Pakistan J. Zool., vol. 46(3), pp. 725-731, 2014.

Using Infra-Red Camera Trapping Technology to Monitor Mammals along Karakorum Highway in Khunjerab National Park, Pakistan

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Abstract.- Infra-red digital camera trapping technology was used in this research study in order to investigate the richness and abundance of mammal species along Karakorum Highway (KKH) in Khunjerab National Park (KNP). This study was performed for the purpose of building a database of wildlife activity and to provide wildlife protective measures after the KKH improvement project. 10 infra-red cameras were installed on 4 locations along KKH in KNP from June 24 to November 8, 2013. Results indicated that 5 mammals were captured with the following relative abundance index (RAI) ranking: red fox (*Vulpes vulpes*), cape hare (*Lepus capensis*), Himalayan ibex (*Capra ibex sibirica*), snow leopard (*Uncia uncial*) and Mustelidae species. Surprisingly, snow leopards emerged in 3 cameras of the total 10 cameras. Species richness and abundance in roadside forest, which is located on the bottom of valleys, are less than on that of the mountain slopes, which is likely the result of short monitoring time (about 4 months) and mammal vertical migration behavior. Our investigation indicated that mammal species richness adjacent to the highway was not low and protective values were great. Infra-red camera trapping technology was found to be an effective method to monitor mammals in KNP. We suggest the protection of vegetation along KKH in KNP, limiting the traffic volume and speed at night and reduced livestock activity in this area in order to better protect the valuable and endangered mammal species in KNP.

Key words: Biodiversity conservation, roadside, snow leopard, road ecology.

INTRODUCTION

Karakorum Highway (KKH) passes through Khunjerab National Park (KNP) with length of about 60km. KNP is one of the hot spots of biodiversity in the cold desert area of Pakistan with the main purpose of protecting international significant wildlife species, such as Marco Polo sheep (*Ovis ammon polii*) and snow leopard (Qureshi *et al.*, 2011). KKH improvement project was initiated in 2008 with one of the main objectives to enhance the beauty of the highway and to protect the valuable wildlife species in the area. This project eventually completed at the end of 2013. The impact of road on wildlife is regarded as one of intensive impact of artificial impaction (Forman *et al.*, 2003). The most obvious impact of the KKH improvement project on wildlife was habitat loss, while some innovative construction measures and practices were applied to protect the habitat along KKH effectively (Wang *et al.*, 2012).

Concerning the investigation methods of wildlife in KNP, mostly are data collecting from references, field investigations, interviews on daytime and questionnaires (Shafiq and Ali, 1998; Schaller, 2007; Nawaz, 2007; Fakhri, 2009; Qureshi *et al.*, 2011; Wang *et al.*, 2012; Khan *et al.*, 2012). Investigation time is always limited because of cliffy area and hard environmental conditions in KNP. A variety of carnivore species inhabited in KNP, they are nocturnal species with secretive and cryptic behavioral characters. Therefore, it is very difficult to carry out mammal's investigation only rely on traditional methods. In recent decade, infra-red digital camera trapping technology permits the location and study of many secretive and cryptic mammals in remote area, especially to investigate medium to large terrestrial mammals (Mohd-Azlan, 2006; Samejima *et al.*, 2012; Sunarto *et al.*, 2013), tiger (Mohd-Azlan and Dionysius, 2003; O'Brien *et al.*, 2003). Therefore, using this new technology to monitor wildlife in KNP is an exciting research. According to references review, the infra-red trapping technology has not been used to monitor

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0030-9923/2014/0003-0725 $ 8.00/0
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wildlife along KKH in KNP. Therefore, this is the first mammal monitoring research by infra-red camera trapping method in KNP. The objective is to learn about roadside mammal's species richness; time and location of activity, in order to better preserve them by manage traffic vehicle and highway maintenance after KKH open and operation.

