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Study on Crossing Tendencies of Birds by Road Type for Validation of Wildlife Crossing Structures Targeting Avian Species

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Abstract

The purpose of this study is to compare the bird crossing of roads by type (Expressway 1, railroad-provincial road and Highway 4) and the crossing of roads according to the size of birds. The greatest number of avian species and individuals crossing road per 10 minutes were found on railroad-provincial road (8.96±1.92 and 29.33±11.94, respectively), while the lowest number of avian species and individuals were found on Expressway 1 (2.96±1.04 and 6.13±2.89, respectively), which has the widest width. In addition, the number of small-sized bird (<20 cm) crossing the Expressway 1, railroad-provincial road, and Highway 4 was lower than that of the medium-sized bird (≥20 cm). Current wildlife crossing structures have been focused on mammals, amphibians and reptiles, but future structures should also consider birds.

Key Words: wildlife crossing structure, avian species, birds, road, habitat fragmentation

Introduction

Roads have developed with mankind for a long time, and as transportation infrastructure has become diversified in recent years, types of transportation have also been varied (Ullman 1956; Coffin 2007). The development of roads has various economic and cultural functions, and has a great influence on economic growth and industrialization (Kansky 1963; Taaffe 1996; Coffin 2007). However, habitat fragmentation and habitat loss due to the development of transportation are not specific to a particular species, but rather affect various species of different taxa (Keller and Pfister 1997; Villard et al. 1999; Fahrig 2003; Forman et al. 2003; Keller and Largiader 2003; Stephens et al. 2004). In addition, noise, vibration, and night lighting caused by transportation infrastructure can also affect wildlife population density, migration, and breeding, resulting in habitat fragmentation (Forman and Deblinger 2000; Trombulak and Frissell 2000; Forman et al. 2003; Coffin 2007).

Roads generate road kills for most species, including birds (Forman and Deblinger 2000; Kocciolek et al. 2011). In the United States, approximately 80 million birds per year are road killed each year (Erickson et al. 2005). Moreover, edge effect causes changes in birds' movement

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range, resource availability, and breeding success (Angelstam 1986; Magura 2002; Batary and Baldi 2004; Kociolek et al. 2011). While the road has many negative impacts on ecology of birds, the positive aspect is that the surface heat of the road reduces the metabolic costs while they are resting on the road (Whitford 1985; Kociolek et al. 2011) and also the road infrastructure provides secure areas for nest building (Forman and Deblinger 2000; Kocciolek et al. 2011). Therefore, it is predicted that there will be a change in frequency and distribution of birds crossing the road due to changes in the habitat environment depending on the road.

Wildlife crossing structures are artificial structures that connect fragmented ecosystems caused by roads and railroads, and are designed to allow wild animals to cross roads without touching the actual road surface (Soule and Gilpin 1991; Macdonald 2003; Korean Ministry of Environment 2010). The guideline for design and management of wildlife crossing structure in Korea has specified the standards for installation and maintenance of wildlife crossing structures and fences; however, this guideline only considers mammals, amphibians and reptiles (Korean Ministry of Environment 2010). Although there are more than 470 wildlife crossing structures installed in the Republic of Korea (National Institute of Ecology 2016), there is very low number of wildlife crossing structures installed for bird usage.

The purpose of this study is to analyze the validation of wildlife crossing structure targeting avian species by 1) the number of species and number of individuals that cross roads according to road type, and 2) the number of individuals that cross roads according to bird size.

Materials and Methods

Study areas

The Expressway 1 (36°12'11.59 "N, 128°0'4.94" E), the Gyeongbu railroad-provincial road (36°12'7.49"N, 128°0' 17.41"E), and Highway 4 (36°12'9.02 "N, 128°0'26.14" E) are located in Gimcheon city, which is the fragmentation area of Baekdudaegan Mountains. The Expressway 1 was constructed 40 m wide with 6 lanes, and the Highway 4 was constructed with a width of 22 m by four lanes. The railroad-provincial road is 35 m wide with each two lanes, and

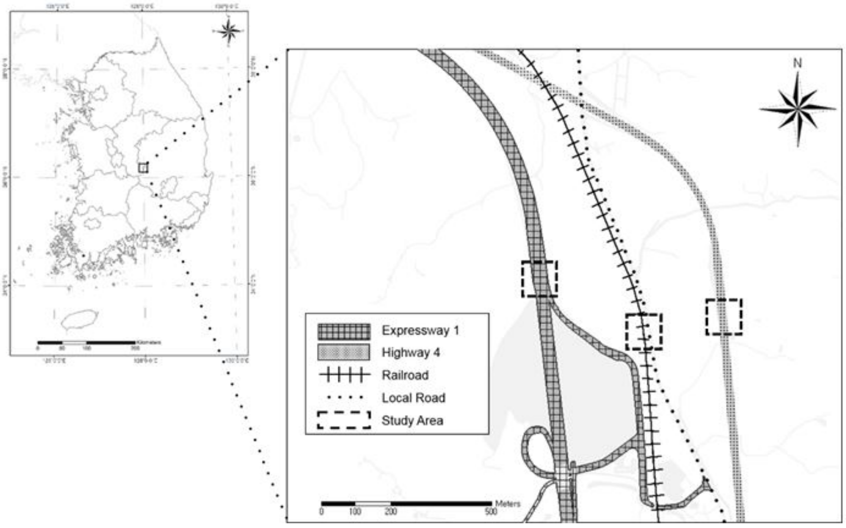

Fig. 1. Map of road type in study area.

