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Faunal mortality on roads due to religious tourism across time and space in protected areas: A case study from south India

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ABSTRACT

The presence of roads in any landscape is known to negatively influence terrestrial and aquatic ecosystems. Many tourist destinations and religious enclaves in developing countries are inside protected areas (PA). They are well connected by roads and attract thousands of visitors. The effect of such large human congregations inside PA on biodiversity is not well understood. Here, we address the impacts of increased vehicular traffic due to religious tourism on local fauna inside the Kalakad Mundanthurai Tiger Reserve in south India. We sampled sections of surfaced roads for mortalities before and during an annual festival across three habitats in 2008 and 2009. Millipedes, anurans, insects and reptiles dominated the mortalities and mammals avoided the roads. A total of 1413 individuals belonging to 56 species were killed on roads. Nocturnal species constituted 50% of these mortalities and 64% of the species composition. There was a 299% increase in road mortalities and 648% increase in nocturnal species mortality during the festival compared to those before the festival. Mean mortalities varied across habitats and were highest in moist deciduous forests. Mortalities were influenced significantly by vehicular traffic rather than rainfall. Indications of a temporary local extinction were evident beyond certain threshold of vehicular movement. The number of vehicles plying on the roads was three times higher than the threshold level as determined in this study. The festival also had a spillover effect by causing increased mortalities on roads not connected to the temple. We discuss several strategies to minimize impacts due to large scale vehicular movement inside protected areas.

1. Introduction

Roads are both important and integral part of development. Connectivity being a priority, large areas of pristine habitats has been sacrificed for laying roads resulting in several direct and indirect negative impacts on ecosystems (Goosem, 2007). Fragmentation of habitat by roads and the frequent passage of vehicles on them act as physical barriers for species dispersal across a range of taxa (Carr and Fahrig, 2001; Goosem, 2007; Laurance, 2004; Ree et al., 2009). Animal abundance and population structure is often negatively affected by road mortalities resulting from frequent vehicular movement (Fahrig and Rytwinski, 2009). These effects of roads are not limited to the road itself but often extended to varying distances perpendicular to the road (Forman and Deblinger, 2000; Eigenbrod et al., 2009; Trombulak and Frissell, 2000).

Road mortalities are primarily influenced by habitat variability along the road corridor (Inbar and Mayer, 1999; Seshadri et al., 2009). Seasonality of climate in general and rainfall in particular is an important factor that influences mortalities of certain taxonomic groups like amphibians by timing and triggering reproductive activity and dispersal (Duellman and Trueb, 1994; Vijaykumar et al., 2001). Vehicular movements at night are considered to substantially increase the mortality in certain nocturnal animals like amphibians (Mazerolle, 2004). The possible synergistic effects of the two aforementioned factors could increase negative impacts on populations.

High densities of roads passing through protected areas (PA) often result in mortality of large bodied animals. Much attention is given to understanding and mitigating the impact of roads through PAs on these animals as roads experience some form of traffic all through the year (e.g. Grosman et al., 2009; McLellan et al., 1999; Mech, 1989). Unlike in many developed countries, relatively large proportion of the traditional religious enclaves and scenic landscapes in Asia including India are located inside PAs. These areas attract millions pilgrims and tourists to the PA which brings additional seasonal traffic; the impact of which, on fauna, is not known. Sudden surge in traffic through forest areas can push populations of large animals away from the disturbance area but, smaller organisms that do not show such quick adaptive responses are often killed (Goosem, 2007; Rao and Girish, 2007). We have no clear understanding on how additional vehicular traffic affect these

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organisms in terms of the habitat they use, behavior of the species and their populations.

Vehicular densities on Indian roads have increased from 0.3 to 30 million in the last 50 years and many of them pass through PA and non-PAs (Raman, 2009; Seshadri et al., 2009). The Western Ghats of India which is a global biodiversity hotspot is known for high endemism among reptiles and amphibians. There are few scientific studies in India on the impact of these roads inside PA's and except for three which investigate road mortalities in relation to habitat (Seshadri et al., 2009; Rao and Girish, 2007; Vijaykumar et al., 2001), others only documented species killed on roads due to vehicular movements (Baskaran and Boominathan, 2010; Chhangani, 2004; Gokula, 1997; Kumara et al., 2000). Moreover these studies are taxa specific and no attempt was made to document the wide range of taxa killed on the roads. In the hilly areas such as the Western Ghats where the diversity is high and mainly comprises of smaller animals from a variety of taxa, documenting the species and individuals killed across taxa becomes important to understand the effects of road traffic on biodiversity loss.

