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Monitoring wildlife crossing structures along highways in Changbai Mountain, China

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ABSTRACT

In China, the construction and monitoring of wildlife crossing structures is uncommon. Mountainous area occupies two-thirds area of China. A lot of tunnels (similar to overpasses in developed countries), bridges, and culverts (similar to underpasses) are constructed along highways. In general, these structures are multifunctional, including wildlife migration. However, studies on monitoring these potential crossing structures are almost vacant. Taking two highways in Changbai Mountain area as case studies, infra-red camera trapping and snow tracking were used to investigate the efficiency of tunnels, bridges and culverts on the highways. A total of 13 medium and large-sized wildlife species crossed highway through tunnels, bridges and culverts. One third of species were Chinese national protective species, and almost all species were present within 500 m from Ring Changbai Mountain Scenic highway used bridges and culverts to cross this highway. The tunnel along the expressway (length = 1000 m) and the bridges along the highway (width > 8 m) have been important passages for ungulates, Eurasian red squirrels (*Sciurus vulgaris*), yellow throated martens (*Martes flavigula*) and sables (*Martes zibellina*). Different species preferred to different types of structures, although most species preferred to bridges and tunnels. We suggest that short fences should be set around the bridges and culverts to guide animals to cross the passages, especially for ungulates. Monitoring programs of uses of crossing structures by wildlife should be conducted for at least 2 months to catch most species activity.

1. Introduction

The impact of roads on wildlife has been recognized widely in Europe, North America and Australia. The primary negative impacts include (1) road mortality (Glista et al., 2009; Baskaran and Boominathan, 2010; Wang et al., 2013a; Kušta et al., 2014a,b), (2) changes in wildlife migratory routes caused by roads and vehicles (Hoeven et al., 2009; Neumann et al., 2012), (3) barrier effects that restrict wildlife activity and gene flow (Gerlach and Musolf, 2000; Shepard et al., 2008), (4) changes in roadside environment (Ascensao et al., 2012), (5) deteriorate and fragmentation of wildlife habitats (Ortega and Capen, 1999; T.A. Li et al., 2010; Z.X. Li et al., 2010). Some positive effects including creating roadside habitat for some species (Meunier et al., 2000), and serving as corridors that may improve the move ability of some species (Laursen, 1981).

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The main measures to mitigate these negative impacts include locating the suitable road network planning (Rhodes et al., 2014), and building different types of wildlife crossing structures, commonly, which consist of overpasses and underpasses, with long-term monitoring programs (Iuell et al., 2003; Ng et al., 2004; Grilo et al., 2008; Olsson et al., 2008; Ford et al., 2009). The first comprehensive and systematic manual for design and evaluation of wildlife crossing structure was published by Federal Highway Administration of USA in 2011 (Clevenger and Huijser, 2011). Globally, although presently almost all studies prove that wildlife crossing structures contribute to the movement of wildlife along roads and improve the stability of wildlife population, the study on monitoring of wildlife crossing structures is limited (Glista et al., 2009), particularly in developing countries.

In China, presently only 3 studies focus on monitoring wildlife crossing structures. The first is to monitor wildlife crossing structures along Qinghai-Tibet Railway by the video cameras and observation (Xia et al., 2007). The second is to monitor Asian Elephant underpass along Simao-Xiaomengyang expressway in Yunnan Province by track transecting, rural surveys and direct monitoring (Pan et al., 2009), and the third is to monitor underpass along Ring Changbai Mountain Scenic highway by snow tracking (Wang et al., 2013b). As one of the richest biodiversity countries in the world, China has many endemic wildlife species (Liu et al., 2003). Presently, road construction is spreading over the wide west areas, which is sensitive and fragile, it is urgent to initiate the construction and monitoring of wildlife crossing structures (Kong et al., 2013).