METHODS

Setting of infra-red camera

For setting infra-red camera along KKH in KNP, we cooperate with China Road and Bridge Corporation-CRBC KKH office in Gilgit to submit our application to the local government on May, 2013. We received the official permission from Government of Gilgit-Baltistan in June 2013.

Ten cameras were installed in 4 different locations along KKH in KNP from June 24th to November 8th 2013. Specifically, 3 cameras locate at left side of K760 (kilometer marker), 5 cameras locate at K763 with 4 at left side and 1 at right side, 1 camera locate at right side of K767 and 1 camera locate at left side of K768 (Fig. 1, Table I). Each camera operating time was set differently because of highway construction, human disturbance, and error in some photos.

Method and step to set cameras refer to previous research (Ma *et al.,* 2006; Mohd-Azlan and Engkamat, 2013; Liu *et al.,* 2013). We consulted local wildlife ecologist in Deeh office of KNP to select the best locations to set cameras in order to increase the probability of detecting mammals. The locations were commonly selected near scats, tracks, food, hair etc. Vegetation types, altitude, perpendicular distance to highway and landforms are important factors influencing the efficiency of cameras, so that the selections of points to install cameras were focused on these factors. The height of cameras was kept about 40-60cm aiming to take photos of middle and large sized mammals. Directions of camera lenses were toward north to avoid direct sunlight to trigger ineffective shooting. Space in front of camera was cleaned to keep the unobstructed sight and high quality photos. The cameras used were Chinese brand, ltl5210, with 8 dry battery used to charge the energy, and 8G memory card sized, and commonly will last 3-4 months according to the weather and artificial disturbance, which may resulted the camera produced errors, stop work, or take plenty of ineffective photos.

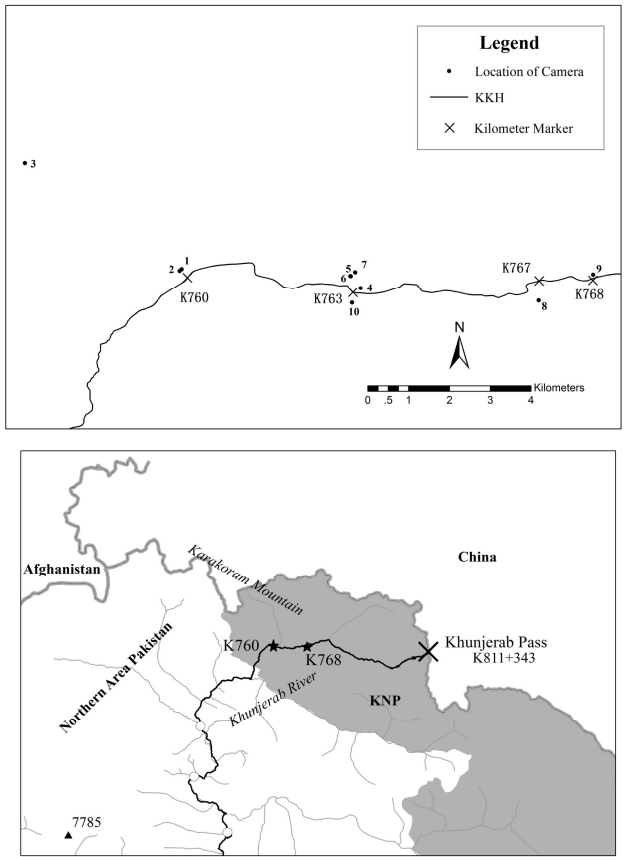

Fig. 1. Sketch map of 10 infra-red cameras site along KKH from Kilometer Marker 760 to 768 in KNP (note: Number 5 and 6 cameras locate the same site with different direction).

All the parameters of each camera were unified such as camera mode (camera), image size (5MP), capture number (1 photo), interval (1S to take photos of wildlife most probability), set clock (year, month, date, hour, minute, second) with time and date will be stamped on each photo, sensor level (normal), etc. Meanwhile, we recorded the GPS, elevation, kilometric Marker of each camera correspondingly, perpendicular distance of each camera to KKH (by Distance Measuring Equipment in field or in Google-earth), habitat, landform, etc as

well (Table I).

