Short Communication
pISSN: 2288-9744, eISSN: 2288-9752
Journal of Forest and Environmental Science
Vol. 35, No. 4, pp. 281-284, December, 2019
https://doi.org/10.7747/JFES.2019.35.4.281

JFES
Journal of Forest and Environmental Science

Korea Road-Kill Observation System: The First Case to Integrate Road-Kill Data in National Scale by Government

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Abstract

Efficient management of road-kill data is difficult at national scale when there are many organizations that are in charge of different road types. Here, we described the first case to integrate road-kill data through Korea Road-kill Observation System (KROS) by the Korean government. The system was launched in June 2018 to approximately 3,000 road menders. During 15 months, 5,812 road-kill observations were registered on KROS including mammals, birds, reptiles and amphibians. Of them, about 86 % was occupied by five species (*Hydropotes inermis*, *Felis catus*, *Capreolus pygargus*, *Nyctereutes procyonoides*, and *Canis lupus familiaris*) listed in number of occurrences. The observed road-kill frequency rapidly increased until April 2019 and peaked on May 2019. However, as the system is just starting, the results from KROS cannot be treated as the exact representation of road-kill trend in the country. Although the efficient method to manage national road-kill statistic is arranged, still there are some limitations to overcome to make the system stable.

Key Words: road-kills, road-kill observation system, mitigation plan, road-kill hotspot, road menders

Introduction

Road-kill mitigation measures, such as wildlife crossings and fences, are generally known to be crucial to reduce collisions at road-kill hotspots (Huijser et al. 2007; Langen et al. 2012). Understanding overall road-kill trend and planning efficient road-kill mitigation measures at national scale largely depend on data collection methods and data quality. For instance, identifying the appropriate location to install such measures or making a plan at certain road sections would be laborious when road-kill data are scattered by various management agencies.

In the Republic of Korea, it has been continuously pointed out that unification of managing road-kill data and research on road-kill mitigation measures are necessary in the whole range of the country (Fig. 1). As a result, an estab-

Received: September 19, 2019. Revised: December 2, 2019. Accepted: December 4, 2019.

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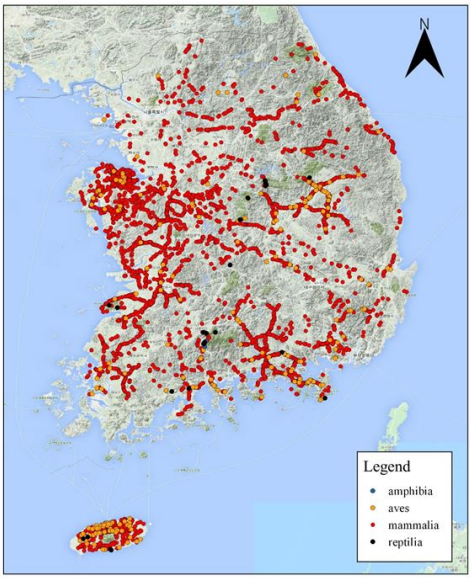

Fig. 1. Map of study area with KROS registered sites.

lished guideline named "Guideline of road-kill survey and management" has been enacted by the Ministry of Environment (MOE) and the Ministry of Land, Infrastructure and Transport (MOLIT) on May 28 2018, to solve the problem. Based on the established guideline, the National Institute of Ecology (NIE) was commissioned by the Ministry of Environment to integrate and manage scattered road-kill data, which led to the launch of the Korea Road-kill Observation System (KROS, ecobank.nie.re.kr/goodroad) in June, 2018.

