Journal of Wetlands Research
Vol. 17, No. 4, November 2015, pp. 402-406

ISSN 1229-6031 (Print) / ISSN 2384-0056 (Online)
DOI http://dx.doi.org/10.17663/JWR.2015.17.4.402

Use of stream environment by river otters in Hongcheon river, Gangwon Province, Korea

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강원도 홍천강 유역의 수달 서식지 이용

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(Received: 08 October 2015, Revised: 28 October 2015, Accepted: 04 November 2015)

Abstract

This study aims at favorable environmental conditions by river otter residing in Hongcheon river ecosystems using spraints along the river. Otter spraints were indicative of habitat use pattern and marking a territory in the areas. Nae-chon and Kuneob-chon river otter spraints were collected totaling 478 with 8 times during 2009-2011, and based on the number river use patterns were analyzed with the technique of index of dispersion. Results with larger than one indicated that river otter habitat use pattern were not random; instead they used preferred areas for habitat use. 'I' values greater than one indicate a clumped distribution and lower than one indicate random distribution. This study also demonstrated that we need a sophiscated linear model that should be developed to identify key habitat elements in river ecosystems.

Key words : Index of dispersion, *Lutra lutra*, Naechon river, feces, habitat analysis

요 약

본 연구는 강원도 홍천강 유역에 서식하는 수달이 선호하는 지역을 파악하기 위해 수달의 배설물을 이용하여 하천환경의 현황을 분석하였다. 수달의 배설물은 영역표시 및 서식지이용에 대한 근거로 활용되기 때문이며, 이를 통한 하천의 주요 서식지를 확인할 수 있다. 내촌천과 군업천의 수달은 2009-2011년 총 8회 기간에 478개의 서식흔적이 발견되는 지점을 중심으로 조사되었으며 서식지 이용현황을 파악하기 위한 분산지수를 활용하였다. 두 하천 모두 계절적 이용의 변화가 나타났으며, 분산지수 값 1은 배설물이 집중되는 것을 의미하며 이는 하천 이용이 임의적이 아닌 것임을 나타내었다. 수달은 하천 주변의 5m 이내의 지역이며, 어류와 잔목이 풍부한 수변지역을 선호하는 것으로 나타났다. 수달의 서식지 이용에 대한 정확한 환경조건을 파악하기 위한 모델의 개발이 시급한 것으로 조사되었다.

핵심용어 : 분산지수, 수달, 내촌천, 배설물, 서식지분석

1. Introduction

The Eurasian otter (*Lutra lutra* L. 1758) is a semi-aquatic mammal (Carnivora: Mustelidae) which feeds mainly on aquatic vertebrates and large aquatic invertebrates whose habitat is linked to the existence of fresh water, available shelter (vegetation, rocky structures and others) and abundant prey (Macdonald and Mason, 1994). This species, once wide-spread in Europe, Asia and Africa, has shown a sharp decline in distribution in the last few decades (Meliquist and Dronkert, 1983). Various international and regional conservation actions have been taken towards to this species. Eurasian river otter is listed in Appendix I of the CITES, Appendix II of the Bern Convention, Annexes II and IV of the EU Habitats and Species Directives and Appendix I of the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals (Duarte et al., 2011). In Republic of Korea, it was categorized as an endangered species in 1998 (Ministry of Environment, 2008) and designated as a Natural Monument (No. 330) in 1982 (Cultural Heritage Administration, 2003). Studies in Korea also reported a decline of its population size (Han, 1998). It is, therefore, necessary to understand habitat use and selection patterns by otter for effective conservation

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and management.

The analysis of species–environment relationship has always been a central issue in ecology. The quantification of such species–environment relationships represents the core of predictive geographical modeling in ecology. These models are generally based on various hypotheses as to how environmental factors control the distribution of species and communities. Besides its prime importance as a research tool in autecology, predictive geographical modeling recently gained importance as a tool to assess the impact of accelerated land use and other environmental change on the distribution of organisms (Kienast et al., 1996, 1998; Guisan and Zimmerman., 2000), to test biogeographic hypotheses (Leathwick, 1998), to improve floristic and faunistic atlases or to set up conservation priorities (Margules et al, 1994).

