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BIRDS AROUND THE ROAD: EFFECTS OF A ROAD ON A SAVANNAH BIRD COMMUNITY IN SOUTHERN BRAZIL

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ABSTRACT · Birds are highly susceptible to habitat fragmentation, traffic noise, roadkills, and other disturbances generated by the presence of roads. These impacts are manifested in the structure of bird communities and are mainly noticed near road edges. The main goal of this study was to evaluate the effects of a road on a savannah bird community in southern Brazil. The study was carried out within the Espinilho State Park (ESP), Rio Grande do Sul state. The ESP is divided by a road and we quantified bird abundance and richness along three transects, parallel to the road at different distances from it (T1: 10 m, T2: 250 m, T3: 500 m). To estimate bird richness and abundance we sampled five point counts along each transect. Sampling took place throughout the month of January 2015, during the summer. Bird species were categorized according to their feeding habits and habitat use. Richness and abundance increased with greater distance from the road. Transects closer to the roads were less similar than those more distant from the road. Insectivore species and species that use grassland and Espinilho habitat were less common in transects nearest the road. Our data indicate that road edges alter the species composition and structure of the bird community in the ESP, although our limited temporal sampling means that our results should be treated as preliminary. This effect is due to some species being attracted by the road whereas others avoid it or decline. Based on our findings, we reinforce the recommendation that roads should be avoided near or within areas destined for conservation. If roads must be built within or around protected areas, studies on the impact of these roads and possible mitigation measures are essential and urgent.

Resumo · Efeitos de uma rodovia numa comunidade de aves de savana no sul do Brasil

Aves são altamente suscetíveis a fragmentação do habitat, barulho de tráfego, atropelamentos e outros distúrbios gerados pela presença de rodovias. Estes impactos são manifestados principalmente na estrutura das comunidades de aves que ocupam as bordas de rodovias. O objetivo deste estudo foi avaliar os efeitos de uma rodovia sobre uma comunidade de aves de savana no sul do Brasil. O estudo foi desenvolvido no Parque estadual do Espinilho (PEA), estado do Rio Grande do Sul. O PEA é cortado pela rodovia BR472 e nós quantificamos a abundância e riqueza de aves em três transectos em diferentes distâncias e paralelos a rodovia (T1: 10 m, T2: 250 m, T3: 500 m). Para amostragem de riqueza e abundância das aves em cada ponto amostral e em cada transecto foi utilizado o método de “Point cont”. A amostragem ocorreu no mês de janeiro de 2015, durante o verão. As espécies de aves registradas foram categorizadas de acordo com o hábito alimentar e uso do ambiente. A abundância e riqueza de aves aumentou com maior distância da rodovia. Os transectos mais próximos da rodovia mostraram menos similaridade que aqueles mais distantes. Espécies insetívoras e espécies que usam preferencialmente ambientes de campo e espinilho foram menos comuns nos transectos mais próximos da rodovia. Nossos dados indicam que os o efeito de borda gerado pela rodovia altera a composição e estrutura da comunidade de aves no PEA, embora nossa amostragem seja imitada ao período de verão. Isto ocorre em função da atração de algumas espécies para próximo da rodovia e exclusão ou redução populacional de outras. Com base nos nossos resultados, reforçamos a recomendação que rodovias devem ser evitadas próximas ou dentro de áreas destinadas a conservação. Em áreas protegidas onde as rodovias estão presentes faz-se necessário estudos sobre os impactos das rodovias e possíveis medidas mitigadoras.

KEY WORDS: Conservation · Diversity · Edge effect · Impact · Road ecology

INTRODUCTION

An inevitable consequence of forest fragmentation is a drastic increase in the amount of habitat edges (Murcia 1995). Thus, animal and plant populations in fragments are reduced, separated, and exposed to abiotic and

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biotic changes associated with forest edges (Harper et al. 2005). Roads are high-impact fragmentation agents because they affect the physical, chemical, and biological characteristics of an ecosystem (Forman & Alexander 1998, Rezzadori et al. 2016). The most obvious impacts are the loss of habitat, fragmentation, and wildlife mortality from roadkill (Spellerberg 1998, Clevenger et al. 2003; Hartmann et al. 2011, 2012). Thus, a road effect zone is formed after the road is built (Forman & Deblinger 1999). Road effect zones can influence the dynamics of local wildlife and interfere with the distribution and structure of populations (Trombulak & Frissell 2000, Bissonete & Rosa 2009, Parris et al. 2009).

Birds are highly susceptible to habitat fragmentation, traffic noise, roadkill, and other disturbances generated by the presence of roads (Develey & Stouffer 2001). These impacts can be manifested in the structure of bird communities, such as changes in richness and abundance (Parris & Schneider 2008, Bager et al. 2012, Astudillo et al. 2014).

