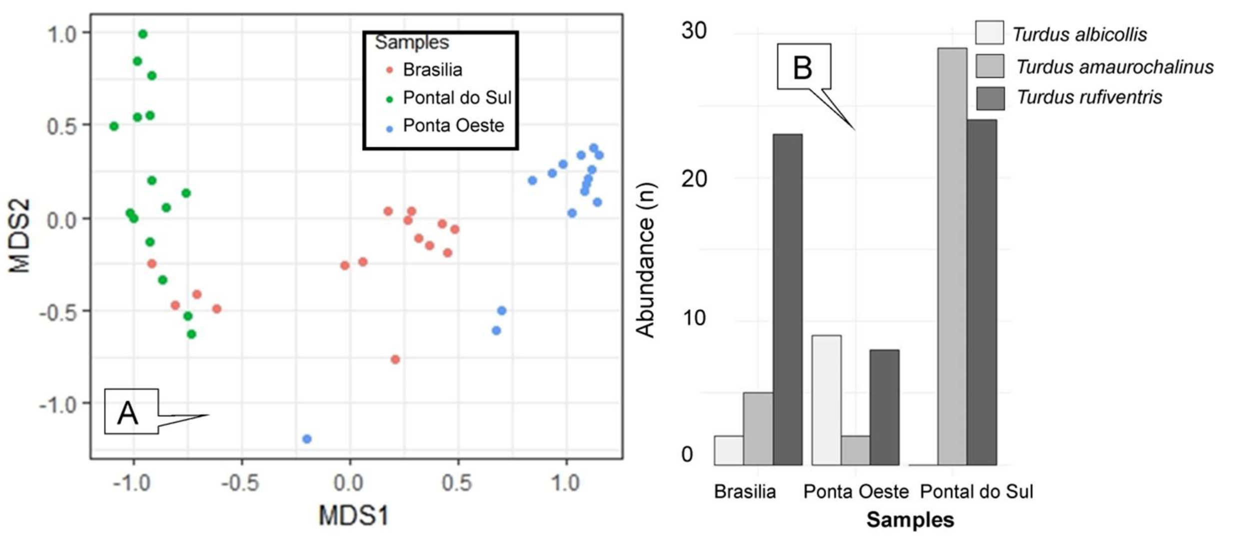

Figure 2. In "A" ordering in non-metric multidimensional scaling (NMDS), stress = 0.0553. Differences in the environmental structure among three areas: Pontal do Sul (S), Brasília (B), and Ponta Oeste (O). In "B" abundance of *Turdus rufiventris*, *T. amaurochalinus*, and *T. albicollis* to Pontal do Sul, Brasília, and Ponta Oeste.
Figura 2. Na ordenação "A" em escala multidimensional não métrica (NMDS), *stress* = 0,0553. Diferenças na estrutura ambiental entre três áreas: Pontal do Sul (S), Brasília (B) e Ponta Oeste (O). Em "B" abundância de *Turdus rufiventris*, *T. amaurochalinus* e *T. albicollis* para Pontal do Sul, Brasília e Ponta Oeste.

Table 2. Models showing which variable best predicted the abundance of *Turdus rufiventris, T. albicollis,* and *T. amaurochalinus* on the coast of Paraná.
Tabela 2. Modelos mostrando qual variável melhor previu a abundância de *Turdus rufiventris*, *T. albicollis* e *T. amaurochalinus* no litoral do Paraná.

Species		Models	Estimate	Std. Error	z value	Pr (> |z|)
Turdus rufiventris	1	(Intercept)	0.548	0.154	3.551	0.0003
		Litter depth	-0.018	0.006	-3.05	0.002
	2	(Intercept)	0.481	0.167	2.870	0.004
		Litter depth	-0.024	0.008	-2.973	0.002
		DBH 30-40cm	0.111	0.089	1.244	0.2
	3	(Intercept)	0.517	0.157	3.288	0.001
		Litter depth	-0.027	0.010	-2.592	0.009
		DBH 10-20cm	0.032	0.027	1.172	0.2
	4	(Intercept)	0.242	0.332	0.730	0.4
		Litter depth	-0.014	0.007	-2.096	0.03
		% Bare ground	0.010	0.009	1.083	0.2
	5	(Intercept)	0.345	0.251	1.375	0.1
		% Organic matter	0.009	0.008	1.087	0.2
		Litter depth	-0.017	0.006	-2.629	0.008
Turdus albicollis	1	(Intercept)	-0.245	0.353	-0.696	0.4
		% Anthropic	-0.41	0.555	-0.739	0.4
		% Bare ground	-0.07	0.043	-1.821	0.06
		Model 2				
	2	(Intercept)	0.089	0.424	0.212	0.8
		% Anthropic	-0.480	0.577	-0.832	0.4
		% Moss	-0.058	0.056	-1.032	0.3
		% Bare ground	-0.088	0.044	-1.976	0.04
		Model 3				
	3	(Intercept)	-3.544	0.970	-3.652	0.0002
		% Fern	0.207	0.126	1.644	0.1
		% Litter	0.030	0.012	2.394	0.01
		Model 4				
	4	(Intercept)	-2.157	0.459	-4.694	0.000
		% Litter	0.309	0.093	3.312	0.0009
		Model 5				
	5	(Intercept)	-0.788	0.615	-1.282	0.2
		% Anthropic	-0.388	0.566	-0.685	0.4
		% Fern	0.152	0.128	1.184	0.2
		% Bare ground	-0.071	0.045	-1.554	0.1
Turdus amarochalinus	1	(Intercept)	0.521	0.175	2.973	0.002
		DBH 10-20cm	-0.336	0.094	-3.569	0.0003
	2	(Intercept)	0.882	0.336	2.620	0.008
		% Bare ground	-0.012	0.010	-1.184	0.2
		DBH 10-20cm	-0.361	0.096	-3.752	0.0001
	3	(Intercept)	0.336	0.246	1.366	0.1
		% Anthropic	0.009	0.007	1.182	0.2
		DBH 10-20cm	-0.308	0.095	-3.241	0.001
	4	(Intercept)	0.521	0.176	2.962	0.003
		% Fern	0.146	0.143	1.020	0.3
		DBH 10-20cm	-0.401	0.127	-3.154	0.001
	5	(Intercept)	0.528	0.174	3.027	0.002
		% Litter	-0.019	0.023	-0.832	0.4
		DBH 10-20cm	-0.219	0.152	-1.439	0.1