Main objectives of this study were to found out important habitat components for river otter, to understand habitat use and selection by otter at different scale of environment, therefore to use this knowledge to understand river otters inhabiting in Nae-chon and Kuneob-chon in Gangwon Province catchments.

2. Methods

2.1 Study area

Nae-chon river (37° 42'N, 128° 13.5'E) which flows from east to west in Seoseok town, Hongcheon county, Gangwon province, South Korea is a second order stream therefore is a tributary of Hongcheon river. This river has discharge of 0.650 $m^3/sec/km^2$ at junction point with Hongcheon river and catchment area of 345.09 km^2. Water course length of this river is about 54.5 km. The annual average precipitation is 1296.23 mm of which 70.3% is made up by precipitation in June, July, August and September. Water quality is moderate. A total 30 weirs are located along the river and most of them have no fish way installed. The river catchment is made of 33.703 km^2 areas of farmlands (9.85%) located mainly along the river, 291.423 km^2 areas of forest (85.2%) and 15.88 km^2 area of other land cover (4.95%). A 75.1% of the farmland is supplied by pumping station and small reservoir for irrigation while 394.7 ha or 24.9% area is supplied by reservoir (Fig. 1).

Kuneop-chon river (37° 41'N, 127° 54'E) which flows from south east to north west in Hwachon town, Hongcheon county, Gangwon province, South Korea is a second order stream therefore is a tributary of Hongcheon river. This river has discharge of 0.582 $m^3/sec/km^2$ at junction point with Hongcheon river and catchment area of 81.51 km^2. Water course length of this river is about 21.86 km. A

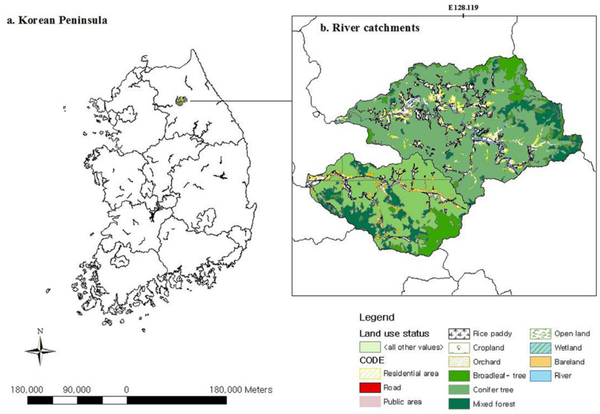

Fig 1. (a) Study area locates in Gangwon province, the most northern part of Korean peninsula (b) Land cover map for the catchments of the study rivers. Upper catchment is of Nae-chon river and the lower one is of Kuneob river.

total 16 weirs are set up along the river and five of them have fish way. The annual average precipitation is 1310.7 mm of which 72% is made up by precipitation in June, July, August and September. BOD amount was 0.7 mg/l indicating category I by Environmental Policy Act, ROK or a level preserved its natural condition (Ministry of Construction and Transportation, 2004). A Kuneob river supplies water to Hwachon county with 1907 residences. Industrial water supply accounts for only one factory with three workers so it is considered as non industrial supply. A river catchment is consisted of 6.127 km^2 area of arable land (7.52%), 69.852 km^2 area of forest (85%), 0.516 km^2 area of bareland (0.63%), and 5.013km^2 area for other land use (6.15%), (Fig. 1).

2.2 Field survey and riverine habitat

Otter sign data from the field survey (Park, 2010) was used in this study. The survey was conducted 8 times in 2009 with monthly intervals (May- November of 2009 and November 2010). The field sign data covered about 78 km waterside of two rivers visited on walk. Only fresh spraints and clear footprints were accepted as evidence of otter sign. Geographical locations of the signs were recorded by GPS device.