The Espinilho State Park (ESP), Rio Grande do Sul state, Brazil, is a protected area considered of special ornithological interest due to the presence of endemic and endangered species (Bencke et al. 2003, ICMBio 2013). The ESP management plan estimates that 185 bird species (belonging to 52 families) are found here (SEMA 2014). In Brazil, the only site with the phytophysiognomy characteristic of the Espinilho formation is the ESP and its surrounding area, to the west of Rio Grande do Sul. In Argentina, this ecosystem is considered endangered and is of high conservation priority (SAyDS 2006, Johnson & Zuleta 2013).

Natural protected areas in Brazil are known as conservation units and regulated by the National System of Conservation Units (SNUC). The main objective of integral protection conservation units, such as those in the Park category, is to provide greater protection to biodiversity (SNUC 2000). It is assumed that species in these areas are not exposed to anthropogenic impacts present in other locations. However, the ESP is divided by the BR472 road, which might have a negative impact on its wildlife. Here we aimed to evaluate the effects of the BR472 road on the richness and abundance distribution of birds in the ESP and to explore the changes in the community in accordance with the ecological characteristics of the birds. We expected changes in community composition, with a decrease in bird species richness and abundance closer to the road due to the disturbances generated by the presence the road.

MATERIAL AND METHODS

The study was carried out within the ESP (30°11’51”S, 57°29’46”W), municipality of Barra do Quaraí, in the southwest of the state of Rio Grande Sul, the southernmost tip of Brazil. The ESP covers an area of 1617.14 ha (SEMA 2014) and the landscape is dominated by the Espinilho formation (Marchiori 2004). The vegetation of the ESP is steppe-savannah and park-savannah, with a predominance of thorny woody plants, which rarely exceed five meters in height and grow alone or in small groups (Marchiori 2004). According to Köeppen’s Cfa, the climate is subtropical humid, with an average annual temperature of 19°C and precipitation of 1346 mm. The ESP is divided by the BR472 road for about 5.5 km. The road consists of a single paved lane, with road sides of about 1,5 m, and speed is limited to 80 km/h. There is no formal monitoring of vehicular traffic flow, but according to the Highway Police it is considered low (< 1000 vehicles/day) and characterized by cars, agricultural machinery, buses, and trucks.

Two sites inside the ESP and along the BR472 road were selected for data collection, separated from one another by 1 km. In each area, three transects were established, one parallel to the road and two at different distances from it. Transects were distributed as follows: transect one (T1), in the marginal strip of the road (about 10 m from roadside); transect two (T2), 250 m away from the road; and transect three (T3), 500 m away from the road. Transects measured 500 m long and were divided into five sampling points, with 100 m between nearest points (Figure 1). There were no differences in habitat or elevation among transects. The vegetation typology was predominantly Savannah Park (SEMA 2014). The elevation in the study area is homogeneous and ranges from 40–60 m a.s.l..

Sampling took place in Austral summer throughout the month of January 2015. Observations were done early in the morning (07:00–11:00 h) and in the afternoon (16:00–20:00 h). Three sampling repetitions were performed in each transect in the morning and three in the afternoon, totaling six repetitions per point/transect. To quantify richness and abundance of birds at each sampling point of each transect, we used the point count method (Blondel et al. 1970). The observer spent 10 min at each sampling point and recorded all birds heard or seen within approximately 40 m around the point. Birds were observed with binoculars and, whenever possible, they were photographed and their songs recorded. Photographs and recorded vocalizations served to identify or confirm the identification of species. To aid visual identification, guides of birds covering the study area were consulted, notably Belton (2004), Narosky & Yzurieta (2006), Sigrist (2007), Glayson et al. (2010), and Piacentini et al. (2015). We followed the nomenclature proposed by the Brazilian Committee of Ornithological Records (CBRO).

Bird species were categorized according to their feeding habits and habitat use. To determine these, we followed the descriptions of Sick (1997) and Piacentini et al. (2015). The following feeding habits were found among the ESP birds: carnivores (Car; eat meat, including rodents, mammals, fish, amphibians or reptiles), detritivores (Det; eat primarily carcasses), frugivores (Fru; fruit-eating specialists), granivores (Gra; eat primarily grains or seeds), herbivores (Her; eat primarily plants), insectivores (Ins; specialized car-

