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Research Paper

Avoidance of high traffic levels results in lower risk of wild boar-vehicle accidents

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HIGHLIGHTS

- We modelled traffic accidents and road crossings by wild boar.
- Wild boar avoid crossing roads in high traffic.
- Thus most accidents occur at intermediate trafic levels.
- Wild boar cross roads late in the year in foraging habitats.
- Accidents could be reduced by driving in a more aggregated fashion.

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ABSTRACT

Traffic accidents between cars and wildlife cause loss of lives, suffering and economic loss. Many studies have quantified the characteristics of accident sites, but factors affecting wildlife behaviour near roads and traffic are less explored. Hence, the mechanisms affecting animal movement and collision risks are poorly understood. Previous work suggests that roads and traffic may alter the behaviour of many animals, with temporal and spatial effects on daily movements, migration patterns and land cover selection. Here we analyze data from GPS-collared female wild boar (Sus scrofa) in Sweden to study factors affecting road crossings and traffic accidents involving wild boar. Our results show that wild boar cross roads in habitats mainly used for foraging. Avoidance of traffic results in few accidents at high traffic levels, causing most accidents to occur at intermediate traffic levels. A conclusion from this study is that wild boar appears to be able to make behavioural adjustments that reduce the risk of close vehicle encounters. Applications of these results for mitigating accidents between wild boar and vehicles involve changes in behavioural patterns of drivers and changes in farming practices close to accident prone roads.

1. Introduction

Collisions between vehicles and wildlife inflict injuries to humans and animals, occasionally cause death, and damage property (Forman & Alexander, 1998; Gunson, Mountrakis, & Quackenbush, 2011). One key to understanding wildlife vehicle collisions lies in the question of animal behaviour before and during road crossings (Clair & Forrest, 2009; Litvaitis & Tash, 2008). Understanding why, when and how animals cross roads, and why some are involved in accidents with vehicles and some are not, might be helpful to reduce the number of accidents. Previous studies have focused on the properties of accidents in space (Baker, Dowding, Molony, White, & Harris, 2007; Bruinderink & Hazebroek, 1996; Langbein, Putman, & Pokorny, 2011; Seiler, 2005) and time (Lagos, Picos, & Valero, 2012; Langbein et al., 2011), and on movement of animals in relations to roads (Beyer, Ung, Murray, & Fortin, 2013; Langbein et al., 2011; Laurian et al., 2008) and traffic (Northrup et al., 2012), and combinations thereof (Neumann et al., 2012). These studies show that accidents are highly seasonal (Lagos et al., 2012; Langbein et al., 2011; Neumann et al., 2012) and that most accidents occur during animal activity peaks (Lagos et al., 2012). Since many animals show activity peaks at dawn or dusk, or during the night, this increase is likely due to a combination of increased encounter rates and decreased visibility for vehicle

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drivers. At the same time animals seem able to avoid roads with heavy traffic, which leads to fewer accidents, for example, moose (*Alces alces*) are involved in fewer accidents on roads with heavy traffic (Seiler, 2005) and elk (*Cervus elaphus*) have been shown to avoid crossing heavily trafficked sections of roads (Dodd, Gagnon, Boe, & Schweinsburg, 2007).

Wild boar (*Sus scrofa*) and feral pigs (*Sus domestica*) are colonizing (Dzieciolowski, Clarke, & Fredric, 1990; Engeman, Constantin, Nelson, Woolard, & Bourassa, 2001; Merino, Carpinetti, & Abba, 2009; Mitchell, Dorney, Mayer, & McIlroy, 2007; Simberloff, Relva, & Nunez, 2003) or recolonizing (Saez-Royuela & Telleria, 1986; Truve & Lemel, 2003) many areas of the world, and as a consequence accidents involving wild boar are increasing in number (Bruinderink & Hazebroek, 1996; Lagos et al., 2012). Female and juvenile wild boar are gregarious while adult males are solitary (Briedermann, 2009). They are commonly found in close proximity to humans, including cities (Jansen et al., 2007), and consequently often appear close to roads and traffic. In Sweden, the number of reported wild boar-vehicle accidents has increased rapidly, from 755 in 2003, to 4198 in 2012 (Sävberger, 2010). Previous studies of other large wildlife suggest that the true number may be even larger as many accidents are unreported (Seiler, 2005). There is no calculation what a collision with a wild boar costs society, but it is estimated to be closer to the cost of a collision with a moose (∼€50,000 in todays prices) in cost than to a roedeer (∼€7000 in todays prices) (Olsson & Widén, 2007). A better understanding of wild boar behaviour in the vicinity of traffic and factors affecting the risk of accidents is therefore highly desirable.