The Eurasian river otters are closely connected to a linear living space. Most portion of their activity is concentrated to a narrow strip on either side of the interface between water and land (Kruuk, 1995). Mean width of the study rivers range from 30-50 m and considered as small streams. Thus we assumed that most of the otter activities are concentrated on area within 100 m from centreline of the stream to the both riversides. Besides previously published data showed that the majority of sings (about 70-80%)

Table 1. Environmental variables that associate with river otter habitat based on literature reviews.

Environmental Variables		Description
Stream characters	Width	< 10m, 10-25m, 25-35m, 35-50m, 50m <
	Bottom structure	Sandy or unidentified Gravel (< 15cm in diameter) Boulder (>= 15cm)
	Bankment type	Cement Natural or built but covered by vegetation Directly attached to the forest edge
Bankside vegetation	Vegetation type	Bareland Grass Shrub Tree
	Width of riparian vegetation zone	<19m 20- 39m 40- 59m 60- 100m
Adjacent areas	Forest coverage per unit area	< 10% 10- 30% 30- 60% 60% <
	Field(rice, paddy) coverage per unit area	70%< 50- 70% 30- 50% 30%>
Human built structures	Dam Bridge Road	Presence/absence of dike per unit area Presence/absence of bridge per unit area Presence/absence of road per unit area

was always found within the first 200 m of the search (Mason and Macdonald, 1986, 1987; Romanowski et al., 1996).

Each stream was divided into 200 x 200 m unit areas parallel to the stream centreline to relate otter presence/absence with the habitat variables.

On each stream, the numbers of otter spraints were counted in every unit area. Units where otter spraints found were considered an otter habitat whereas units with no spraints found were considered a non-habitat. 1/5000 scaled land cover map (Ministry of Environment, 2004).

Land use or percentages of the forest and field cover per units were extracted from the land cover map while presence/absence of road or the disturbance effect per units was obtained from transportation map of Korea. Water course characters (stream width, bottom structure type, bankment type), bankside vegetation types, width of riparian vegetation zones, presence/absence of the bridge and dam were checked visually from high resolution satellite images and measured using GIS and remote sensing techniques (Table 1).

2.3 Spatial and seasonal analysis

2.3.1 Distribution pattern of the otter spraint

An estimate of a population's density or dispersion index is proposed by Pielou, based on distances from sample points to the nearest member (Pielou, 1969). If population members tend to be uniformly spaced, the estimate will be low, whereas if they are distributed in clumps the estimate will be high. The index is defined as:

$$I=\pi \lambda [\omega] \quad (1)$$

where π is constant, λ is density of the spraints per habitat units, $[\omega]$ is expected distance. I values greater than one indicate a clumped distribution and lower than one indicate random distribution.

Bas et al. (1984) applied Pielou's index of dispersion (I) for assessing distribution pattern of otter spraints based on spraint counts per 1 km length of river. Sprаints were calculated index of dispersion using spraint counts per habitat unit (200m x 200m) with expected distance 0.2 km for two streams with monthly interval. Latter differences in dispersion indices between two streams and between months were tested for statistical significance (Chi-square test with P=0.05 level) to see if the distribution of spraintіng patterns by otters along two streams were significantly different.

3. Results

3.1 Distribution pattern of the otter spraint

A total 456 otter spraints were discovered along the

Table 2. Indices of dispersion (I) for two rivers by monthly interval during 2009-2011.

