



Research Letters

Matrix type affects movement behavior of a Neotropical understory forest bird



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ABSTRACT

Fragmentation alters landscape structure and its relationship with organisms, where movement is one of the most affected processes. Movement choices are influenced by a cost and benefit evaluation, associated particularly to risks of predation and access to new resources. We analyzed the effect of matrix type on matrix-transfer success of a bird, *Pyriglena leucoptera*. We used a translocation-monitoring approach and evaluated time and trajectories used to reach an adjacent forest patch when released inside the matrix. The risk of predation was estimated by quantifying the density of birds of prey in three matrices (pastures, cornfields, and *Eucalyptus*) with different degrees of exposure given by differences in their vegetation structure. This variation was perceived by individuals, as evidenced by changes in their movement patterns and differences in their matrix-transfer success. The *Eucalyptus*, a low-risk matrix with the lowest density of predators and with more resources and shelters, resulted in tortuous movements by translocated birds. The pasture, an intermediate-risk with a wide visual field, resulted in straight and fast movements. The cornfields, a high-risk matrix with the highest density of predators and an increased obstruction of the visual field (when compared with pastures), resulted in more tortuous movements and longer exposure to risk, and thus in lower successful arrivals to forest patches. Our results highlight the importance of quantifying the effects of matrix type on movement behavior and on the persistence of species in fragmented landscapes. The proper management of matrices appears as a cost-effective option for improving connectivity in modified landscapes.

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Introduction

In fragmented and human modified landscapes, different types of matrices (i.e. extensive non-habitat areas surrounding remaining habitat fragments, Fahrig, 2003) can have variable levels of quality for native habitat species because of their different structural and compositional characteristics (Ricketts, 2001). These characteristics result in different levels of permeability because each matrix type has a diverse set of risks and benefits for the survival of animals passing through it (Ries and Debinski, 2001; Rodríguez et al., 2001; Antongiovanni and Metzger, 2005). As a consequence, modifications of habitat configuration or matrix composition due to fragmentation and land-use expansion can lead to decreased connectivity (Fahrig, 2003).

Animals can perceive levels of matrix quality and then modify their movement behavior in order to minimize risks and maximize benefits according to each environment (Zollner and Lima, 2005; Cornelius et al., 2017). Matrices can have different degrees of permeability depending on their vegetation structure, acting as either a complete or a semi-permeable barrier, and they can also contribute to species persistence functioning as a habitat complement (Gascon et al., 1999; Castellón and Sieving, 2006; Driscoll et al., 2013;).

Among risks, predation is one of the main factors affecting animal choices when crossing a matrix. Individuals may be more or less vulnerable to predators depending on the structure of the matrix (Desrochers and Hannon, 1997; Bélisle, 2005; Zollner and Lima, 2005; Roth et al., 2006). In order to minimize risks and/or maximize benefits in each site, animals can modify their movement behavior, permanence in the matrix and spatial distribution (Powell, 1974; Schooley and Wiens, 2003; Zollner and Lima, 2005; Haynes and Cronin, 2006). In forested landscapes, open matrices may present high risk of predation. Thus, forest animals tend to move fast in the

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matrix and they generally use straight pathways toward the nearest forest fragment (Zollner and Lima, 2005). On the other hand, where the risk of predation is low (e.g. with higher or denser vegetation cover), animals can stay longer and do more tortuous (or randomic) pathways to explore the available resources (Powell, 1974).

There is an increasing knowledge about how different animals use different landscape elements, but some challenges remain. Several studies have shown that this relationship depends on the structure of each landscape and is species-specific (Turcotte and Desrochers, 2003; Uezu et al., 2005; Fahrig, 2007; Van Houtan et al., 2007; Lees and Peres, 2008; Turlure et al., 2011a), which makes obtaining general rules very difficult (Zollner and Lima, 2005; Moore et al., 2008). This emphasizes the need of studies that assess animal movement in different matrix types in order to generate more accurate data sets and develop assertive mitigation actions to improve connectivity in fragmented and human-modified landscapes.

In order to clarify the influence of matrix characteristics on animals' movement, this study aims to test how permeability, as a function of different levels of predation risk and vegetation structure, changes among different matrices. We chose the risk of predation as a main variable to be tested and used an understory forest bird to investigate its movement patterns and behavior in three matrix types (clean pastures, cornfields and *Eucalyptus* plantations). Here we assessed three questions: I) How much does the density of predators vary among the three matrix types? II) Do bird trajectories across the matrix differ among the three matrices? and, if so, III) Do these differences result in different capacities to cross the matrix?