Current protected area management regulates the entry of vehicles into PAs but during tourist seasons such practices are relaxed, especially in developing countries due to public and political pressures. This is often due to inadequate knowledge and awareness on the impacts such high density traffic have on the native biota and ways to negate it. Even though the issues highlighted above are common across several countries it may need site specific solutions for conservation action. The aim of this study is to identify the impacts of increased vehicular movement on fauna due to religious tourism inside the Kalakad Mundanthurai Tiger Reserve a protected area in the Western Ghats. It addresses the following specific objectives:

1. Compare and contrast the diurnal and nocturnal species composition and mortality rate of fauna killed on the roads before and during the festival.
2. Identify habitats and microhabitats that are prone to high faunal mortality.
3. Quantify the impacts of and rainfall on road mortalities of vertebrate, invertebrate, diurnal and nocturnal species.

2. Study area

Kalakad Mundanthurai Tiger Reserve (KMTR), 895 km^2 (8°25′–8°53′ N and 77°10′–77°35′ E) is located in the south Indian state of Tamil Nadu. It comprises a matrix of habitats ranging from thorny scrub to the wet evergreen forests thus sustaining a high diversity of flora and fauna (Johnsingh, 2001). KMTR experiences two monsoon seasons; the southwest (June to September) and the northeast (October to January) with annual rainfall ranging from 3000 mm in the western parts to about 750 mm on the eastern parts (Ishwar et al., 2001). The elevation of the reserve ranges from 100 to over 1900 m amsl.

There are 28 enclaves in form of dam sites, waterfalls, religious sites and human settlements inside the reserve and the road network connecting these are utilized by public and private vehicles for occupation, tourism and religious and cultural activities (Ali and Pai, 2001). Among these enclaves, the religious sites attract a large influx of people and vehicles during annual temple festivals. The *Sorimuthian* temple, where one such festival celebrated annually during July to August, is situated on the banks of river *Tamiraparani* inside the tiger reserve. It attracts a regular flow of pilgrims and tourists in low numbers (ca.20 vehicles/day) all through the year. The road network (Fig. 1) leading to this enclave passes through rocky scrub and thorn forest from *Papanasam* till *lower camp* and later through moist deciduous forest to the temple. *Banatheertham*, a water cascade at *Karaiyar* located past the temple area is a tourist site and the road passes through the unique dry evergreen forests. *Servalar* is a dam site located away from the temple area and the road passes through moist deciduous forest. *Mundanthurai* is the junction where the roads meet.

Many of the pilgrims to the *Sorimuthian temple* visit *Banatheertham* during the festival but not to *Servalar*. The festival is celebrated during the new moon day and varies every year depending on the lunar calendar. Nearly 0.2 million people congregate for 10 days, construct temporary houses to reside in the forest around the temple, park vehicles in the forest and use the river water for domestic and recreational purposes. Entry of vehicles into the reserve is controlled by imposing a nominal entry fee and vehicle entry is banned during night hours for the general public. The roads are open to regular buses and bonafide users of the enclaves. However, during the festival, in order to cope up with the large influx of vehicles all restrictions are removed and vehicles are free to enter. This results in an increase in vehicular traffic on roads leading to the temple during the festival compared to the regular traffic on non-festival days (ca.70 vehicles/h and ca.5 vehicles/h, respectively). As the roads leading to Temple, *Karaiyar* and *Servalar* experience varying levels of vehicular movement (pers. obs.) and pass through different habitats; they were chosen for this study (Table 1).

2.1. Sampling

Hundred meter segments of the road were sampled for road mortalities at every 0.5 km on all road sections. The segments were permanently marked using tags on tree and white paint on roads. The number of segments sampled depended on the total length of the road in each habitat (Table 1). Sampling was done three days prior to and three days during the festival with one day gap in between. The survey was started at 06:00 h to avoid the possibility of road kills being macerated and hampering identification because of repeated vehicular movement and to reduce incidents of dead animals being picked by birds and other scavengers (Goosem, 2007).

The survey was carried out by a team of two persons walking the road segment and documenting road mortalities. Three different teams carried out the sampling simultaneously every morning in different habitats and the species and the number of individuals killed in each segment were recorded. The carcasses were photographed with a digital camera (Canon S5IS) when their identity was ambiguous. All the carcasses were removed and scraped out from the road using forceps in order to avoid recounting it during the next sampling session. The road segments passing through human settlements were not sampled as they might have influenced the species composition and mortality. Road mortalities were recorded only if they were on the surfaced part of the road and not beyond it. The mortalities were identified to the lowest possible level and classified as either nocturnal or diurnal using field guides for respective taxa (Das, 2002; Ganesh et al., 2010; Prater, 1997; Narendra and Kumar, 2006; Whitaker and Captain, 2004). Due to lack of information on invertebrates and the macerated condition of carcasses, they were identified only up to genus level or as taxonomically recognizable units. Only a few were identified to species level. The road mortalities were pooled and standardized to individuals per kilometer (ind./km) for before and during the festival for the two years of sampling.

The vehicular density data was obtained from another study conducted at the same time in the reserve (Prashanth and Ganesh, 2010). Data on animal movement was also taken from another study where two observers moved at 20 kmph on a motor bike between 21:00 h and 00:00 h on all road sections and all animals detected within 50 m of the road were recorded (Goswami et al., 2010). Daily rainfall data was obtained from the *Papanasam*,