River	Months	No of spraints	Habitat units	Spraints/unit	Index of Dispersion (I)	Chi- square test
Nae-chon	May-10	28	15	1.9	1.2	x^2= 80 P 〉 0.05
	Jun-10	32	13	2.5	1.5	
	Jul-10	34	14	2.4	1.5	
	Aug-10	36	22	1.6	1.0	
	Sep-10	32	19	1.7	1.1	
	Oct-10	30	14	2.1	1.3	
	Nov-10	29	15	1.9	1.2	
	Nov-11	31	14	2.2	1. 4	
	Total	252	31			
Kuneob	May-10	25	8	3.1	2.0	x^2= 16 P 〉 0.05
	Jun-10	30	11	2.7	1.7	
	Jul-10	30	8	3.8	2.4	
	Aug-10	33	9	3.7	2.3	
	Sep-10	26	7	3.7	2.3	
	Oct-10	26	9	2.9	1.8	
	Nov-10	22	8	2.8	1.7	
	Nov-11	23	6	3.8	2.4	
	Total	215	16			

* Two-tailed significance levels based on a chi-square approximation to the sampling distribution, Index of dispersion (I) greater than '1' means a clumped distribution indicating river use pattern was not random.

watersides of two streams, Nae-chon and Kuneob during 8 times survey in 2009 (May-Nov of 2009 and Nov, 2010). On Nae-chon stream, 262 spraints were found in 31 habitat units with average 8.5 spraints per habitat unit. On Kuneob stream, 194 spraints were found in 16 habitat units with 13.9 average sprain‍ts per habitat unit.

Indices of dispersion (I) shown in table 2 indicated distribution pattern of otter spraints for two streams by monthly intervals. I values greater than one suggested a clumped distribution of otter spraints. Differences in dispersion indices between two streams and between months were tested for statistical significance (Chi-square test with P=0.05 level). However Kuneob river had greater values of dispersion indices than Nae-chon river had, no statistical significance was found (P>0.05) between two rivers (Table 2). Difference in dispersion indices among months was not significant as well. In all months, spraints showed a clumped pattern presumably reflecting in part the repeated usage of some sites.

4. Discussion

Otter spraints on Kuneob river showed more clumped distribution than that on Nae-chon river having greater values of dispersion index (mean 1.25 vs. 2.08). It may be due to intra- specific relations of the otter population at the two rivers such as social structure, foraging, breeding and protecting one's own core area or may be due other environmental and human factors. Otter use in habitat can be dependent on social and environmental factors.

There was general tendency in indices of dispersion having higher values or clumped distribution during late and midsummer (August, July and June) and tended to decrease in autumn and early winter (September, October, and November) for both rivers. Dispersion indices for November 2011 were relatively higher than those for November 2011 on both streams. Since this data from one time survey was collected from different temporal population, it may be less meaningful to draw conclusions comparing it with the cases in 2010.

Statistical test on spatial and seasonal distribution of otter spraint was not significant indicating that need to develop a single predictive habitat model for river otters inhabiting on two different rivers with temporal resolution of one year.

Seasonal variation in the number of spraints might be related to water and food availability and fluctuation over years. High temperature in ecosystems with high water availability during summer allow a greater productivity (Rosenzweig, 1968), which usually leads to greater food availability increasing relative abundance of crayfish, amphibians, insects, and some species of cyprinids that can temporarily provide food for the otter (Lee, 2012; Ruiz-Olmo and Palazon, 1997). On the other, low temperature and water level decrease during late autumn and winter may have decreased food and water resource resulting decreased amount of sprainting activity. This could be a factor for fluctuation in water and food resources over a year (Park and Lee, 2012) reflecting different spraint counts in rivers. In conclusion river otter spraints along the river can be a useful tool to indicate habitat use pattern, but lacking in population density of river otters. This study showed that spraints were collected were not in a random but a clumped pattern implying river otters use habitats selectively, and further study needs to identify key habitat areas. In conclusions river otters prefer habitats with trees and shrubs that seem to be correlated with high abundance of fishes and tree cavities, wood debris presumably for nesting and breeding activities. Also vegetations within 5 m of the river edge should be managed and protected. This study showed that materials along the bank and river formation should be important characteristics for river habitat use pattern based on the density of spraints.

Acknowledgements

This study was supported by Korea Express Cooperation river otter monitoring study (2015), KEITI (2014-0001-30010) and ERC (NRF 2009-83527). Spraints collection was done by Ms. Park B.H. and S. Altjin and author wishes to thank them.

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