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Habitat Use of the Eurasian Otter *Lutra lutra* in the Hangang River Water System, South Korea

[1, 2]Jung-Hoon Kang, [1]Shin-Jae Rhim and [3]Sung-Yong Han
[1]School of Bioresource and Bioscience, Chung-Ang University, 456-756 Ansung, Korea
[2]National Research Institute of Cultural Heritage, Cultural Heritage Administration, 302-834 Daejeon, Korea
[3]Korean Otter Research Center, 209-808 Hwacheon, Korea

Abstract: This study was conducted to clarify the habitat use of the Eurasian otter *Lutra lutra* in the Hangang River Water System, South Korea. Researchers evaluated a total 358 habitat points of this species during April 2009 and October 2010. Altitude, river width, river depth, water velocity, bottom status, bankside vegetation, vegetation cover and pollutants were significantly different among Bukhangang, Namhangang and control areas. Correlation analysis revealed that several habitat variables were correlated with each other. Habitat type, spraints and available habitat, classification of rural and urban areas, surrounding conditions for hiding, direct human disturbance and degree of pollution were the most important factors determining the habitat use of the Eurasian otter in the Hangang River Water System. Long-term ecological studies of the ecology and habitat use patterns of the Eurasian otter are essential to conserve this species and its habitat.

Key words: Eurasian otter, habitat use, Hangang river, *Lutra lutra*, South Korea

INTRODUCTION

The Eurasian otter *Lutra lutra*, a mammal in the Order Carnivora, Family Mustelidae, obtains its food directly from river and ocean environments. Its habitat in the aquatic trophic chain and high metabolic requirements (Kruuk, 1995) make the Eurasian otter a sensitive species to changes in habitat conditions. The presence of otters is therefore used as an indicator of a Healthy Aquatic System (Chanin, 2003).

The Eurasian otter ordinarily has a linear home range that encompasses 5-20 km of river bank and surrounding the wetlands (Green *et al*., 1984). This species, however is sensitive to pollution (Yamaguchi *et al*., 2003) and has suffered severe declines in most Eurasian countries (Robitaille and Laurence, 2002; Jo *et al*., 2006). Furthermore, the Eurasian otters are habitat specialists so their home range probably encompasses fewer species (Bifolchi and Lode, 2005).

Because it is difficult to study the Eurasian otter due to its solitary, secretive and nocturnal behavior (Conroy and Chanin, 2002) indirect methods such as surveys of spraints or footprints are used (Lanszki *et al*., 2008). Spraint surveys are the most popular methods for studying or monitoring this species and are considered to provide a rough index of otter habitat use (Prenda and Granadio-Lorencio, 1996; Han, 1987).

To establish effective conservation strategies for the Eurasian otter, assessment of its habitat using pattern is essential. However, the relative importance of environmental and human impacts on this species has not been assessed on a large scale in water systems in South Korea (Jo *et al*., 2006). South Korea is located on the eastern edge of the Eurasian otters' distribution range. Water systems are well developed and allow inhabit of this species (Han, 1987). In South Korea, the population size of the Eurasian otter has decreased over the past few decades. This species was designated as a Natural Monument and endangered species by the Korean government (Won and Smith, 1999).

In this study, researchers describe general features of the habitat of the Eurasian otter and determine the relative importance of habitat variables at habitat points along the Hangang River Water System, South Korea for the conservation of the species and its habitats.

MATERIALS AND METHODS

This study was conducted along the Hangang River Water System (37°21'N, 128°00'E), South Korea. The total length of the Hangang River Water System is 494 km and its size is 25,954 km^2 (KWRC, 2002). The Hangang River Water System covers the central part of the Korean peninsula. It is a very important water resource for Seoul,

Corresponding Author: Shin-Jae Rhim, School of Bioresource and Bioscience, Chung-ang University, 456-756 Ansung, Korea

the capital city of Korea. Moreover, the Hangang River Water System plays critical role as a habitat of numerous organisms (Lee *et al*., 2000). The Hangang River Water System is composed of the Bukhangang and Namhangang regions in the Gyeonggi, Gangwon and North Chungcheong provinces of South Korea.