4. DISCUSSION

Urban structures and forest fragmentation change bird habitat availability, and more specifically, they can influence thrush frequency and abundance (ROSENBERG et al., 2003; SILVEIRA, 2015). The smaller tree diversity and increase of unvegetated patches affects directly the resources available to these birds, which feed on invertebrates and fruits in most of the vertical strata, foraging on trees and the ground (COLLAR, 2005, MALMORIA, 2021). This also suggests a narrow link between natural ground habitats, also influenced by the number of trees in study sites, emphasizing the importance of natural sites for population maintenance.

Our results showed that the abundance of *Turdus rufiventris* is negatively related to the depth of litter. In our interpretation, the Rufous-bellied Thrush inspects the litter for prey, having a predilection for these locations (SICK, 1997; COLLAR, 2020). However, the increase in the litter deposition layer can limit the search for prey as it accumulates, mainly because it requires more significant search effort to find food because the Rufous-bellied Thrush turns the leaves one by one, inspecting for prey hidden in the leaf litter (COSTA, 2011). Perhaps this behavior could be related to the species' adaptability in urban areas. Perhaps this behavior could somehow be related to the adaptability of the species in urban areas, places where he eats fruit (GASPERIN; PIZO, 2009; COLLAR, 2020) and recently proved that prey invertebrates with a preference for detritivores and litter predators (BOSENBECKER; BUGONI, 2020).

We also found that *Turdus amaurochalinus* abundance was negatively related to the presence of trees with DBH between 10-20cm. These species are commonly seen in urban sites near houses and squares, with fewer trees and litter than forested sites (COLLAR, 2005; VALLS et al., 2016). The preference for poorly vegetated areas by the Creamy-bellied Thrush can be related to the reproduction of the species. According to Batisteli et al. (2020), the Creamy-bellied Thrush can find suitable breeding places in areas with poor native vegetation cover, which may enhance its settlement on urban sites and agricultural landscapes.

The same connection could be inversely related to the results from *T. albicollis*. This species was found more abundant in sites with more litter and less bare ground, characteristics of more intact forest environments, and preferential habitat of the species (CLEMENT, 2000). It is one of the species most commonly captured in forests with little disturbance, an essential disperser of seeds in the understory, playing an important role in disseminating seeds (ALVES et al., 2008).

The alteration of natural habitats into anthropic environments can decrease the availability of essential habitat features due to habitat modification. The effects of these modifications will also depend on the characteristics of each species, the degree of alteration, the matrix, and the fragment size and location (PFEIFER et al., 2017; MARIANO-NETO; SANTOS, 2023). Identifying habitat attributes affecting these species' abundance can help to understand how they adapt to constant changes in habitat structure (LIKER et al., 2008; MEILLÈRE et al., 2015).

Lastly, thrushes are well-known as effective generalist seed dispersers to different stages of plant succession (MALMORIA, 2021); the fact that landscape conditions impact their abundance suggests that patterns of forest regeneration may be threatened.

5. CONCLUSIONS

Our results showed that some habitat characteristics measured in this study can influence the abundance of thrushes in forested sites on the coast of Paraná. The number of individuals seems to be influenced by some of the measured habitat attributes, such as the amount of litter for *T. rufiventris*, the number of trees with DBH 10-20cm for *T. amaurochalinus* and the inverse relation of *T. albicollis* abundance, and percentage of bare ground. We confirmed their habitat preferences and suggested that differences measured here can influence human-altered habitats. Some species can adapt and maintain their populations in altered habitats, as evidenced by *T. rufiventris* and *T. amaurochalinus*. On the other hand, some species are more sensitive to habitat alteration, such as *T. albicollis*, and can be replaced by more resistant species, such as *T. rufiventris*. We then suggest that ground features are essential determinants to be considered in habitat conservation for thrushes. Then, we consider the importance of underground vegetation to birds, and these important links to be considered by efficient restoration projects in Atlantic forests.

6. REFERENCES

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