These cameras were checked about every 2 months, including downloading photos from memory card and change dry battery according to factual status.

Data analysis

For each camera, except for the environmental parameters, we also record shoot parameters, such as time of monitoring, total number of photos, number of mammal photos, number of independent photos (IP), and species richness of mammals. We defined IP as (1) photos of different individuals of the same or different species, (2) photos of individuals of the same species taken more than 0.5 hours apart, (3) nonconsecutive photos of individuals of the same species (O'Brien *et al*., 2003; Mohd-Azlan, 2006; Samejima *et al*., 2012).

We calculated a relative abundance index (RAI) based on formula:

RAI=Ai/N*100 (Liu *et al*., 2013)

In which Ai represents the total number of IP of a species by all cameras, and N equals the total number of IP for all species detected during the study period.

Chi-square test was used to determine the difference among species richness or abundance under different landform, habitat, and perpendicular distance to KKH.

RESULTS

Ten infra-red cameras were installed on 4 different locations along KKH (from K760 to K768) in KNP for 138 days accumulatively, and about 690 camera days which shoot 25595 photos totally, among which 151 were of mammals, independent photos were 99, mammal's species were distinguished from these photos as highly valuable (Table I). RAI sorting is: red fox, cape hare, Himalayan ibex, snow leopard, Mustelidae species (Table II). Noteworthy, 3 of 10 cameras shoot snow leopard which is critically endangered in the world (Fig. 2, Table I).

Species richness and abundance of forest habitat (2 cameras) were less than bush habitat (5 cameras) and grass habitat (3 cameras) (species richness: 2-forest, 4-grass, 4-bush; RAI: 7.14%-forest, 42.86%-grass, 50%-bush). 9 cameras were installed among 500m perpendicular to KKH (species richness-4, RAI-66.33%), only 1 was further installed by 4.2 km distance to KKH, which located on the slope in Deeh valley (species richness-4, RAI-33.67%), so the species richness is similar, while RAI is different significantly (Chi-square 10.449, df=1, p=0.001); 6 cameras on bottom of valley took photos belong to 4 species, RAI is 23.47%, 4 cameras on slope took photos belong to 5 species, RAI is 76.53%, so RAI is different significantly (Chi-square 29.16, df=1, p=0.000).

Fig. 2. Snow leopard emerged along KKH in KNP.

Table I.- Related parameters of 10 infra-red cameras along Karakorum highway in Khunjerab National Park in Pakistan.

GPS	Altitude (m)	Habitat	Kilometer marker	Perpendicular distance to KKH	landform	Monitoring time	Total No. of photos	No. of mammal photos	Independent photo	No. of mammal species	English name
N36° 51'790" E74° 59'765"	3316	Forest	K760	427	Bottom of Deeh valley	6.24-9.4 9.6-11.8	394	5	5	2	Cape Hare, red fox
N36° 51'811" E74° 59'792"	3330	Grass	K760	428	Slope of Deeh valley	6.24-11.8	735	2	2	1	Mustelidae (Unidentified species)
N36° 53'208" E74°57'721"	3743	Spare bush, rock	K760	4200	Slope of Deeh valley	7.7-8.26	718	62	33	4	Red fox; cape hare; Himalayan ibex; Snow Leopard
N36° 51'722" E75° 02'022"	3363	Spare bush	K763	230	Bottom of Karchanai Valley	6.24-7.3	5686	5	5	2	Red fox; Snow Leopard
N36° 51'762" E75° 02'095"	3371m	Spare bush	K763	300	Bottom of Karchanai Valley	6.25-8.27,8.28-11.8	385	2	2	1	Himalayan ibex
N36° 51'762" E75° 02'095"	3371	Spare bush	K763	300	Bottom of Karchanai Valley	6.24-6.29	5789	0	0	0	
N36° 51'771" E75° 02'085"	3372	Spare bush	K763	320	Bottom of Karchanai Valley	6.24-7.30	8753	9	9	1	Red fox
N36° 51'395" E75° 04'511"	3477	Grass	K767	150	Slope of Khunjerab valley	7.6-8.26	160	32	18	2	Red fox; Snow Leopard
N36° 51'740" E75° 05'231"	3453	Forest	K768	120	Bottom of Khunjerab valley	6.24-8.26	2878	2	2	1	Red fox
N36° 51'367" E75° 02'045"	3513	Grass	K763	390	Slope of Khunjerab valley	9.13-11.8	97	32	23	3	Himalayan ibex; red fox; Cape Hare