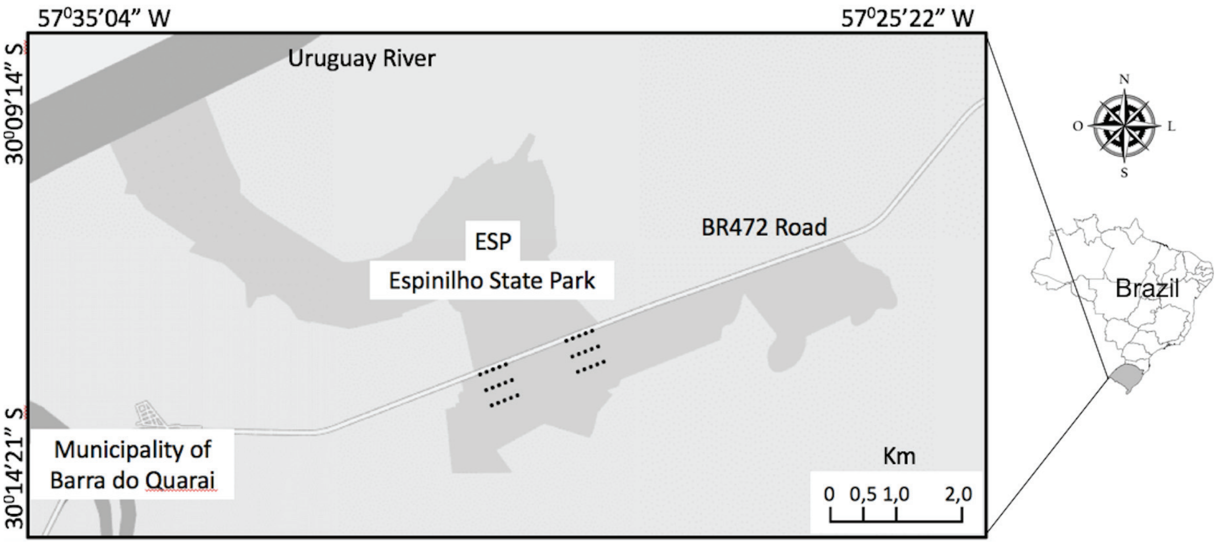

Figure 1. Study area, and location of transects and bird sampling points (filled circles) in Espinilho State Park, Rio Grande do Sul state, southern Brazil in January 2015 (Transect 1: 10 m from the road, Transect 2: 250 m from the road, Transect T3: 500 m from the road).

nivores that feed on insects), malacofagous (Mal; feed on mollusks, such as snails, slugs, or oysters), nectarivores (Nec; feeds on flower nectar), omnivores (Oni; have a widely varied diet), and piscivores (Pis; carnivores that eat primarily fishes). Recorded birds made use of the following habitats: anthropic area (AA, can use areas affected by human activity), wetland (Wet, use primarily swamps), forest edge (FE; use primarily forest borders), grassland (Gra, use primarily native open areas), espinilho (Esp, typical from Espinilho formation), and forest (For, typical from inside forest).

Differences between transects in richness (number of species recorded by sample point), abundance (number of individuals recorded by sample point), and proportion in ecological characteristics (number of species recorded in each category) were tested by an analysis of variance (One-way ANOVA). To compare the similarity between transects we used the Jaccard similarity coefficient (S*Jij*). We used the Chao 1 estimator to obtain a richness estimate (Chao 1984) using the software EstimateS 9.00 (Colwell 2013).

RESULTS

A total of 108 bird species were recorded, belonging to 36 families (1209 records, Appendix 1). The Chao 1 estimator indicated that 83–98% of the estimated species richness present in the study sites was recorded (observed richness = 108, Chao 1 = 114.73 ± 4.52 [mean ± SD]; 95% confidence intervals [CI] = 110.03–130.26).

The number of species recorded by transect increased with greater distance from the road (T1 = 65 species, T2 = 71 species, and T3 = 75 species). Likewise, the number of species per sample point in each transect was lower in transects nearest to the road and higher in transects farthest from the road ($F_{2,27}$ = 5.75, P = 0.01; Figure 2A). The number of species recorded per sample point in each transect was different between transects 1 and 2, and transects 1 and 3. There was no significant difference between transects 2 and 3 (Table 1).

The number of individuals recorded per transect increased with increasing distance from the road (T1 = 536, T2 = 779, and T3 = 846). Likewise, the number of individuals per sample point in each transect was smaller in transects nearest the road ($F_{2,27}$ = 5.84, P = 0.01; Figure 2B). The number of individuals recorded per sample point in each transect was different between transects 1 and 2, and transects 1 and 3. There was no difference between transects 2 and 3 (Table 1).

Of the 108 species recorded, only 38 occurred in all three transects. Insectivore species and species that use grassland and Espinilho habitat were less common in transects nearest the road (Tables 1 and 2). Species that use the forest edge were more common in the transect nearest the road. The only detritivore species was found only in the transect closest to the road (Table 2). There was no difference between transects regarding other ecological characteristics (Table 1). The feeding habits Nectarivores, Piscivores, Detritivores, Herbivores, and Malacofagous, and the habitat use Forest were not analyzed because the low number species registered (N ≤ 3, Table 2).