Field surveys were conducted from April 2009 to October 2010. Researchers only accepted spraints or footprints as evidence of the presence of the Eurasian otter (Madsen and Prang, 2001). Researchers conducted survey by boat and on foot in the Bukhangang and Namhangang regions of the Hangang River Water System. If spraints or footprints of the Eurasian otter were observed at a site researchers recorded that site as a habitat point using a Global Positioning System (GPS) unit.

Data for 17 habitat variables were surveyed and collected to analyze the habitat use of the Eurasian otter (Table 1). For all habitat points and randomly selected control points (no otter activity observed), researchers made a quadrat (100×100 m). Within this quadrat, researchers surveyed physical features (site conditions, river depth, bottom status and bankside vegetation), status of the adjacent areas (land use type, forest type, grass height, shrub height and vegetation cover) and disturbance factors (artificial structures, water use, pollutants, fishnet and angler) during August and September 2011. The variables researchers selected are primarily related to the nature of the water body, cover, and human disturbance.

The data were analyzed using Analysis of Variance (ANOVA) to determine if there were differences in habitat variables among the regions. The Dunnett T3 test was used for post-hoc comparisons of mean values.

Table 1: Description of habitat variables assessed in this study (Madsen and Prang, 2001)

Variables	Description
Altitude	m (a.s.l.)
River width	m
Water velocity	m sec^{-1}
Site conditions	River, confluence, reservoir and dam
River depth	m
Bottom status	Sand, gravel, bedrock and rock
Bankside vegetation	Herbs, shrubs, trees and none
Land use type	Uncultivated, cultivated, fallow and residential
Forest type	Coniferous, deciduous, mixed and none
Grass height	30-60, 60-90, 90-120 and >120 cm
Shrub height	1.0-1.5, 1.5-2.0, >2.0 m and absent
Vegetation cover	1-33, 34-66 and 67-100%
Artificial structures	Bank revetment, sluice gates under bridge, pier, houses and none
Water use	Agricultural, watersports, fishing and conservational
Pollutants	Non polluted, farming, living and industrial
Fishnet	Present and absent
Angler	Present and absent

Researchers performed correlation analysis of the 17 habitat variables to determine their relationships with the habitat use of the Eurasian otter in the Hangang River Water System. Furthermore, researchers performed factor analysis of the habitat variables using Principle Component Analysis (PCA), the Kaiser-Meyer-Olkin (KMO) measurement of adequacy standard form test and the Bartlett test.

RESULTS AND DISCUSSION

Altitude (ANOVA, F = 36.95, p<0.001), river width (F = 50.56, p<0.001), river depth (F = 31.96, p<0.001), water velocity (F = 24.98, p<0.001), bottom status (F = 9.31, p<0.001), bankside vegetation (F = 36.56, p<0.001), vegetation cover (F = 7.97, p<0.001) and pollutants (F = 27.83, p<0.001) were significantly different among areas. However, altitude, river width, river depth, water velocity and vegetation cover of the Bukhangang and Namhagang regions were similar, allowing these regions to be grouped (Tukey HSD, p<0.01) (Table 2).

Site conditions, forest type, grass height, shrub height, artificial structures, water use, fishnet and angler were not significantly different among areas. The habitat points of the Eurasian otter were at higher altitude than control areas in both the Bukhangang and Namhangang regions. The river widths of habitat points in the Bukhangang and Namhangang regions were 3 times greater than those in the control areas. In the Bukhangang and Namhangang regions, the river depth ranged from 1-2 m. However, the river depth in control areas was >2 m. Water velocity was higher in the control areas than the Bukhangang and Namhangang regions. The bottom of the river in the Bukhangang region was composed of bedrock and rock. In contrast, gravel and rock were found at the bottom of the river in the Namhangang and control areas.