Table 1. Studied road type and status

Study area	Location	Construction year	Road Width (m)	Study dates
Gimcheon city	Expressway 1	1970	40	June 27, 28, 29, July 25, 26,
	Railroad- provincial road	1905	35	27, Aug. 29, 30, Sep. 12,
	Highway 4	2010	22	13, Oct. 17, 18

there is a 12 m wide green area between the railroad and provincial road (Fig. 1).

Research and analysis methods

In order to monitor the crossing of wild birds, the study was carried out from June to October, 2017, two hours after sunrise (06:00-08:00) and two hours before sunset (17:00-19:00) when birds are known to be most active (Smith et al. 1995; Park et al. 2011) (Fig. 1). In June and July of 2017, three surveys were conducted, and two surveys were conducted in August, September and October. The survey was carried out at the same time with three experts on the road side where the road crossing of the bird was visible (Fig. 1). The number of species and the number of individuals were investigated by counts of all birds seen using binoculars (Nikon 10×42°10) and by bird calls (Huff et al. 2000).

Post hoc Scheffe test analysis was conducted to compare the number of species and individuals of the birds crossing

Table 2. Number of species and individuals per 10 minute among Expressway 1, railroad-provincial road, Highway 4 crossing road in study area

Family	Scientific name	Study Area		
		Expressway	R-P road	Highway
Phasianidae	*Phasianus colchicus**			0.04±0.20
Ardeidae	*Butorides striata**		0.04±0.20	
Columbidae	*Streptopelia orientalis**	2.83±1.93^A	9.17±3.53^B	2.79±1.67^A
Cuculidae	*Cuculus canorus**		0.04±0.20	0.04±0.20
Picidae	*Dendrocopos kizuki*		0.25±0.53^B	0.04±0.20^AB
	*Dendrocopos leucotos**		0.17±0.48	0.04±0.20
	*Dendrocopos major**	0.04±0.20^A	0.58±0.78^B	0.17±0.48^A
	*Picus canus**	0.04±0.20	0.71±1.04	
Laniidae	*Lanius bucephalus*		0.08±0.28	0.04±0.20
Oriolidae	*Oriolus chinensis**		3.25±3.45^B	0.46±0.72^A
Corvidae	*Garrulus glandarius**	0.63±0.88^A	3.21±2.19^B	0.63±0.82^A
	*Pica pica**	1.67±1.20^A	1.25±1.65^A	0.33±0.70^B
	*Corvus corone**	0.38±0.77	0.50±0.66	0.29±0.62
	*Corvus macrorhynchos**	0.08±0.28	0.21±0.51	0.04±0.20
Paridae	*Parus major*	0.13±0.34^A	2.79±2.54^B	1.58±2.06^B
	Parus ater		0.04±0.20	
	Parus varius		0.25±0.53	0.29±0.55
	Parus palustris		0.79±1.56^B	0.42±0.65^AB
Aegithalidae	*Aegithalos caudatus*		0.04±0.20^AB	0.42±0.88^B
Panuridae	*Paradoxornis webbianus*			0.38±0.58^B
Pycnonotidaewsx	*Microscelis amaurotis**	0.33±0.56^A	3.92±2.60^B	1.38±1.41^A
Sturnidae	*Sturnus cineraceus**			0.13±0.34
Turdidae	*Turdus hortulorum**		0.04±0.20	
	*Turdus pallidus**			0.08±0.28
Stenostiridae	*Phoenicurus auroreus*		0.33±0.76	0.08±0.28
Ploceidae	*Passer montanus*		1.46±1.02^B	1.63±1.17^B
Motacillidae	*Motacilla cinerea*		0.04±0.20	0.04±0.20
Fringillidae	*Fringilla montifringilla*		0.04±0.20	
	Carduelis sinica		0.04±0.20	
Emberizidae	*Emberiza elegans*		0.08±0.28^AB	0.29±0.62^B
	Number of species	2.96±1.04^A	8.96±1.92^B	6.25±1.82^C
	Number of individuals	6.13±2.89^A	29.33±11.94^B	11.63±4.92^A

Number of individuals (mean±SD), $p < 0.05$, post hoc Scheffe test. Different character at the upper number represents the difference.
*represents the birds size 20 cm.

the Expressway 1, railroad-provincial road, and Highway 4 (Keppel and Wickens 2004). In addition, T-test analysis was conducted to compare the crossing of the birds and the crossing of the bird below 20 cm and over 20 cm in size (Johnson and Jones 2017).