The change in species composition was greater in transects closer to the road. Transects closer to the road showed lower similarity (N = 44, S*Jij* = 0.48, between transects 1 and 2) than those that were more distant from the road (N = 57, S*Jij* = 0.64, between transects 2 and 3).

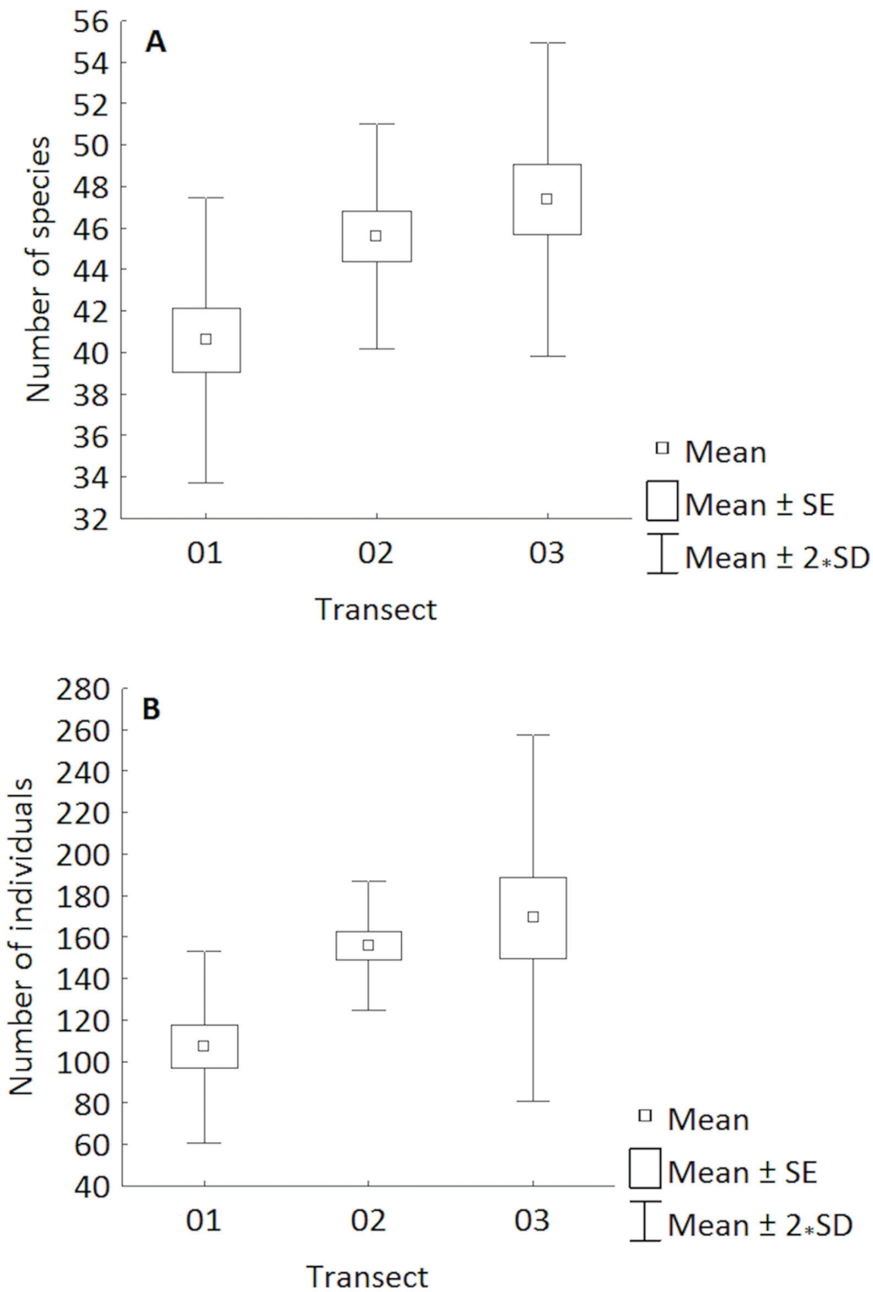

Figure 2. Number of bird species (A) and number of individuals (B) recorded by sampling point counts in each transect (T1: 10 m from the road, T2: 250 m from the road, T3: 500 m from the road), along BR472 in Espinilho State Park, Rio Grande do Sul state, southern Brazil in January 2015.

DISCUSSION

The main result of this study was that bird richness and abundance decreased the closer sampling points were to the road. Given that the study site has a homogeneous landscape, the differences in bird diversity or abundance that we detected are not because of variation in elevation or habitat type. The reduction in bird richness and abundance close to the road can be explained by the edges created by the road and how these affect the birds. Edges are often influenced by the external environment and have different community structures compared to non-edge areas (Godefroid & Koedam 2003, Vergara 2011).

