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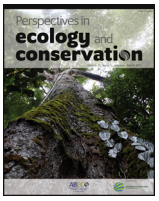

Research Letter

Assessing the consistency of hotspot and hot-moment patterns of wildlife road mortality over time

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ABSTRACT

Spatial and temporal aggregation patterns of wildlife-vehicle collisions are recurrently used to inform where and when mitigation measures are most needed. The aim of this study is to assess if such aggregation patterns remain in the same locations and periods over time and at different spatial and temporal scales. We conducted biweekly surveys ($n = 484$) on 114 km of nine roads, searching for road casualties ($n = 4422$). Aggregations were searched using different lengths of road sections (500, 1000, 2000 m) and time periods (fortnightly, monthly, bimonthly). Our results showed that hotspots and hot-moments are generally more consistent at larger temporal and spatial scales. We therefore suggest using longer road sections and longer time periods to implement mitigation measures in order to minimize the uncertainty. We support this finding by showing that the proportional costs and benefits to mitigate roadkill aggregations are similar when using different spatial and temporal units.

Introduction

Roads have a variety of ecological effects on their surrounding environment, and one of the most studied is wildlife-vehicle collisions (WVC) (Forman et al., 2003; Ree et al., 2015). Several researchers have demonstrated that roadkills are often spatially and temporally aggregated, hereafter referred as Wildlife-Vehicle Aggregations (WVA). WVA are generally related to species' biological traits (e.g. mating), road features (e.g. traffic volume), the surrounding landscape or climate conditions (Gunson et al., 2011; Malo et al., 2004; Smith-Patten and Patten, 2008). Therefore, WVA may indicate preferential targets (hotspots and hot-moments) for implementing mitigation measures (Malo et al., 2004; Morelle et al., 2013; Ree et al., 2015). The identification of WVA is one of the approaches most used by researchers and decision makers to implement mortality mitigation on roads (Santos et al., 2015).

Mitigation measures must be planned to ensure effectiveness, due to the high cost of installation and maintenance (Ree et al., 2015). Thus, it is necessary to determine the best spatial scale(s) at which putative predictors indicate locations of WVA (Langen et al., 2007; Ree et al., 2015). Ideally, WVA need to be spatially restricted in length, since short road sections can be more easily mitigated by faunal passages and drift fencing than when WVA segments on road are distributed over a broader extent of the road (Langen et al., 2007). On the other hand, understanding the role of seasonality on road mortality allows the identification of possible WVA in certain periods (hot-moments), and decision makers can direct mitigation measures toward the period of higher WVA, which will reduce the costs (Sullivan et al., 2004).

The aim of this study was to investigate if the spatial and temporal patterns of WVA were similar during the same time period for the different taxonomic groups. If WVA occur consistently in the same location and time period, i.e. do not change over time, mitigation measures applied therein will probably be

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more cost-effective (Costa et al., 2015). Additionally, we evaluated how different road segment length or time period affected the consistency of spatial and temporal WVA patterns. We consider that higher correlation of WVA patterns between consecutive years indicate higher reliability in using such locations as mitigation targets. Hence, we evaluate how cost-benefit effectiveness could vary when targeting mitigation to short/long road sections or time periods. Cost-benefit analysis can be complex in road ecology (Costa et al., 2015). Here, we adopt a simple approach where we count the number of casualties that could have been prevented if road mitigation was implemented in WVA (assuming full effectiveness).

Materials and methods

Study area

We conducted the study in Brasília (Federal District), located in the Cerrado biome of Central Brazil. A total of 114 km pertaining to nine different roads were surveyed. More details of the study

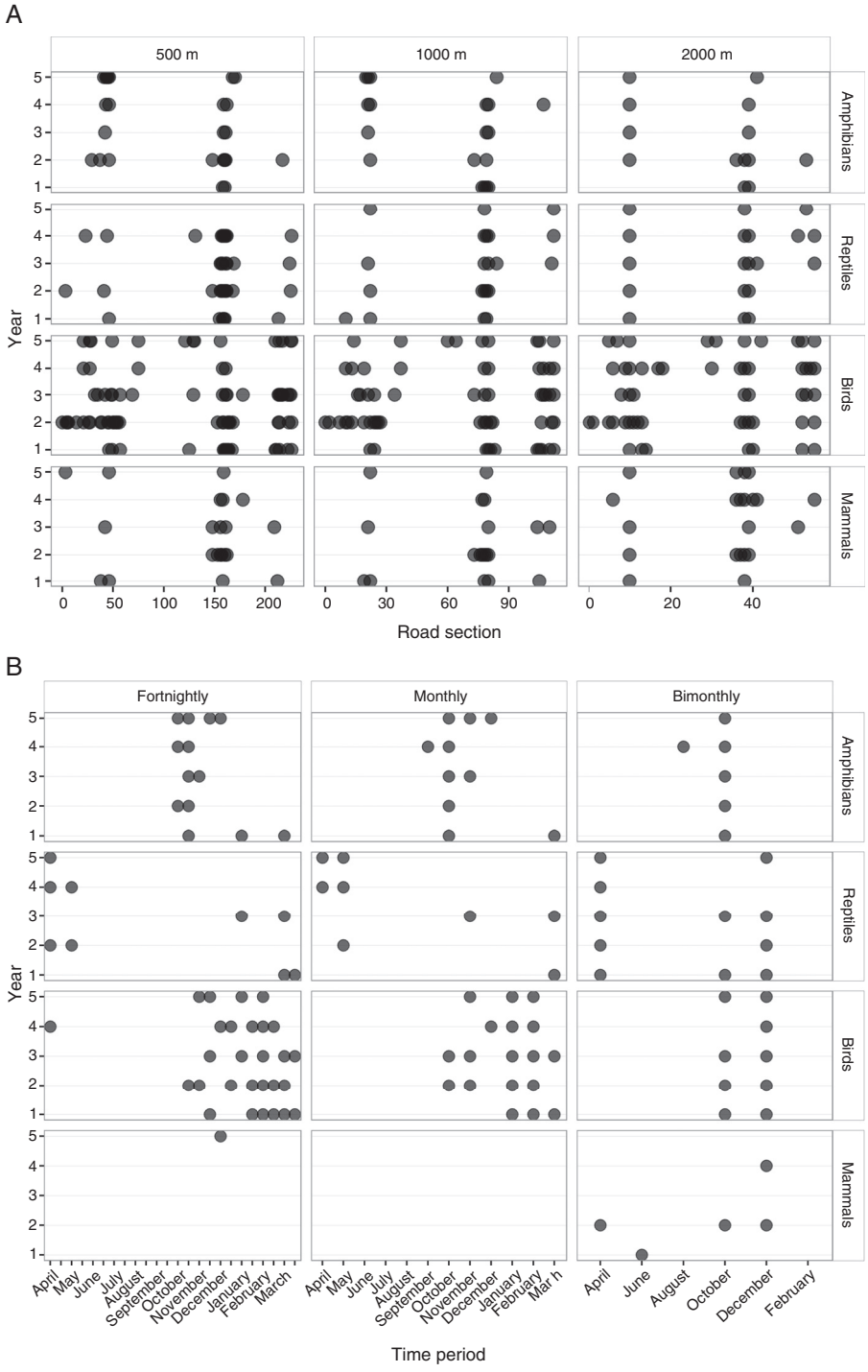

Fig. 1. Location of wildlife-vehicle aggregations (WVA) per year and class, along the 114 km of road surveyed (A) and along the year (B). Each vertical panel presents the locations when using different spatial (A) or time (B) units to detect WVA.