Results and Discussion

Total number of 30 species were identified to cross the Expressway 1, railroad-provincial road, and Highway 4. On Expressway 1, nine species were discovered: species with the most number of crossings per 10 minutes were *Streptopelia orientalis* and *Pica pica*, and the least number of crossings were *Dendrocopos major* and *Picus canus*. On railroad-provincial road, 26 species were discovered: species with the greatest number of crossings were *Streptopelia orientalis* and *Microscelis amauroti*, and the lowest number of crossings were *Motacilla cinerea*, *Fringilla montifringilla*, *Aegithalos caudatus*, and five other species. On Highway 4, 24 species were identified including: species with the most number of crossings were *Streptopelia orientalis* and *Passer montanus*, and the least number of crossings were *Phasianus colchicus*, *Corvus macrorhynchos*, *Dendrocopos leucotos*, and four other species (Table 2).

Total number of 14 species showed statistically significant differences (post hoc Scheffe test, $p < 0.05$) when comparing road crossings by road type. Comparison of Expressway 1 and Highway 4 by road crossings per 10 minutes, six species resulted in non-significant values. However, the comparisons of six species between Expressway 1 and railroad-provincial road and between railroad-provincial and Highway 4 showed significant statistics. The six species on railroad-provincial road had the largest number of road crossings. *Pica pica* and *Paradoxornis webbianus* had the highest number of crossings on Highway 4 compared to other road types. Two species including *Parus major* and *Passer montanus* had the lowerst number of road crossings on Expressway 1. *Emberiza elegans* and *Aegithalos caudatus* showed lower number of road crossing on Expressway 1 than on Highway 4, while the numbers of these species discovered on the railroad-provincial road were statistically equal to other road types (non-significant). *Dendrocopos kizuki* and *Parus palustris* showed 0.25±SD 0.53 and 0.79±SD 1.56 individuals crossing on the railroad-provincial road, while the number of these species discovered on Highway 4 were statically equal to other road types (non-significant).

The number of species crossing road per 10 minutes was discovered highest to lowest from railroad-provincial road, Highway 4 and Expressway 1. The total width of the railroad-provincial road is 35 m and the 12 m wide green area between railroad and provincial road is considered to be the important area for the bird crossings. On Expressway 1, which has the greatest width, the lowest number of species and individuals were identified, 2.96±SD 1.04 and 6.13±SD 2.89, respectively. The results of the Expressway 1 and the Highway 4 showed non-significant values ($p=0.051$), however Bonferroni adjustment and Duncan's test showed significant differences ($p < 0.05$) (Miller 1981; Moran 2003).

On Highway 4 and railroad-provincial road, average crossings of individuals per 10 minutes was higher in medium-sized species (≥20 cm) than in small avian species (<20 cm). However, the results on Highway 4 was non-significant. In the case of Expressway 1, 0.38±SD 1.00 individuals bigger than 20 cm crossed per 10 minutes, while only 0.01±SD 0.09 individuals smaller than 20 cm crossed. On railroad-provincial road, species bigger than 20 cm crossed with 1.44±SD 2.85 individuals and 0.45±SD 2.85 individuals smaller than 20 cm crossed (Fig. 2). Park (2011) stated that species smaller than 20 cm such as *Paradoxornis webbianus, Parus major, Parus palustris, Parus varius*, etc. avoid road crossing and mostly cross the roads using wildlife crossing structures.

Thinh (2012) noted that a narrow road in the forest could inhibit dispersal of understory birds. Choi (2017) has

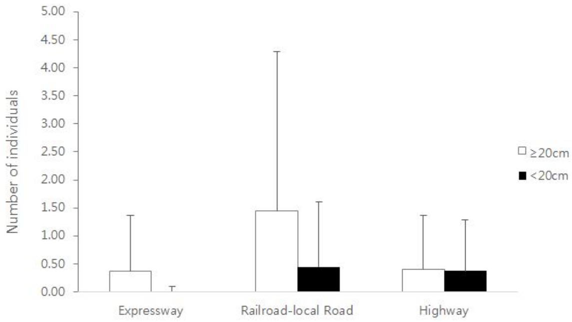

Fig. 2. Number of individuals crossing per 10 minutes between bird size and road type in this study (T-test, $0.05 < p$).

discovered that the birds of the order Passeriformes prefer shrubbery and avoid road crossing. In a study by Johnson and Jones (2017), small birds (<20 cm) were less likely to cross the road than those of medium (20-29 cm) and large (30 cm<) birds. Park (2011) studied road crossing of birds near wildlife crossing structures and he discovered more species and individual crossings near 90m wide wildlife crossing structures than on near 15 m wildlife crossing structures. Consideration of vegetation inside the wildlife crossing structure for future construction plans could encourage bird crossings (Clevenger and Huijer 2009). Moreover, the overpass type structure could provide the shortest pathway for birds, as well as decreasing mortality rate (Trocme et al. 2003). Based on the findings of this study, it can be concluded that more efficient wildlife crossing structures need to consider mammals, amphibians, reptiles, and as well as avian species. We believe that the consideration of all size of birds in the planning of future wildlife crossing structures would benefit the conservation of wildlife in Korea.

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