Roads that cross natural environments can cause changes in the physical, chemical, and biological components of an ecosystem (Forman et al. 2003). Bird richness and abundance typically decrease in areas close to roads. Birds that occupy the areas closest to roads are more likely to be run over, causing possible population declines, and their reproductive success tends to be negatively affected, mainly due to vehicular traffic (Forman et al. 2002, Forman et al. 2003). Areas near roads are also noisier, which can also limit the occurrence of birds (Develey & Stouffer 2001).

Table 1. Analysis of variance between transects (Transect 1: 10 m from the road, Transect 2: 250 m from the road, Transect T3: 500 m from the road) to richness, abundance, and proportion in ecological characteristics, tested by One-way ANOVA (Degree of freedom $F_{1,18}$). Espinilho State Park, Rio Grande do Sul state, southern Brazil in January 2015.

	Transect 1 and 2	**Transect 1 and 3**	**Transect 2 and 3**
Richness	F = 6.54, P = 0.03	F = 8.85, P = 0.01	F = 0.75, P = 0.41
Abundance	F = 15.26, P < 0.01	F = 7.70, P = 0.02	F = 0.40, P = 0.54
Feeding habit			
Insectivore	F = 3,35, P= 0,10	F = 5.94, P = 0.04	F = 0,26, P = 0,62
Omnivores	F= 2,47, P = 0,15	F = 3,12, P = 0,11	F = 0,11, P = 0,74
Granivores	F = 0,72, P = 0,42	F = 0,05, P = 0,81	F = 0,36, P = 5,31
Carnivores	F = 0,90, P = 0,37	F = 1,28, P = 0,29	F = 0,68, P = 5,31
Frugivores	F = 1,52, P = 0,25	F = 0,80, P = 0,39	F = 4,80, P = 0,05
Habitat use			
Grassland	F = 4,92, P = 0,05	F = 6.80, P = 0.03	F = 0,06, P = 0,80
Wetland	F = 2,70, P = 0,13	F = 4,61, P = 0,06	F = 0,62, P = 0,45
Anthropic area	F = 0,03, P = 0,85	F = 0,17, P = 0,68	F = 0,41, P = 0,53
Forest edge	F = 1,97, P = 0,19	F = 7.65, P = 0.02	F = 0,12, P = 0,73
Espinilho	F = 0,90, P = 0,37	F = 8.50, P < 0.01	F = 1,72, P = 0,22

Furthermore, habitat edges might also increase brood parasitism (Patten et al. 2006, Benson et al. 2010). Therefore, even those species able to tolerate edge areas might show reduced abundance.

How animals cope with habitat fragmentation affects their chances of survival and stability in certain landscapes (Fahrig & Rytwinski 2009). For birds, the edge effect is a major environmental factor that influences the richness and species composition of a region (Gimenes & Anjos 2003). Birds that tolerate the effects caused by roads are generalists and have high dispersal capacity (Wiens 1994, Gimenes & Anjos 2003). In our study site, these species were found both at the road edges and further away within the ESP (e.g., *Agelaioides badius*, *Guira guira*, *Pitangus sulphuratus*, *Turdus rufiventris* and *Zonotrichia capensis*; Appendix 1). These species add to those that are found only in the most remote areas from the road. Thus, the richness decline towards the road proximity might be associated with the loss of species more susceptible to edge effects. The greater richness away from the road appears to be associated with reduced edge effect. The lowest similarity in transects closest to the road indicates greater difference in species composition in these areas compared with areas more distant from the road. This finding supports the hypothesis that edges generated by roads exert a strong influence on the structure of bird communities (Develey & Stouffer 2001, Parris & Schneider 2008, Bager et al. 2012).

Some ecological characteristics seem to influence the distribution of birds more strongly than others, depending on the distance from the road. Insectivore species and species that use grassland and Espinilho as their main habitat were found mainly in transects farthest from the road. These species might show an avoidance response to areas near the road, common in animal groups that are dependent on the most pristine habitat conditions (Andrews 1990, Reijnen & Foppen 1991, Develey & Stouffer 2001).

On the other hand, bird species that live in forest edges might occur naturally at the road edges and avoid the inner areas of the ESP. These species might be better able to cope with the edge effects generated by roads (Bager & Rosa 2012). For example, detritivore species, such as *Coragyps atratus,* can be attracted to the roads due to the presence of animal carcasses killed by vehicles (Antworth et al. 2005, Erritzoe et al. 2003).