There are other countries which have their own road-kill observation system. For exampl Sweden, the Swedish National police operates the National Wildlife Accident Council (www.viltolycka/hem/). It has the largest collection with over 200,000 records of road-kill in the last five years. It also has data as early as 1985 and online reporting and data display service has been operating since 2010. Data collection is through website and apps with real-time map of online road-kill. Another case Belgium, Natuurpunt of Belgium has been operating Animals under the Wheels (http://waarnemingen.be) since 2013 and has over 14,000 road-kill observations. Data collection is through online registration by researchers and volunteers by website and apps. The two most used road-kill management systems in the United States are California Roadkill Observation System (CROS; http://wildlifecrossing.net) and Idaho Fish and Wildlife Information System (IFWIS). UC Davis Road Ecology Center operates CROS since 2009 and it is one of the first in the world to use web reporting of road-kill with over 30,000 entries. Regular updates up to 30 and 90 days on a map of road-kill and entries are searched by species with pictures and observation information. The Idaho Department of Fish and Game operates the IFWIS since 2011 and has over 22,000 entries as of October 2014. Data collection is through website by registered users (Van et al. 2015).

KROS is the first management agency to integrate scattered road-kill data into one database system designated by the central government. We hope the KROS will enable efficient management and collection of road-kill data, as well as identification of road-kill hotspots by analyzing the collected data, and thus suggest practical road-kill mitigation measures in various environments at national scale. Our future plan is to investigate road-kill hotspots using the data collected by our system at national scale and to suggest and encourage municipalities to set appropriate mitigation measures at priority locations. Road-kill hotspots will be identified every year considering changes in population density or size in local areas (Zimmermann et al. 2017).

Materials and Methods

We developed a smartphone application that is linked with the website (KROS), and released the application to approximately 3,000 road menders affiliated in Korea Expressway Cooperation (national and private-funded expressway), Ministry of Land, Infrastructure, and Transport (highways), and Local municipals (provincial, city and other minor roads) who are in charge of removing dead animals on the roads. We asked road menders to take pictures whenever carcass is found while their work. When they take pictures, location and time information are recorded and conveyed to our website in real-time with the taken photos. When each data is collected into our system, professional wildlife researchers identify the species at the website.

Results and Discussion

During the 15 months of study from June 2018 to September 2019, 5,812 road-kills were collected into our

Table 1. Number of road-kills registered on KROS by species

Class	Scientific name	Number of road-kills
Amphibia	*Bufo gargarizans*	2 (0.03%)
	Pelophylax nigromaculatus	2 (0.03%)
Aves	*Corvus dauuricus*	1 (0.02%)
	Parus varius	1 (0.02%)
	Troglodytes troglodytes	1 (0.02%)
	Corvus corone	29 (0.5%)
	Pica pica	17 (0.29%)
	Phasianus colchicus	93 (1.6%)
	Gallus gallus domesticus	8 (0.14%)
	Aegypius monachus	1 (0.02%)
	Phoenicurus auroreus	1 (0.02%)
	Buteo buteo	2 (0.03%)
	Lyrurus tetrix	1 (0.02%)
	Streptopelia orientalis	19 (0.33%)
	Cyanopica cyanus	4 (0.07%)
	Monticola solitarius	1 (0.02%)
	Sinosuthora webbiana	1 (0.02%)
	Accipiter nisus	2 (0.03%)
	Ninox scutulata	1 (0.02%)
	Gallinula chloropus	1 (0.02%)
	Bubo bubo	22 (0.38%)
	Strix aluco	2 (0.03%)
	Ardea cinerea	3 (0.05%)
	Hypsipetes amaurotis	3 (0.05%)
	Columba livia	8 (0.14%)
	Accipiter gentilis	1 (0.02%)
	Passer montanus	2 (0.03%)
	Picus canus	1 (0.02%)
	Zoothera dauma	1 (0.02%)
	Falco tinnunculus	1 (0.02%)
	Turdus pallidus	2 (0.03%)
	Anas poecilorhyncha	6 (0.1%)
	Unidentified species	16 (0.28%)
Reptilia	*Elaphe schrenckii*	1 (0.02%)
	Gloydius saxatilis	1 (0.02%)
	Elaphe dione	6 (0.1%)
	Dinodon rufozonatum	4 (0.07%)
	Gloydius blomhoffii	4 (0.07%)
	Gloydius ussuriensis	3 (0.05%)
	Rhabdophis tigrinus	4 (0.07%)
	Unidentified species	5 (0.09%)
Mammalia	*Canis lupus familiaris*	281 (4.84%)
	Hydropotes inermis	2,606 (44.84%)
	Felis catus	1,228 (21.13%)
	Nyctereutes procyonoides	454 (7.81%)
	Capreolus pygargus	420 (7.23%)
	Eutamias sibiricus	37 (0.64%)
	Martes flavigula	2 (0.03%)
	Mogera robusta	3 (0.05%)
	Apodemus agrarius	1 (0.02%)
	Sus scrofa	44 (0.76%)
	Lepus coreanus	46 (0.79%)
	Prionailurus bengalensis	92 (1.58%)
	Lutra lutra	49 (0.84%)
	Capra aegagrus hircus	1 (0.02%)
	Meles leucurus	72 (1.24%)
	Mustela sibirica	84 (1.45%)
	Rattus norvegicus	2 (0.03%)
	Sciurus vulgaris	19 (0.33%)
	Unidentified species	87 (1.5%)