We expect different density of predators among matrices because different vegetation types may offer different amount of resources or even facilitate or hinder access to prey (Jullien and Thiollay, 1996; Rodríguez et al., 2001, 2014). As a consequence, forest-birds should move accordingly when crossing the matrix. In the pasture birds should move fast and straight toward the nearest forest fragment (Powell, 1974), which is facilitated by the open vegetation structure (Zollner and Lima, 1997; Schooley and Wiens, 2003; Zollner and Lima, 2005). In the matrices with closed vegetation, *Eucalyptus* and cornfields, we expect a slower and more tortuous movement, because birds have more protected sites provided by vegetation structure (e.g. they should be less noticeable for predators; Fahrig, 2007; Williams et al., 2012). Also, the *Eucalyptus* matrix can have some structural similarity with the natural forest, which could provide cues that are familiar for forest birds (Laurance and Yensen, 1991; Forman, 1995; Mesquita et al., 1999; Caryl et al., 2012; Magrath et al., 2012).

Material and methods

This study was conducted from October 2009 to February 2010 and from November 2010 to February 2011 on the Atlantic Plateau of São Paulo, in the southeast of Brazil, where pastures, agricultural fields and *Eucalyptus* plantations have replaced extensive areas of the original Atlantic Forest. In the past, Atlantic Forest covered a vast area of southeastern Brazil (Joly et al., 2014), but approximately only 11–16% of the original forest remains today, which is mostly distributed in isolated small forest fragments (1–280 ha) (Ribeiro et al., 2009).

We used *Pyriglena leucoptera* (Passeriformes: Thamnophilidae), an understory insectivorous bird (Sick, 1997) that is endemic to the Atlantic forest (Stotz et al., 1996) as study species. Understory birds are generally considered adequate organisms to study the effects of fragmentation on movement patterns (Castellón and Sieving, 2006), as they depend on forest habitat, but some may be able

to explore the matrices that make up the mosaic of fragmented landscapes (Uezu et al., 2005; Hansbauer et al., 2008a).

Pyriglena leucoptera is a forest specialist and has medium sensitivity to fragmentation (Anjos, 2006; Hansbauer et al., 2008a, 2008b, 2010), thus occurring also in secondary forests and forest fragments (Parker et al., 1996; Stotz et al., 1996; Uezu et al., 2005). It prefers environments with vine-tangles and bamboos, and it forages moving actively through the forest understory (Lopes et al., 2006) and along edges in fragmented landscapes (Hansbauer et al., 2008b). Their territories do not seem to exceed 2 ha (Duca et al., 2006), but their home range is estimated at 15.4 ha (Hansbauer et al., 2008b).

We described predation risk and movement patterns of *P. leucoptera* individuals in three types of matrices: clean pastures, cornfields and *Eucalyptus* plantations. We selected 30 experimental landscapes (Fig. 1), 10 for each type of matrix, with at least 2 km of distance among them. The pastures were areas in use, covered by grass with no more than 10 cm high; the cornfields were areas with plants that had 1.5 m high at minimum; and *Eucalyptus* were plantations with 8–10 m high trees and poor understory. The understory density was estimated visually by the researchers. All the selected landscapes were composed by a matrix area adjacent to a forest fragment with at least 150 m of contact between the matrix and the focal fragment.

We assessed risk of predation by estimating the density of birds' predators in each matrix type. Because *P. leucoptera* is a diurnal species (Sick, 1997) and most dispersal events should occur during the day, we used density of birds of prey to assess risk of predation. Birds of prey are the most representative group of predators that consume birds and forage during the day; other predators that commonly consume birds and their eggs, such as snakes and small mammals (Sick, 1997), are mostly nocturnal.

We used matrix-specific detection functions to estimate the density of birds of prey (in individuals/ha) with the Distance Sampling method (Buckland et al., 2001) (See supplementary material S1). An 800 m transect was established in each matrix, approximately 100 m distant from the focal fragment edge. Transects were sampled during 1 h along the morning (between 9 am and 12 pm) by three observers. Each transect was sampled twice in different days and times, totalizing 60 h of sampling (Whitacre et al., 1992). Only potential predator species of *P. leucoptera* were included in the analyses, excluding all the species with no literature records of feeding on small birds (Sick, 1997). All detections that occurred at more than 500 m orthogonally distant to the transect line were excluded to avoid identification errors (Buckland et al., 2001).

We tested the differences of movement behavior of *P. leucoptera* in the three matrix types, using a capture-translocation-monitoring approach. All individuals were captured with mist-nets in forest fragments at least 8 km away from the experimental matrix, avoiding translocations inside their well-known own territories (e.g. Bélisle et al., 2001). Besides, we chose capture areas with the same matrix of the released area, ensuring that the experimental individuals had previous experiences with the considered matrix. The time between capture and release varied from 1 to 2.5 h, regardless of the matrix type.

For our translocation experiment, we used only adult males of *P. leucoptera*. Bird species commonly have sex-biased dispersal (Johnson and Gaines, 1990). The main reason for this pattern is that males in most bird species show resource defense (e.g. territories). Thus, the movement costs are different for each sex, with the sex that keeps the resources (in most cases males) being the less dispersive one (Greenwood, 1980; Clobert et al., 2004). A recent study demonstrated sex-bias dispersal for *P. leucoptera*, with females having a higher success when dispersing through fragmented landscapes (Awade et al., 2017). Thus, males are more prone to be affected by changes in the landscape and may

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