The size of the ecological zone of influence of a road may vary depending on the ecological characteristics of the study group and the landscape (Reijnen et al. 1995, Laurance 2007, Laurance et al. 2009, Benítez-Lopez et al. 2010). Forman & Deblinger (2000) generally consider the zone of influence to be 200 m for single paved roads, such as the one studied. For birds that have high dispersal capacity, this distance may be greater.

Based on our data, we were able to estimate the bird-specific zone of ecological influence of the road, which was strongest in the first 250 m but could still be detected at 500 m away. A stretch of 1.9 km of road divides the ESP in half, and another 3.6 km of road borders only one side of the park. Considering a zone of ecological influence of 250 m, an area of about 185 ha is strongly influenced by the road, as least for birds. This area represents 11.5% of the ESP. If we consider the zone of ecological influence of the road as 500 m, this area doubles. This situation even worsens if we consider that the ESP suffers from other edge effects, such as agricultural neighboring systems (SEMA 2014).

Table 2. Ecological characteristics of birds recorded at different distances from the BR472 road (Transect 1: 10 m from the road, Transect 2: 250 m from the road, Transect T3: 500 m from the road), Espinilho State Park, Rio Grande do Sul state, southern Brazil in January 2015.

Ecological characteristics	No. of species	T1 (%)	T2 (%)	T3 (%)
Feeding habit				
Insectivores	42	19 (29.2)	27 (38.0)	30 (40.0)
Omnivores	24	18 (27.6)	18 (25.3)	19 (25.3)
Granivores	16	13 (20.0)	9 (12.6)	11 (14.6)
Carnivores	13	8 (12.3)	10 (14.0)	9 (12.0)
Frugivores	5	3 (4.6)	4 (5.6)	3 (4.0)
Nectarivores	3	2 (3.0)	2 (2.8)	1 (1.3)
Piscivores	2	1 (1.5)	0 (0.0)	1 (1.3)
Detritivores	1	1 (1.5)	0 (0.0)	0 (0.0)
Herbivores	1	0 (0.0)	0 (0.0)	1 (1.3)
Malacofagous	1	0 (0.0)	1 (1.4)	0 (0.0)
Habitat use				
Grassland	29	18 (27.6)	22 (31.0)	22 (31.7)
Wetland	25	12 (18.4)	16 (22.5)	20 (28.2)
Anthropic area	23	23 (35.3)	14 (20.0)	15 (16.8)
Forest edge	20	10 (15.3)	7 (12.6)	13 (14.1)
Espinilho	10	1 (1.5)	9 (12.6)	4 (7.0)
Forest	1	1 (1.5)	1 (1.4)	1 (2.3)
Total	108	65	71	75

In Brazil, many other protected areas have roads that cut through or border their areas. Data from 2014 indicate that about 62% of the federal protected areas are crossed by roads and 72% are under direct or indirect effects of roads (Botelho et al. 2014). As there is no specific legislation on the implementation and operation of roads in federal protected areas, it is the responsibility of the management plan of each area to allow the use and creation of roads, while at the same time balancing their biodiversity conservation goals (SNUC 2000, Bager et al. 2016).

Our data indicate that the edge effects generated by the road alter the species composition and structure of the bird community in the ESP. This effect is caused by some species being attracted to the road whereas others are excluded or decline. However, it should be kept in mind that our sampling was limited in time; in order to gain a better understanding of the effects of the road, year-round sampling would be required. Nevertheless, based on our findings, we suggest that roads should be avoided near or within areas destined for conservation, as has been recommended before (Forman & Dublinger 2000, Clevenger et al. 2003, Garriga et al. 2012). If roads must be built within or around protected areas, studies on the impact of these roads and possible mitigation measures are essential and urgent.

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Appendix 1. Bird species recorded by transect in the Espinilho State Park, southern Brazil, in January 2015.