Table II.- Relative Abundance of mammals along KKH by Infrared-camera traps.

Animal names	Scientific name	Status IUCN 2005	RAI (%)
Red fox	*Vulpes vulpes*	DD	47.47
Cape hare	*Lepus capensis*	VU	30.30
Himalayan ibex	*Capra ibex sibirica*	LC	17.17
Snow leopard	*Uncia uncial*	CR	3.03
Mustelidae species (undefined)	-	-	2.02

Legend: LC, least concern; DD, data deficient; CR, critically endangered; RAI, Relative abundance index; VU, vulnerable.

DISCUSSION

Ten infra-red cameras near Deeh valley along KKH inside KNP were installed for about 4 months (summer and autumn). During this time 5 mammal's species of high importance were trapped. Snow leopard as a critical endangered species in the world, cape hare as a vulnerable species were detected in the area. Most infra-red cameras were distributed adjacent to KKH. Therefore, the roadside wildlife protective value is highly significant (Wang *et al.,* 2012).

There is an obvious relationship between vegetation and landform along KKH in KNP. The forests along KKH are mainly composed of *Salix spp, Myricaria elegans, Populus afghanica* which are commonly distributed on the bottom of valley, and grass (mainly *Ephedra intermedia*) spread over the slopes, and bushes (*Juniperus* L., *Rosa* L.) sparsely grow both on the bottoms and on slopes of mountains. Species richness and abundance of mammals in forest were less than those in bushes and grass which is likely determined by two reason, first the temperature was relatively high during monitoring time (summer and autumn), and most wildlife move up on the slopes and ridges where food resource were rich enough for wildlife where they don't need to go down to bottom; secondly, KKH was under construction during investigation time, so that the intensive noise and artificial disturbance of machines and vehicles made unavoidable impact on wildlife to use forest habitat on the bottom. In winter, during the snow fall on the ridges and slopes, almost all wildlife species move down to bottom to feed on the forests and drink water in Khunjerab river along KKH. Workers of KKH construction camp reported that they usually see ibex move down from top close to KKH to the bottom of valley to drink and feed the vegetation during October to December, which were also verified by our research team during visiting KKH between October and December. The species richness adjacent to the KKH (within 500m along KKH) is similar to further way, although the abundance is higher, for only 1 camera in the further location. Therefore, wildlife activity is plenty both adjacent to KKH and further areas.

Infra-red camera trap technology is suitable to carry out snow leopard investigation in mountainous area (Ma *et al.,* 2006). Surprisingly, we recorded photos of snow leopard in 3 cameras (series number 3-K760-Deeh Valley, 4-K763-Karchanai Valley and 8-K767-Khunjerab Valley), perpendicular distance of 3 cameras to KKH is 4200m, 230m and 150m, and vegetation is either grass or bushes. Landform is slope or bottom. Photos of snow leopard were shot on 2, 24 July and 4 October, showing that snow leopard's activity very close KKH in summer and Autumn. Furthermore, by interview with workers of KKH construction, on October, 2012 on K749, a snow leopard pursued and attacked ibex herd where perpendicular distance to KKH is about 150m, on 27 March, 7 pm on K760, a snow leopard walked on riverbank where perpendicular distance to KKH is about 150 m (private communication). Therefore, almost through all the year, snow leopards will activity on KKH roadside both adjacent and further area. An adult leopard, a leopard cub at Mudumalai Tiger Reserve in India in February 1998 and an adult tiger at Bandipur, were killed by speeding vehicles in 2006 (Baskaran and Boominathan, 2010). The Amur tigers living in the vicinity of lightly traveled primary and secondary roads incurred greater mortality and lower reproductive success than those with territories away from roads, authors advised that roads through protected tiger habitat should be closed at night and speed limits should be strictly enforced (Kerley *et al.,* 2002). Vehicle collisions are a major threat to the Florida panther