River width was correlated with site conditions (Pearson correlation, r = 0.71, p<0.01). River depth was also significantly correlated with site conditions (r = 0.68,

Table 2: Differences among habitat variables at sites with evidence of the presence of the Eurasian otters *Lutra lutra* in the Bukhangang (Buk), Namhangang (Nam) and Control (Con) areas along the Hangang River Water System, South Korea as determined by the Tukey HSD post-hoc test. Different letters indicate significant differences between mean values (p<0.05)

Variables	Buk	Nam	Con
Altitude (m)	267.04 ± 12.37^{a}	256.79 ± 10.91^{a}	99.44 ± 6.040^{b}
River width (m)	124.86 ± 14.56^{b}	99.65 ± 9.370^{b}	320.14 ± 25.42^{a}
River depth (m)	2.40 ± 0.110^{b}	2.18 ± 0.080^{b}	3.45 ± 0.110^{a}
Water velocity (m sec^{-1})	0.34 ± 0.030^{a}	0.37 ± 0.020^{a}	0.10 ± 0.020^{b}
Bottom status (CDV*)	3.32 ± 0.080^{a}	2.93 ± 0.060^{b}	2.76 ± 0.120^{b}
Bankside vegetation (CDV)	1.62 ± 0.060^{b}	1.31 ± 0.040^{c}	2.03 ± 0.130^{a}
Vegetation cover (%)	3.75 ± 0.050^{a}	3.68 ± 0.040^{a}	3.39 ± 0.090^{b}
Pollutants (CDV)	1.15 ± 0.040^{c}	1.40 ± 0.050^{b}	1.97 ± 0.120^{a}

*CDV: Categorical Data Value

I																	
II																	
III		0.71 p<0.01															
IV		0.68 p<0.01	0.62 p<0.01														
V		-0.57 p<0.01	-0.44 p<0.01														
VI																	
VII																	
VIII																	
IX																	
X				-0.42 p<0.01													
XI																	
XII																	
XIII		-0.76 p<0.01	-0.64 p<0.01	-0.58 p<0.01	-0.44 p<0.01												
XIV								-0.62 p<0.01									
XV																	
XVI																	
XVII																	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XII	XIV	XV	XVI	XVII

Fig. 1: Analysis of correlation among habitat variables of the Eurasian otter *Lutra lutra* in the Hangang River Water System, South Korea. I: Altitude; II: Site conditions; III: River width; IV: River depth; V: Water velocity; VI: Bottom status; VII: Bankside vegetation; VIII: Land use type; IX: Forest type; X: Grass height; XI: Shrub height; XII: Vegetation cover; XIII: Artificial structures; XIV: Water use; XV: Pollutants; XVI: Fishnet; XVII: Angler

p<0.01) and river width (r = 0.62, p<0.01). Water velocity showed a correlation with site conditions (r = -0.57, p<0.01) and river width (r = -0.44, p<0.01). Grass height was correlated with bottom status (r = -0.42, p<0.01). Artificial structures were highly correlated with site conditions (r = 0.76, p<0.01), river width (r = 0.64, p<0.01), river depth (r = 0.58, p<0.01) and water velocity (r = -0.44, p<0.01). Furthermore, water use was significantly correlated with land use type (r = -0.62, p<0.01) (Fig. 1).

With regard to habitat, factor 1 variables were site conditions, river width and river depth and factor 2 variables were bottom status and altitude. Factor deductions were habitat type and spraints and available habitat. For adjacent areas, factor 1 variables were grass height and land use type and factor 2 variables were vegetation cover and forest type. Factor deductions were the classification of rural and urban areas and surrounding conditions for hiding. For direct-indirect disturbances, factor 1 variables were artificial structures and fishnet while factor 2 variables were angler and pollutants. The direct human disturbance and degree of pollution were factor deductions (Fig. 2).