Species	Feeding habit	Habitat use	T1	T2	T3
Agelaioides badius (Vieillot, 1819)	Omnivorous	Anthropic area	X	X	X
Ammodramus humeralis (Bosc, 1792)	Granivorous	Grassland			X
Anas flavirostris Vieillot, 1816?	Herbivorous	Wetland			X
Anas georgica Gmelin, 1789?	Omnivorous	Wetland	X	X	X
Aramides saracura (Spix, 1825)	Omnivorous	Wetland	X	X	
Aramides ypecaha (Vieillot, 1819)	Insectivorous	Forest edge		X	X
Aramus guarauna (Linnaeus, 1766)	Malacofagous	Wetland		X	
Ardea alba Linnaeus, 1758?	Omnivorous	Wetland	X	X	X
Ardea cocoi Linnaeus, 1766	Carnivorous	Wetland	X		
Asthenes baeri (Berlepsch, 1906)	Insectivorous	Espinilho			X
Basileuterus culicivorus (Deppe, 1830)	Insectivorous	Forest		X	
Bubulcus ibis (Linnaeus, 1758)	Insectivorous	Wetland	X	X	X
Butorides striata (Linnaeus, 1758)	Carnivorous	Wetland	X	X	X
Callonetta leucophrys (Vieillot, 1816)	Insectivorous	Wetland		X	X
Caracara plancus (Miller, 1777)	Omnivorous	Anthropic area	X	X	X
Chloroceryle amazona (Latham, 1790)	Piscivorous	Wetland	X		
Chlorostilbon lucidus (Shaw, 1812)	Nectivorous	Forest edge	X	X	X
Chordeiles minor (Forster, 1771)	Insectivorous	Forest edge			X
Ciconia maguari (Gmelin, 1789)	Carnivorous	Wetland			X
Circus buffoni (Gmelin, 1788)	Carnivorous	Wetland	X	X	
Cistothorus platensis (Latham, 1790)	Insectivorous	Grassland			X
Coccyzus melacoryphus Vieillot, 1817	Carnivorous	Forest edge	X	X	X
Colaptes campestris (Vieillot, 1818)	Insectivorous	Grassland			X
Colaptes melanochloros (Gmelin, 1788)	Insectivorous	Grassland	X	X	X
Columbina picui (Temminck, 1813)	Granivorous	Anthropic area		X	X
Columbina talpacoti (Temminck, 1810)	Granivorous	Anthropic area	X		X
Coragyps atratus (Bechstein, 1793)	Detritivorous	Anthropic area	X		
Coryphistera alaudina Burmeister, 1860	Insectivorous	Espinilho			X
Cyclarhis gujanensis (Gmelin, 1789)	Insectivorous	Forest edge	X		
Dendrocygna viduata (Linnaeus, 1766)	Omnivorous	Wetland		X	X
Egretta thula (Molina, 1782)	Carnivorous	Wetland	X	X	X
Elaenia flavogaster (Thunberg, 1822)	Frugivorous	Grassland			X
Elaenia parvirostris Pelzeln, 1868	Frugivorous	Grassland	X	X	X
Elaenia spectabilis Pelzeln, 1868	Frugivorous	Grassland	X	X	
Elaenia sp.	Frugivorous	Grassland		X	
Embernagra platensis (Gmelin, 1789)	Granivorous	Grassland	X		

Appendix 1. Continuation.

Species	Feeding habit	Habitat use	T1	T2	T3
Empidonomus varius (Vieillot, 1818)	Insectivorous	Forest edge		X	X
Falco sparverius Linnaeus, 1758	Carnivorous	Anthropic area	X		
Furnarius rufus (Gmelin, 1788)	Insectivorous	Anthropic area	X	X	X
Gallinula galeata (Lichtenstein, 1818)	Omnivorous	Wetland			X
Geranoaetus albicaudatus (Vieillot, 1816)	Carnivorous	Anthropic area	X		
Griseotyrannus aurantioatrocristatus (d'Orbigny & Lafresnaye, 1837)	Insectivorous	Forest edge	X	X	X
Guira guira (Gmelin, 1788)	Omnivorous	Anthropic area	X	X	X
Heliomaster furcifer (Shaw, 1812)	Nectivorous	Espinilho		X	X
Hylocharis chrysura (Shaw, 1812)	Nectivorous	Forest edge	X		
Jacana jacana (Linnaeus, 1766)	Insectivorous	Wetland		X	X
Lepidocolaptes angustirostris (Vieillot, 1818)	Carnivorous	Espinilho		X	X
Leptasthenura platensis Reichenbach, 1853	Insectivorous	Espinilho		X	X
Leptotila verreauxi Bonaparte, 1855	Granivorous	Forest edge	X	X	
Machetornis rixosa (Vieillot, 1819)	Insectivorous	Grassland	X	X	X
Megarynchus pitangua (Linnaeus, 1766)	Omnivorous	Forest edge			X
Melanerpes candidus (Otto, 1796)	Insectivorous	Grassland		X	
Microspingus melanoleucus (d'Orbigny & Lafresnaye, 1837)	Granivorous	Espinilho		X	
Mimus saturninus (Lichtenstein, 1823)	Omnivorous	Grassland	X	X	X
Molothrus bonariensis (Gmelin, 1789)	Omnivorous	Grassland	X	X	X
Molothrus rufoaxillaris Cassin, 1866	Omnivorous	Grassland	X		X
Mycteria Americana Linnaeus, 1758	Piscivorous	Wetland			X
Myiodynastes maculatus (Statius Muller, 1776)	Insectivorous	Forest edge			X
Myiopsitta monachus (Boddaert, 1783)	Granivorous	Grassland	X	X	X
Myiothlypis leucoblephara (Vieillot, 1817)	Insectivorous	Forest edge	X		
Nannopterum brasilianus (Gmelin, 1789)	Carnivorous	Wetland		X	X
Nothura maculosa (Temminck, 1815)	Omnivorous	Grassland	X	X	
Pardirallus sanguinolentus (Swainson, 1838)	Insectivorous	Wetland			X
Paroaria coronate (Miller, 1776)	Granivorous	Forest edge	X	X	X
Passer domesticus (Linnaeus, 1758)	Omnivorous	Anthropic area	X		
Patagioenas maculosa (Temminck, 1813)	Granivorous	Grassland	X		
Patagioenas picazuro (Temminck, 1813)	Granivorous	Grassland	X		
Phacellodomus sibilatrix Sclater, 1879	Insectivorous	Espinilho		X	X
Phacellodomus striaticollis (d'Orbigny & Lafresnaye, 1838)	Insectivorous	Wetland			X
Phimosus infuscatus (Lichtenstein, 1823)	Omnivorous	Wetland	X	X	X
Pitangus sulphuratus (Linnaeus, 1766)	Omnivorous	Anthropic area	X	X	X
Platalea ajaja Linnaeus, 1758	Omnivorous	Wetland		X	X
Podager nacunda (Vieillot, 1817)	Insectivorous	Grassland		X	
Polioptila dumicola (Vieillot, 1817)	Insectivorous	Grassland	X	X	X
Progne chalybea (Gmelin, 1789)	Insectivorous	Anthropic area		X	
Pseudoleistes guirahuro (Vieillot, 1819)	Granivorous	Wetland	X	X	X
Pseudoseisura lophotes (Reichenbach, 1853)	Insectivorous	Espinilho		X	X
Pygochelidon cyanoleuca (Vieillot, 1817)	Insectivorous	Grassland	X		
Pyrocephalus rubinus (Boddaert, 1783)	Insectivorous	Grassland	X	X	X