population, even caused 46.9% of documented mortality (Maehr *et al.,* 1991), countermeasures are provided consist of additional protected lands, road closings, traffic control measures, fencing, and appropriate wildlife underpasses, and wildlife underpass have been proved successful(Forman *et al.,* 2003;Schwab and Zandbergen, 2011). Therefore, to avoid the disturbance to this endangered species manage and control traffic volume and speed limit at night is vital. In the future, wildlife crossing structures should be constructed during KKH improved again.

Although no villages locate along KKH in KNP, but still plenty of livestock emerged in our photos during our monitoring period, besides, one camera and one memory card were lost, which showed that artificial disturbance cannot be neglected. Overgrazing was regarded as one of main threats to wildlife in KNP (Qureshi *et al.,* 2011). Especially, the vegetation coverage was extremely low in KNP, forest and bush mainly distributed along bottom of valley, while KKH was also passes by these green belts, they were parallel to each other, and therefore livestock and wildlife have to compete for the same limited food resource. On the other hand, livestock was likely to be the prey of carnivores (such as snow leopard), so it is suggested that strong management (not grazing at night) and perfect compensation policy could be helpful to protect the wildlife and make livestock and wildlife coexist in KNP.

Infra-red cameras have many advantages, such as detect secretiveness/elusiveness species, locate remote/cliff/hard environment, animal identification with minimum ambiguity, non-invasive to wildlife, photos can cause public interests (Mohd-Azlan, 2009; Sunarto *et al.,* 2013), which has been used to monitor the population density, activity patterns of large mammals, cryptic animal surveys, especially for those nocturnal species or small groups at low density carnivore (McCallum, 2013). Concerning road ecology research, infra-red cameras has been used to monitor wildlife crossing structures and roadside crossing behavioral (Ford *et al.,* 2009; Clevenger and Huijser, 2011). In KNP, the temperature vary very sharply between noon and night, the climate is severe, and the landform is very cliffy, so logistics is bad, which strongly limit the human investigation about wildlife with large-scale. Furthermore, plenty of wildlife in KNP are nocturnal, also are difficult to see in daytime. Fortunately, infra-red cameras are remedy for this shortcoming. 3 cameras of 10 cameras shoot the photos of snow leopards have proved the advantage of this method. Presently our monitoring time was short, while for the future better assessments, we should extend the monitoring time, improve the density of cameras, and carry out the long time research of wildlife activity along KKH after highway improvement construction period to provide the scientific basement and basic data for wildlife protection and perfect our protective measures along roadside of KKH.

ACKNOWLEDGEMENTS

We would like to thank all the concerned people in Deeh office of KNP, Forest Bureau of Gilgit for their helpful and important advice and guidance both on monitoring planning and camera setting in the field. Many thanks to Mr. Yaohua Shi, the Manager of Camp D of KKH construction office for his vital help and support in the field investigation. We also thank Mr. Guiming Ma of CRBC-Gilgit office for his help in official application process for permission in initial stage. Thanks to Mr. Lei Guan for helping us to make the sketch map of this paper. Thanks to Dr. Marcel Huijser from the Western Transportation Institute at Montana State University in USA and Dr. Leonard E. Sielecki of British Columbia Ministry of Transportation and Infrastructure in Canada for their great advice and encouragement.This research was funded by the International S&T Cooperation Program of China (Grant No. 2012DFA20980).

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(Received 27 February 2014, revised 17 March 2014)