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Research Letters

Do the size and shape of spatial units jeopardize the road mortality-risk factors estimates?

Clara Grilo[a,*], *Thálita de Resende Cardoso*[a], *Ricardo Solar*[b], *Alex Bager*[a]

[a] *Post-Graduate Program in Applied Ecology, Brazilian Center for Studies on Road Ecology, Universidade Federal de Lavras, Lavras, MG, Brazil*
[b] *Laboratory of Ecology Communities, Department of Entomology, Universidade Federal de Viçosa, Viçosa, MG, Brazil*

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ABSTRACT

We aimed to evaluate the role of spatial units with different shapes and sizes on road-kill modeling for small vertebrate species. We used the road-kill records of two reptiles, water snake (*Helicops infrataeniatus*) and D'Orbigny's slider turtle (*Trachemys dorbigni*), and three mammals, white-eared opossum (*Didelphis albiventris*), coypu (*Myocastor coypus*) and Molina's Hog-nosed skunk (*Conepatus chinga*). Hierarchical partitioning was used to evaluate the independent influence of different land-use classes on road-kill by varying the shape and size of the spatial units. Variables that most explained road-kill were consistent over the different spatial unit types. The standard size seemed to be a reasonable solution for these species. Prior analysis with several sizes and shapes is needed to identify the appropriate spatial unit to model road-kill occurrence for larger vertebrates with different history traits.

Introduction

In recent decades, researchers have used the available locations of wildlife–vehicle collisions (WVC) to model distribution patterns along roads and implement measures to minimize the road mortality rate (Gunson et al., 2010). Because different ecological patterns are created by processes occurring at different spatial scales (Collinge, 2001), the role of spatial units in characterizing the context of road–wildlife interactions is needed (Barrientos and Miranda, 2012). In general, a spatial unit comprises two different components: shape (point or road segment) and size (the area by which a point or road segment is buffered). Although the majority of mortality studies have mainly focused on spatial units of segments of 1000 m/1 mile in length (e.g. Grilo et al., 2011), unit sizes are arbitrarily chosen, ranging from 50 m to 5000 m for the buffer radius (e.g. Barrientos and Bolonio, 2009; Colino-Rabanal et al., 2011) and from 100 m to 1000 m for the road segment length (e.g. Malo et al., 2004; Jancke and Giere, 2011).

* *Corresponding author*.
E-mail address: clarabentesgrilo@gmail.com (C. Grilo).
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The influence of the spatial unit shape and size in determining the factors that explain the likelihood of WVC is poorly known. Only a few studies have compared the unit size when using buffers to identify the features promoting road-kill with contrasting results (e.g. Colino-Rabanal et al., 2011; Danks and Porter, 2010). The wrong choice of spatial units may affect the identification of factors explaining WVC and therefore, the placement of mitigation measures will be biased and ineffective. Here, we argue that the selection of the spatial units is species-specific depending critically on their life-history traits.

The main goal of this study is to investigate whether changes in either the size of spatial units or their shape alter the road-kill risk. Using records of small vertebrates with different life-history traits, we evaluated whether variables related to the mortality risk vary according to the shape and size of spatial units. We also analyzed the variance explained by these variables among spatial units with different shapes and sizes.

In the absence of road- and landscape-related features at the microscale, we used land use data as predictors of habitat quality, which play a key role in road-kill models by improving their predictive capacity (Roger and Ramp, 2009). Because small-sized species and habitat specialists are more focused on particular features of land use, we expect that variables may not vary when changing the shape and size of the units. Likewise, we expect that explained variance decreases as the spatial units size increases.

Methods

Study area

The study site is located in the coastal plain in Southern Brazil (Fig. 1). This region is characterized by a coastal plain with a low and rectilinear relief dominated mainly by wetlands associated with fresh- and salt-water lakes (Tagliani, 2003). A total of 137 km of two Brazilian Federal paved roads was surveyed: BR392 (33 km) and BR471 (104 km) (Fig. 1). BR392 and BR471 are 2-lane roads with an average daily traffic volume of 247 vehicles and an average speed of 80 km/h (Bager, 2006).

Target species

We focus our analysis on five species representing different life-history traits. Water snake *Helicops infrataeniatus* is an aquatic species and is particularly vulnerable to road mortality (e.g. Bager and Fontoura, 2013). D'Orbigny's slider turtle *Trachemys dorbigni* is a fresh-water turtle with an observed road-kill rate of 0.23 individuals/100 km/day (Bager and Fontoura, 2013). White-eared opossum *Didelphis albiventris* is a habitat generalist, solitary and omnivorous species with a high road-kill incidence (Cherem et al., 2007). Coypu *Myocastor coypus* is an aquatic rodent with a road-kill rate of 8.25 individuals/100 km/day in BR471 (Bager and Fontoura, 2013). Molina's Hog-nosed skunk *Conepatus chinga* is a carnivore species that is widespread in southern Brazil (Cheid et al., 2006).

Data collection

Road-kill data

Road-kill data were obtained from URUBU System database (http://cbee.ufla.br/portal/sistema_urubu/). The locations were recorded weekly from January to December 2005 by car at approximately 50 km/h, with at least two observers, avoiding weekends, holidays and rainy days. Road surveys ($n = 52$) were performed between 7 am and 3 pm, and the road-kill locations were recorded with GPS.

Land-use data

We used the land-use map from Tagliani (2003). We defined the following land-use classes: predominant rice field, sandbank vegetation, seaside fields, wetlands and non-native vegetation. Predominant rice fields are mainly covered by irrigated rice culture; sandbank vegetation are areas of low open arboreal vegetation that are influenced by the ocean and located high on dunes and slopes and on dry soil; seaside fields are flood fields of low grass; wetlands are floodplains with fertile clay soils; and non-native vegetation areas comprise eucalyptus and pine plantations (*Eucalyptus* sp. and *Pinus* sp.).

Definition of spatial units

We considered two shapes of spatial units: a buffer area around each road-kill location and road segments with a pre-defined length, where road-kills were assigned to each segment. We also considered three measures to define buffer diameters and road segment lengths: (1) the average daily movement length, (2) the standard size and (3) the average natal dispersal distance of each species (Table 1). The daily movement length was found in the literature or using information of the species average home-range size for mammals (see Bissonette and Adair, 2008). We used 1000 m as the standard size used in several studies (e.g. Grilo et al., 2011). Because for water snake, no information on the home-range size was available, we used data from a study on a species of the same family (*Liophis poecilogyrus*) (Hartz et al., 2001). Natal dispersal information was found in the literature or estimated through Bissonette and Adair (2008) for mammals. For all of the spatial units, we extracted the area (m^2) of each land-use class through ArcGIS 9.3 (ESRI, 2010).

Data analysis

Hierarchical partitioning (HP) was used to analyze the role of the shape and size of the spatial units in determining which land-use classes influence road-kill likelihood. This method identifies the key factors underlying the studied processes while reducing multicollinearity problems (Chevan and Sutherland, 1991). We determined the independent (I) contribution of each explanatory variable to the response variable and disentangled it from the joint (J) contribution resulting from correlation with other variables.

A sample of spatial units with an equal number of presence and absence of road-kill was used to estimate the percentage of model adjustment that was explained independently by each land-use class within all of the possible multiple regression models (Mac Nally, 2002). Buffers and segments with absence of road kills were randomly selected on the studied