Habitat type was the most important habitat feature. The Eurasian otter appears to select habitat based on site conditions, river width and river depth. Those factors are likely to be related to the abundance of food resources (Norwak, 1999; White *et al*., 2003). Spatial structure and environmental factors have been shown to affect the choice of habitat of this species (Barbosa *et al*., 2001). Furthermore, spraint and available habitat were important determinants of habitat points. Spraint sites were associated with bedrock, rock, confluence, bridge and nest. Available habitat and spraint sites are key factors affecting this species (White *et al*., 2003).

Classification of rural and urban areas and surrounding conditions for hiding were important factors in adjacent areas. Habitat points were more often observed in cultivated and fallow areas than in urban areas. Furthermore, more habitat use was seen in areas with high vegetation cover and dense forests. The direct human disturbance and degree of pollution were the most important disturbance factors. These factors refer to artificial structures, fishnet, angler and pollutants which have been shown to influence the habitat use and distribution of the Eurasian otter in earlier studies (Beja, 1996; Prenda and Granadio-Lorencio, 1996).

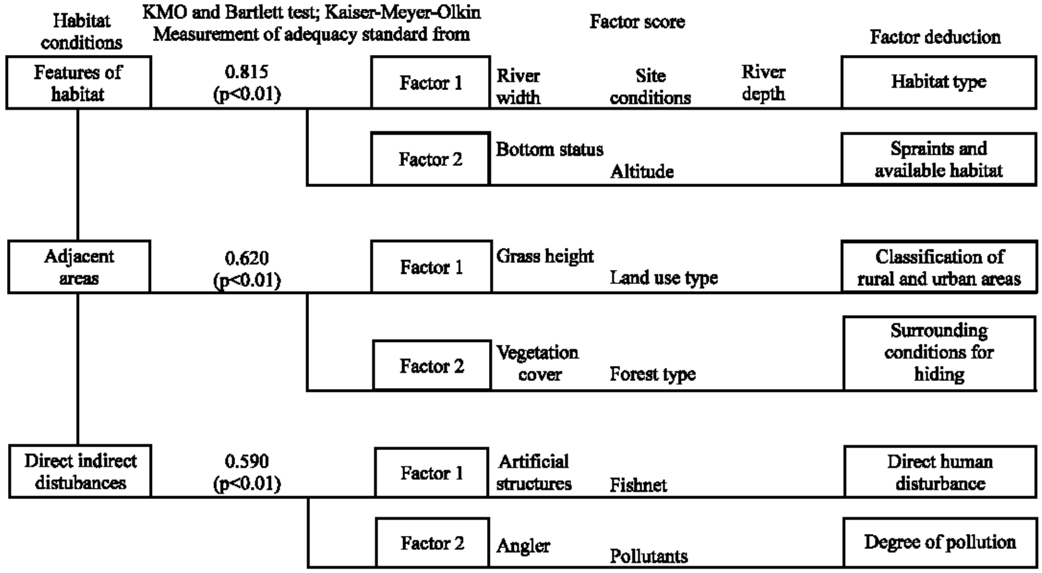

Fig. 2: Results of a factor analysis of habitat variables of the Eurasian otter *Lutra lutra* in the Hangang River Water System, South Korea

The presence of the Eurasian otter is a good indicator of riverine quality (Kruuk and Conroy, 1996; Britton *et al*., 2006; Delibes *et al*., 2009). Otters feed mainly on large aquatic invertebrates and vertebrates and their habitat is linked to fresh water, available shelter and prey (Barbosa *et al*., 2001). In future studies, it would be interesting to use the GIS methodology to evaluate possible conflicts between factors for habitat management of the Eurasian otter. A multifactor analysis of the different conflict factors has to be adopted (Schmidt *et al*., 2008).

CONCLUSION

Habitat condition is critically important for the Eurasian otter as it influences the distribution, abundance, reproduction and mortality of this species (Kruuk, 2006). An in-depth knowledge of the ecology of this species is required to design and implement successful conservation strategies (Smiroldo *et al*., 2009). Long-term ecological studies on the ecology and habitat use of the Eurasian otter are therefore essential to conserve this species and its habitat.

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