Appendix 1. Continuation.

Species	Feeding habit	Habitat use	T1	T2	T3
Rhea americana (Linnaeus, 1758)	Omnivorous	Grassland		X	X
Rupornis magnirostris (Gmelin, 1788)	Carnivorous	Anthropic area		X	X
Saltator aurantiirostris Vieillot, 1817	Frugivorous	Forest edge	X	X	X
Saltator coerulescens (Gmelin, 1788)	Omnivorous	Grassland	X	X	X
Satrapa icterophrys (Vieillot, 1818)	Insectivorous	Forest edge	X		
Schoeniophylax phryganophilus (Vieillot, 1817)	Insectivorous	Grassland		X	X
Serpophaga subcristata (Vieillot, 1817)	Insectivorous	Forest edge	X	X	X
Sicalis flaveola (Linnaeus, 1766)	Granivorous	Anthropic area	X	X	X
Sicalis luteola (Sparrman, 1789)	Granivorous	Anthropic area	X	X	X
Sporophila caerulescens (Vieillot, 1823)	Granivorous	Grassland	X		
Sporophila sp.	Granivorous	Grassland	X		
Suiriri suiriri (Vieillot, 1818)	Insectivorous	Espinilho		X	X
Synallaxis albescens Temminck, 1823	Insectivorous	Espinilho		X	X
Synallaxis frontalis Pelzeln, 1859	Insectivorous	Forest edge	X		
Tangara sayaca (Linnaeus, 1766)	Omnivorous	Anthropic area	X	X	X
Tapera naevia (Linnaeus, 1766)	Insectivorous	Forest edge	X	X	X
Thamnophilus caerulescens Vieillot, 1816	Insectivorous	Forest edge	X		
Theristicus caudatus (Boddaert, 1783)	Omnivorous	Wetland			X
Tigrisoma lineatum (Boddaert, 1783)	Carnivorous	Wetland		X	X
Troglodytes musculus Naumann, 1823	Insectivorous	Anthropic area	X	X	X
Turdus amaurochalinus Cabanis, 1850	Omnivorous	Anthropic area	X		
Turdus rufiventris Vieillot, 1818	Omnivorous	Anthropic area	X	X	
Tyrannus melancholicus Vieillot, 1819	Insectivorous	Forest edge	X	X	X
Tyrannus savanna Daudin, 1802	Insectivorous	Anthropic area	X	X	X
Vanellus chilensis (Molina, 1782)	Carnivorous	Anthropic area	X	X	X
Veniliornis mixtus (Boddaert, 1783)	Insectivorous	Grassland		X	
Xolmis irupero (Vieillot, 1823)	Insectivorous	Grassland	X	X	X
Zenaida auriculata (Des Murs, 1847)	Granivorous	Anthropic area	X	X	X
Zonotrichia capensis (Statius Muller, 1776)	Omnivorous	Anthropic area	X	X	X