Changbai Mountain Nature Reserve, a member of the International Man and Biosphere Reserve Network, is rich in fauna resource, and is the main habitat for Amur Tiger (*Panthera tigris altaica*) historically (Piao et al., 2011). Local Department of Transportation (DOT) plans to accelerate the construction of road network in the future. It is important to study the impacts of road construction on wildlife during highway construction and provide the protective measures. Recent years, Chinese government plans to restore the Amur Tiger passage/corridor in Changbai Mountain area, and restore the habitat inside and around Changbai Mountain Nature Reserve (Z.X. Li et al., 2010). Therefore, the tunnels and bridges and culverts along the highway and the expressway in Changbai Mountain Area are extreme important passages to wildlife movements.

Infra-red camera trapping technology has been used successfully to monitor many species of elusive animals in remote areas (Samejima et al., 2012; Wang et al., 2014). The advantages of the technology include self-contained systems operating unattended for extended periods of time that are capable of 24 h a day monitoring and recording high resolution photos. Infra-red cameras are especially valuable for monitoring species of wildlife which are highly sensitive to human presence. It is regarded as a method superior to sand beds for long-term monitoring, because of its low labor cost and high reliability (Ford et al., 2009). In addition, photographs of wildlife taken during monitoring studies have the advantage of generating more interest in wildlife to public (Ford et al., 2009; Clevenger and Huijser, 2011). Using infra-red camera trapping technology to monitor the wildlife crossing structures in Changbai Mountain area is in vacant, so we will use this method to monitor the uses of crossing structures by wildlife.

The aim of this study is twofold: (1) to determine what species uses wildlife crossing structures to cross the highway, the frequency, and time of crossings; (2) to investigate species specific preference of crossing structures. This is the first study to monitor wildlife movements through a tunnel along expressway using infra-red camera surveillance technology in China.

2. Materials and methods

2.1. Research area

Changbai Mountain National Nature Reserve is located in the Southeast of the Jilin province, across the Antu County of Yanbian Korean Autonomous Prefecture, Fusong County and Changbai County of Hunjiang Area, adjacent to North Korea. The Nature Reserve lies between E 127°42′55″-128°16′48″ and N 41°41′49″-42°51′18″, covering a total area of 196465 ha. The study area experiences a monsoon continental mountainous climate, with long, cold winter and short, warm and humid summer. Changbai Mountain is one of the largest volcanic areas of East Asia, with a volcanic lava tectonic geomorphology, water landscapes, glaciers, and periglacial landforms. Changbai Mountain Reserve is a member of the International Man and Biosphere Reserve Network, and is one of the richest biodiversity regions in China. There are more than 1225 fauna species in the region, with 59 species declared as national key protected species, mainly including the sable (*Martes zibellina*), Siberian roe deer (*Capreolus pygargus*), and Siberian weasel (*Mustela sibirica*). Additionally, the Amur tiger historically inhabited this area (Chen et al., 2010).

The main wildlife species occur along roadside areas in and around Changbai Mountain Nature Reserve are Siberian roe deer, Siberian weasel, Manchurian hare (*Lepus mandschuricus*), wild boar (*Sus scrofa*), Eurasian red squirrel (*Sciurus vulgaris*), sable, red deer (*Cervus elaphus*), Asian badger (*Meles leucurus*), Amur hedgehog (*Erinaceus amurensis*), and others rodent species (Piao and Shen, 2009). Manchurian hare is nocturnal, same as sable which the home range can be 5–10 km^2. Asian badger is nocturnal, and is active mainly in spring, summer and autumn, and hibernates in winter. Wild boar, red deer, and sika deer (*Cervus nippon*) exhibit seasonal movements between high elevation in summer and bottom of valley in winter. Siberian roe deer mainly act in dawn and sunset (Piao et al., 2013).

The JiYan expressway is a fenced, four-lane expressway, which began operation in September 2008. The expressway bisects two National Nature Reserves: the Changbai Mountain Nature Reserve and Wangqing Nature Reserve. Wildlife crossing structures along the expressway are vital to maintain wildlife movements between the two reserves. The 1000 m length