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Edge, height and visibility effects on nest predation by birds and mammals in the Brazilian *cerrado*

Pavel Dodonov [a, *], Ingrid Toledo Paneczko [b], Marina Telles [c]

[a] Applied Ecology and Conservation Lab, Post-Graduation Program in Ecology and Biodiversity Conservation, State University of Santa Cruz, Rodovia Ilhéus-Itabuna, km16, 45662-000 Ilhéus, Bahia, Brazil
[b] Department of Ecology and Evolutionary Biology, Federal University of São Carlos, Rodovia Washington Luis, km 235, 13.562-180 São Carlos, SP, Brazil
[c] Federal Institute of Education, Science and Technology, Avenida C-1, 250, 14781-502 Barretos, SP, Brazil

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ABSTRACT

Edge influence is one of the main impacts in fragmented landscapes; yet, most of studies on edge influence have focused on high-contrast edges, and the impacts of low-contrast edges and narrow linear openings are less understood. Edge influence often affects bird nest predation, but these effects are not ubiquitous and may depend on characteristics such as nest height and visibility. We performed an experiment on nest predation in a migratory passerine, *Elaenia chiriquensis* (Lesser Elaenia; Passeriformes: Tyrannidae), in a savanna vegetation of the Brazilian *Cerrado* biome in South-Eastern Brazil. We used 89 real *E. chiriquensis* nests, collected during previous reproductive seasons, with two plasticine eggs in each, and randomly distributed them at two locations (edge – up to 20 m from a firebreak edge and interior – approx. 150–350 m from the edge) and two heights (low – 60–175 cm and high – 190–315 cm above ground). We also measured leaf and branch density around each nest. We performed this study on two 15-days campaigns, checking the nests every 2–3 days and removing those with predation marks. We sorted the predation marks into those made by birds, mammals, or unidentified predators, and used generalized linear models to assess the effects of location, height and leaf density on survival time and predator type. Only four nests had not been predated during the experiment; 55 nests were predated by birds, 7 by mammals, and 23 by unidentified predators. Low nests in the interior tended to have larger survival times whereas high nests at the edge tended to be more predated by birds and less predated by mammals. Thus, even a low-contrast (firebreak) edge may significantly increase nest predation, which is also affected by the nest's height, mainly due to predation by birds. These effects may be due to predator movement along the edge as well as to edge-related changes in vegetation structure. We suggest that higher-contrast edges which may also be used as movement conduits, for example powerline openings, may have even stronger effects, demanding further studies.

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1. Introduction

Habitat fragmentation and loss are among the main threats to biodiversity and ecological processes worldwide (Brook et al., 2008), and they operate via three main mechanisms: area loss, increased isolation, and edge influence (Saunders et al., 1991; Fahrig, 2003). Edge influence is characterized by differences in ecosystem structure, composition or function between edge and reference conditions (Harper et al., 2005), and may affect both the abundance of different organisms and ecological processes, including species interactions (Fagan et al., 1999; Murcia, 1995; Ries et al., 2004). Although nest predation is a process that is often subject to edge influence (Lahti, 2001; Vetter et al., 2013), there is much variation in the observed processes, with approximately half of the studies failing to detect increases in nest predation at edges, as shown by metaanalytical studies (Lahti, 2001; Vetter et al., 2013). Considering that adult bird survival is usually high (Botkin and Miller, 1974; Lindstedt and Calder, 1976), nest survival is important in determining the population dynamics of bird species (Newton, 1998). Thus, increased nest predation at edges may have far-reaching consequences for the population dynamics of different bird species. This may be especially important for migratory birds, as increased mortality in the breeding range, where density

* Corresponding author.
E-mail address: pdodonov@gmail.com (P. Dodonov).

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dependence and mortality may be especially important, may have disproportionately large effects (Shuter et al., 2011).

Edge influence may depend on several factors, including the type of vegetation (Delgado et al., 2007) and of the adjacent land use (Wright et al., 2012; Cilliers et al., 2008). Even so, edge-related variation in nest predation has been observed in a variety of vegetation types, including tropical forests (Spanhove et al., 2009), woodlands (Robertson et al., 2014) and savannas (Fraser and Whitehead, 2005) as well as temperate and boreal vegetation (Cox et al., 2012; De Gregorio et al., 2014). Although edge influence is usually more pronounced next to edges such as between native vegetation and plantations (Harper et al., 2005), edges such as those with power lines and unpaved roads may also affect nest predation rates (De Gregorio et al., 2014). This may be due to changes in e.g. vegetation structure, which have been observed close to linear openings (Smit and Asner, 2012; Dodonov et al., 2013), or to modification in animal movement patterns (Levey et al., 2005), which may lead to new opportunities for species interactions (Fagan et al., 1999) by, for example, increasing the nest-finding rate of a predator. Regardless of the mechanism involved, edge influence on nest predation is known to vary among predator species, with some predators being favored by edges whereas others are affected negatively or not affected (Cox et al., 2012; De Gregorio et al., 2014). Thus, improved knowledge on predator identity may shed light on the variation in edge influence on nest predation.