system (KROS) including 19 mammalian species, 31 bird species, 8 reptiles and 2 amphibians (Table 1). Of them, 12 were identified as species that are designated as endangered or natural monument. The five species most frequently observed were *Hydropotes inermis*, *Felis catus*, *Capreolus pygargus*, *Nyctereutes procyonoides*, and *Canis lupus familiaris*, in order of frequency (Table 1), and they occupied about 86 % of the total collected data.

Road-kills were found mostly in Highways, Provincial roads, and National expressway, listed in higher frequency (Table 2). In Highways, the most frequent species observed were *Hydropotes inermis*, *Felis catus*, and *Nyctereutes procyonoides*, listed in frequency order, where *Hydropotes inermis* occurrence was over 50%. In Provincial roads, the most frequent species were *Hydropotes inermis*, *Capreolus pygargus*, and *Felis catus*, where the percentage of occurrences was similar within the three species. In National expressway, the most frequent species were *Hydropotes inermis*, *Felis catus*, and unidentified mammals, where the percentage of *Hydropotes inermis* was over 70%. Due to the highest speed limit with high traffic volume of National expressway compared to other roads, many carcass were found in ambiguous condition to identify, thus the highest number of unidentified species' road-kill recorded.

Monthly road-kill occurrences were highest in May, June, April of 2019 with 17.2%, 12.7% and 11.8% in respective order (Fig. 2), of the entire study period (from June 2018 to September 2019). Moreover, the monthly

Table 2. The number of road-kills registered on KROS by road type

	National expressway	Private-funded expressway	Highway	Provincial road	City road	Etc
2018 (Jun-Dec)	66	8	411	172	118	0
2019 (Jan-Sep)	353	59	2,205	569	335	7
All	419	67	2616	741	453	7

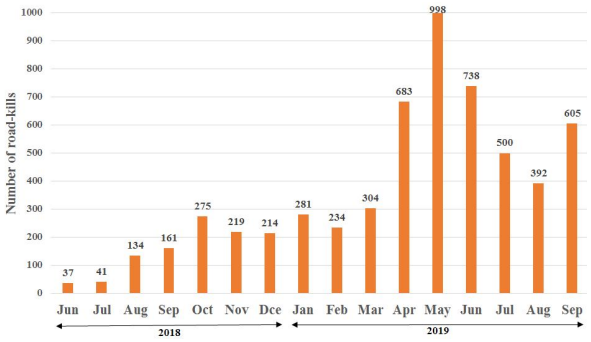

Fig. 2. The number of road-kills registered on KROS from June 2018 to Sep 2019.

road-kill occurrences of *Hydropotes inermis* were highest in May, June, April of 2019 with 68.8%, 62.2% and 48.1% respectively. We believe these occurrences are due to the dispersal of yearling *Hydropotes inermis* during springtime (Coffin 2017). However, as mentioned above, our system is on the beginning phase, the results cannot be considered as the total number or the exact representation of national road-kill trends because not all the participant bodies (road management agencies) are actively participating in the data collection through the app. Thus, we are continuously trying to encourage the road management agencies to get involved in using the app by educating to overcome the limitations.

Acknowledgements

This work was supported by a grant from the National Institute of Ecology (NIE), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIE-C-2019-28).

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