If animals are able to detect vehicles and recognize them as a danger, intense traffic should lead to fewer road crossings (Dodd et al., 2007; Langbein et al., 2011; Seiler, 2005). At the same time, more vehicles will increase the chances of an animal being hit by one while crossing the road (Bruinderink & Hazebroek, 1996; Langbein et al., 2011; Litvaitis & Tash, 2008). This has been shown to lead to most accidents occurring at intermediate sized roads (Langbein et al., 2011; Seiler, 2005), and we predict this to be true for temporal patterns as well, with most accidents occurring at intermediate traffic levels.

Animals may cross roads at certain times of year or day, for example when they are roaming more widely. Factors affecting wild boar roaming could be the main rutting period, late fall in the study area, seasonal foraging patterns (Keuling, Stier, & Roth, 2008; Keuling, Stier, & Roth, 2009; Thurfjell et al., 2009), or when most female wild boar are farrowing (giving birth) (Gethöffer, Sodeikat, & Pohlmeyer, 2007). Rosell and Olsson (2012) suggest that wild boar road collision patterns differ from those of other ungulates. Highways do not seem to be a genetic barrier for wild boar, but it is for red deer (Frantz et al., 2012). Throughout Europe, a marked peak in traffic accidents involving wild boar has been observed during the autumn, which overlaps both the hunting season (Lagos et al., 2012) and the rut period, but the relative importance of each is unknown. If animals perceive roads as risky, crossings should only occur if the expected benefits outweigh the perceived risks (Brown, 1999). We hypothesize that wild boar cross roads to reach desired land covers, where rewards outweigh the risk of crossing a road. For wild boar this leads to the prediction that wild boar should cross into crop fields when they are ripe or deciduous forest when mast is available (Cellina, 2008).

In this paper we explore factors affecting wild boar road crossings, and vehicle-wild boar collisions using data on accidents, traffic, land cover use and daily movement by female wild boar throughout the year. This enables us to test if land covers used during road crossings are foraging land covers, if wild boar change behaviour and avoid crossing roads due to temporal traffic patterns, and thus we will identify when and where accidents involving vehicles and wild boar are likely to occur.

We found that wild boar cross roads in association with crop fields and other open areas, that they temporally avoid traffic and consequently that most accidents occur at intermediate traffic levels. Most accidents between vehicles and wild boar occur during winter.

2. Materials and methods

2.1. Study area

The study area is located in southern Sweden, in the county of Scania, classified as the Nemoral vegetation zone (Ahti, Hämet-Ahti, & Jalas, 1968), covering 16,000 hectares in total. It consists of crop fields (65%), coniferous forest (12%, mainly spruce *Picea abies*, plantations), deciduous forest (7%, mainly beech *Fagus sylvatica*), and open areas (12% such as pastures and reed *Phragmites australis*, zones) and a small amount of open water which also includes wet reed zones, see Thurfjell et al. (2009) for further explanation. The study area is intersected by two national roads with an average of 2200 and 2800 vehicles per day and a network of smaller roads.

2.2. Road and accident data

We used the two largest classes of roads in the study since we assume low odds of accidents on smaller gravel roads with lower vehicle speeds (Seiler, 2005). The two classes used were Swedish national roads which are paved highways usually >7 m wide, with 70–90 km/h speed limits in this study area, and secondary roads, paved usually 5–7 m wide, with 50–70 km/h speed limits. The traffic volume on the secondary roads in the study area was 14.2% of the traffic volume on the national roads (Trafikverket, 2014a). We obtained hourly traffic volume data for two national roads intersecting the study area for every hour of 1998 and 1999 respectively from the Swedish Transport Administration (Trafikverket, 2014b). We assume daily and seasonal patterns of traffic to be relatively constant over time, since no major changes have been made in employment, demography or other parameters that we could assume would change it. Therefore we treated the average number of vehicles per hour throughout the year as an index of traffic volume. The numbers of vehicle kilometres on the roads in Tommelilla municipality (which includes most of the study area) increased by only 4.2% from 2002 to 2006 and by 5.6% from 2006 to 2011 (Holmgren, 2003, 2008; Vestman, 2014) which supports this assumption. We retrieved data on all reported wild boar-vehicle collisions ($N = 604$) in the county of our study area during 2008 from the Swedish police (Polisen, 2014), and used this as an index for when accidents occur. The monthly patterns of traffic accidents seem to be constant over time according to the statistics from the Swedish police (Sävberger, 2010).

2.3. Wild boar location data

We used data from Global Positioning System (GPS) – collared (Vectronic Aerospace, Berlin, Germany) female wild boar to estimate movement rate (defined here as the speed of movement in km/h between two consecutive successful locations) and land cover use collected from August 2004 until May 2007. We captured individuals by darting; this procedure was approved by the Animal Care Committee for Northern Sweden (Dnr A18-04). We collected just over 100,000 locations, at 30-min intervals from 15 female wild boar (1689-12,735 positions per individual), all from different groups, with a 72% success rate. We did not adjust the analysis due to failed attempts for acquiring positions. For details about animal handling procedures and GIS methods please see Thurfjell et al. (2009). We matched each location with a land cover, road crossing (if a line between consecutive locations intersected a road from one