In addition to edge influence, nest predation may also be affected by factors such as nest height and visibility (Martin, 1993; Flaspohler et al., 2000). For example, the location of the nest on a branch may determine its visibility and accessibility to different predators and thus affect its survival (Cresswell, 1997). Thus, higher nests have been observed to suffer more predation than lower nests in a Brazilian savanna area (Leite et al., 2014). Similarly, leaf density surrounding a nest may putatively decrease nest visibility and consequently predation rates. Such effects, however, may vary among predators: for example, a denser vegetation, while decreasing nest visibility, may provide a better microhabitat for small mammals and so increase predation rates (Batáry et al., 2014).

Notwithstanding the large number of studies on edge-related patterns in nest predation, few of them have been performed in tropical savannas (but see Fraser and Whitehead, 2005; Robertson et al., 2014). With this in mind, we performed a study on nest predation in a savanna site within the Brazilian *cerrado* domain (Coutinho, 1978; Ribeiro and Walter, 2008). To our knowledge, only one study about edge influence on nest predation has been previously performed in the *cerrado* (França and Marini, 2009). We studied whether nest predation is affected by a low-contrast firebreak edge as well as by nest height and leaf density. We used real nests, collected during previous reproductive seasons of the model species (*Elaenia chiriquensis*), with plasticine eggs to identify predator identity, and expected that 1) nests close to the edge would experience greater predation, 2) nest height would affect predation by different predators, with higher nests experiencing greater predation by birds and lower nests by mammals, and 3) leaf density would decrease nest visibility and therefore nest predation rates.

2. Methods

2.1. Study site

We performed this study in an open savanna ("*campo cerrado*") area in Itirapina Ecological Station, São Paulo, Southeastern Brazil (22°12′36″ S, 47°55′05″W) (Fig. 1). The climate is humid subtropical, with a yearly precipitation of around 1460 mm and an average yearly temperature of around 22 °C (Reis and Zanchetta, 2006). The most rainy months are December, January and February, with average precipitation between 208 and 275 mm, compared to the driest months of July and August, with average precipitation between 24 and 42 mm (Reis and Zanchetta, 2006). Average temperature ranges from approximately 18 °C in the coldest months (June and July) to approximately 25 °C in January and February.

As other open *cerrado* areas, this site is characterized by a discontinuous woody layer and a continuous herbaceous layer, with a large quantity of the invasive grasses *Urochloa decumbens* (Stapf) R.D.Webster and *Melinis minutiflora* P.Beauv. (Poaceae),

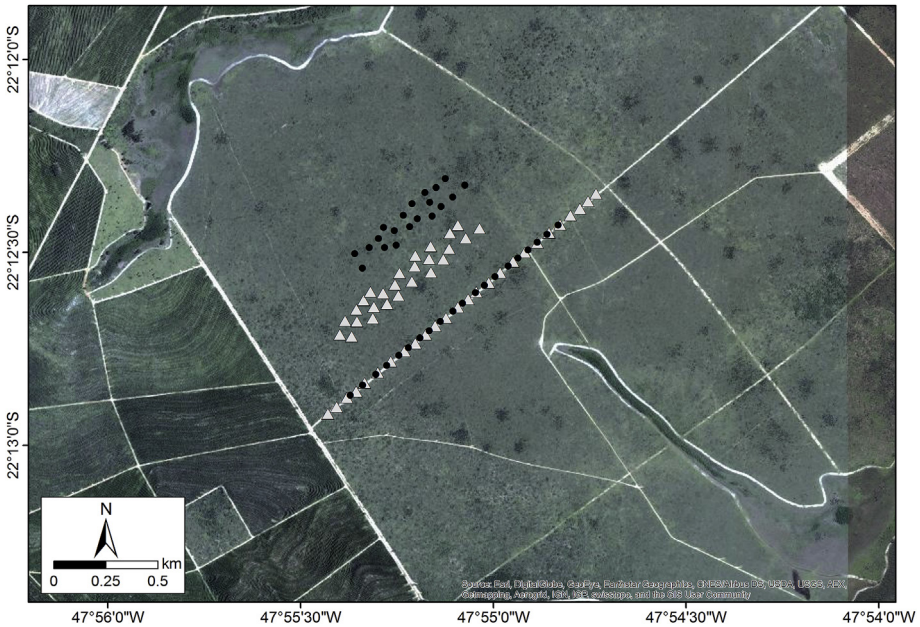

Fig. 1. Satellite image of the area showing the location of the nests placed in during the two campaigns, in the *cerrado* of Itirapina Ecological Station (São Paulo State, Southeastern Brazi). Nests were distributed along a firebreak edge and at a distance of 150–300 m from it, on November 9 (white triangles) and November 27 (black circles), 2011.

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