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

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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. ’T’ values greater than one indicate a clumped distribution and lower than one indicate random distribution. This study also demonstrated that we need a sophisticated 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

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 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
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 Seos eok 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 m³/sec/km² at junction point with Hongcheon river and catchment area of 345.09 km². 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 km² areas of farmlands (9.85%) located mainly along the river, 291.423 km² areas of forest (85.2%) and 15.88 km² 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).

Kuneob-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 m³/sec/km² at junction point with Hongcheon river and catchment area of 81.51 km². Water course length of this river is about 21.86 km. A 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 km² area of arable land (7.52%), 69.852 km² area of forest (85%), 0.516 km² area of bareland (0.63%), and 5.013km² 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                                | &lt; 10m, 10–25m, 25–35m, 35–50m, 50m &lt;                                  |
| Bottom structure                     | Sandy or unidentified Gravel (&lt; 15cm in diameter) Boulder (Q = 15cm)     |
| Bankment type                        | Cement                                                                      |
| Bankside vegetation                  |                                                                             |
| Vegetation type                      | Bareland                                                                   |
|                                      | Grass                                                                       |
|                                      | Shrub                                                                       |
|                                      | Tree                                                                        |
| Width of riparian vegetation zone    | &lt; 19m                                                                    |
|                                      | 20–39m                                                                     |
|                                      | 40–59m                                                                     |
|                                      | 60–100m                                                                    |
| Adjacent areas                       |                                                                             |
| Forest coverage per unit area        | &lt; 10%                                                                    |
|                                      | 10–30%                                                                     |
|                                      | 30–60%                                                                     |
|                                      | 60% &lt;                                                                   |
| Field(rice, paddy) coverage per unit area | 70%&lt;                                                                  |
|                                      | 50–70%                                                                     |
|                                      | 30–50%                                                                     |
|                                      | 30%&gt;                                                                    |
| Human built structures               |                                                                             |
| Dam                                  | Presence/absence of dike per unit area                                      |
| Bridge                               | Presence/absence of bridge per unit area                                   |
| Road                                 | 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 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:

$$I = \pi \lambda [\omega]$$

where $\pi$ is constant, $\lambda$ 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. Spraints 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 sprainting 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                       |                 |
|          | Jun–10 | 32             | 13            | 2.3           | 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            |               |                           | $x^2 = 80$       |
|          |        |                |               |               |                           | $P > 0.05$      |
| Kuneob   | May–10 | 25             | 8             | 3.1           | 2.0                       |                 |
|          | 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            |               |                           | $x^2 = 16$      |
|          |        |                |               |               |                           | $P > 0.05$      |

* 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 resources 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.

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References

Bas, N, Jenkins, D and Rothery, P (1984). Ecology of otters in Northern Scotland: v. the distribution of otter (Lutra lutra) faeces in relation to bankside vegetation on the river dee in summer 1981, J. of Applied Ecology. 21(2), pp. 307–513.

Cultural Heritage Administration (2003). Natural Monuments White Paper. [Korean Literature]

Duarte, J, Farfán, MA and Vargas, JM (2011). The use of artificial lakes on golf courses as feeding areas by the otter (Lutra lutra) in Southern Spain, IUCN otter Spec. Group Bull. 28(1), pp. 17–22.

Guisan, A and Zimmermann, NE (2000). Predictive habitat distribution models in ecology, Ecological Modelling. 135, pp.147–86.

Han, SY (1998). The ecological studies of Eurasian otter (Lutra lutra) in South Korea. Ph. D. Dissertation, Kyounam University, Changwon, Korea. [Korean Literature]

Kienast, F, Brzeziecki, B and Wildi, O (1996). Long-term adaptation potential of central European mountain forests to climate change: a gis-assisted sensitivity assessment, Forest Ecology and Management 80, pp. 133–53.

Kienast, F, Wildi, O and Brzeziecki, B (1998). Potential impacts of climate change on species richness in mountain forests – an ecological risk assessment, Biological Conservation 83, pp. 291–305.

Kruuk, H (1995). Wild Otters: Predation and Populations: Oxford Univ. Press. New York, NY, USA.

Leathwick, JR (1998). Are New Zealand’s nothofagus species in equilibrium with their environment? J. of Vegetation Science 9(5), pp. 719–32.

Lee, SD (2012). Studies on Food Items of River Otter Residing in the Hongchon Stream, J. of Korean Wetlands Society. 14(4), pp. 591–596. [Korean Literature]

Margules, CR, Austin, MP, Mollison, D and Smith, F (1994). Biological models for monitoring species decline: the construction and use of data bases, Philosophical Transactions of The Royal Society B Biological Sciences B 344, pp. 69–75.

Mason, CF and Macdonald, SM (1986). Otters: Ecology and Conservation: Cambridge University Press. Cambridge, United Kingdom/New York, NY, USA.

Mason, CF and Macdonald, SM (1987). The use of spraints for surveying otter Lutra lutra populations: an evaluation, Biological Conservation. 41(3), pp.167–177.

Melquist, WE and Hornocker. MG (1983). Ecology of river otters in western Idaho. Wildlife Monographs 83, pp. 1–60.

Ministry of Construction and Transportation (2004). Report on River Management Plan. [Korean Literature]

Ministry of Environment (2008). Wild Fauna and Flora of Korea. [Korean Literature]

Park, B (2010). A study on the habitat of Hongcheon stream and feces analysis of Eurasian otter (Lutra lutra) in Korea, Master’s Thesis, Ewha Womans University, Seoul, Korea. [Korean Literature]

Park, B and Lee, SD (2012). Studies on river otter habitat use pattern on Hongchun river in Gangwon province, J. of Korean Wetlands Society. 14(3), pp. 413–148. [Korean Literature]

Pielou, EC (1969). An Introduction to Mathematical Ecology. John Wiley & Sons, New York.

Romanowski, J, Cygan, M and Brzezinski, JP (1996). Notes on the technique of the otter field survey, Acta Theriologica. 41, pp. 199–204.

Rosenzweig, ML (1968). Net primary productivity of terrestrial communities: prediction from climatological data, The American Naturalist. 102(923), pp. 67–74.

Ruiz–Olmo, J and Palazon, S (1997). The diet of the otter (Lutra lutra L., 1758) in Mediterranean freshwater habitats, Wildlife Restoration. 2(2), pp.171–181.