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BIODIVERSITY OF KINGDOM ANIMALIA AT THE DOTAN RIVER IN HAPCHEON-GUN PROVINCE IN KOREA

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ABSTRACT

This study is to investigate the biodiversity of animal kingdoms at four regions on the Dotan River in Korea. Animal identification using a means of marking is a process done to identify and track specific animals. For determination of diversity indices random samples of animals were taken from four stations for each season. Examination of all samples resulted in a total number of 52 taxa, representing six classes; Mammalia (Mammals), Actinopterygii (Bony Fish), Chondrichthyes (Cartilaginous Fish), Aves (Birds), Amphibia (Amphibians) and Reptilia (Reptiles). Shannon-Weaver index (H´) for mammals at upper region was higher than those of low region. This area is a forest area and is good for mammals. Although richness indices (R1-R2) and evenness indices (E1-E5) for animal kingdoms during seasons were different from each other (data not shown), there were not shown significant differences ($p < 0.05$). The study of local biodiversity may be necessary to conserve natural regulatory mechanisms of regional species. Such holistic approaches are the essence of ecosystem-based management.

Keywords: Animals, biodiversity, Dotan River, richness indices, Shannon-Weaver index.

INTRODUCTION

People drink fresh water and wash their with it. In addition, we irrigate our crops with it, and we use it in our factories. The abundance or lack of water often determines where we live and how well off we are (Chiras, 1998). Despite its importance to humans and other organisms, water is squandered and polluted by industry, agriculture, and many other systems. Rivers play a major role in the economy of a country by sustaining agriculture, industry, energy generation and providing biological resources.Human activities can lead to either an increase or a decrease in quantity of flow as well as changing the timing, duration and seasonal pattern of ecologically important flow events (Dutta et al., 2017). The river is a home or 'habitat' for plant and animal life. The river environment is often referred to an 'ecosystem'. 'Ecosystem', a term coined by British biologist Arthur Tansley in 1935, is defined by the Oxford Dictionary online as 'a biological community of interacting organisms and their physical environment'. Long time changes are also contributing to changed flow regimes in the rivers such as the reduction in flow seen in various parts of the world. Many of the major rivers of the world no longer support ecologically and socially valued diversity of native species or sustain healthy ecosystems that provide important ecological goods and services (Dudgeon, 2010; Naiman et al., 2008). Big rivers are a major concern of the government, but small rivers are ignored by government policies. Thus, humans have grossly abused the small rivers worldwide by extensive regulation of flows, habitat alteration and disposal of all kinds of wastes into them.

Species coexistence may be considered as stable or unstable. Stable coexistence means that the densities of the species in the system do not show long-term trends (Chesson, 2000). Animal community ecology has not seen parallel development of statistical inference procedures that recognize and explicitly incorporate species detection probabilities (Nichols et al., 1998). The basic idea of a diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities, composed of discrete components, in space or in time (Heip et al., 2001). Indicators for biodiversity are needed in many contexts, e.g., to prioritize habitats in conservation networks (Sarkar, 2002), to determine and monitor management plans (Dziock et al., 2006), to identify stressors on biodiversity (Fränzle, 2006), to assess impacts on biodiversity (Treweek, 1996), and to analyze habitat conditions (Landres et al. 1988). The suitability of an indicator will be established differently, however, for different applications (Failing and Gregory, 2003).

Several key ecological theories contribute to spatial ecology and guide empirical investigations in the field and laboratory (Collinge, 2010) . Ecologists have used these theories to develop and refine our understanding of the implications of spatial variation for ecological processes.
The Dotan River begins at Mt. Heogul (681 m) in Dotan-ri, Gahoe-myeon, Hapcheon-gun, Korea. The development of forest land and the reduction of agricultural land due to industrialization are spreading to rural areas. The quantity of river water in Korea has been declining in recent years. As a result, the habitat environment of animals is reduced. The purpose of this study is to investigate biological species diversity of the fauna on the Dotan River at four regions during four seasons on 2018. Then, based on these diversity patterns and relationships, it is to be used primarily to assess changes in biodiversity over time.

METHODOLOGY

Surveyed regions

This study was carried out on the Dotan River (upper region: 35°478′702″N/128°035′740″E, low region: 35°454′522″N/128°046′988″E), located at Hapcheon-gun, Gyeongsangnam-do province in the South Korea (Fig. 1). Uplands are somewhere around 300 m, while lowlands are usually no higher than 170 m. Landscapes of around this river have been used, and in many places, continue to be used, intensively for agriculture by indigenous peoples.

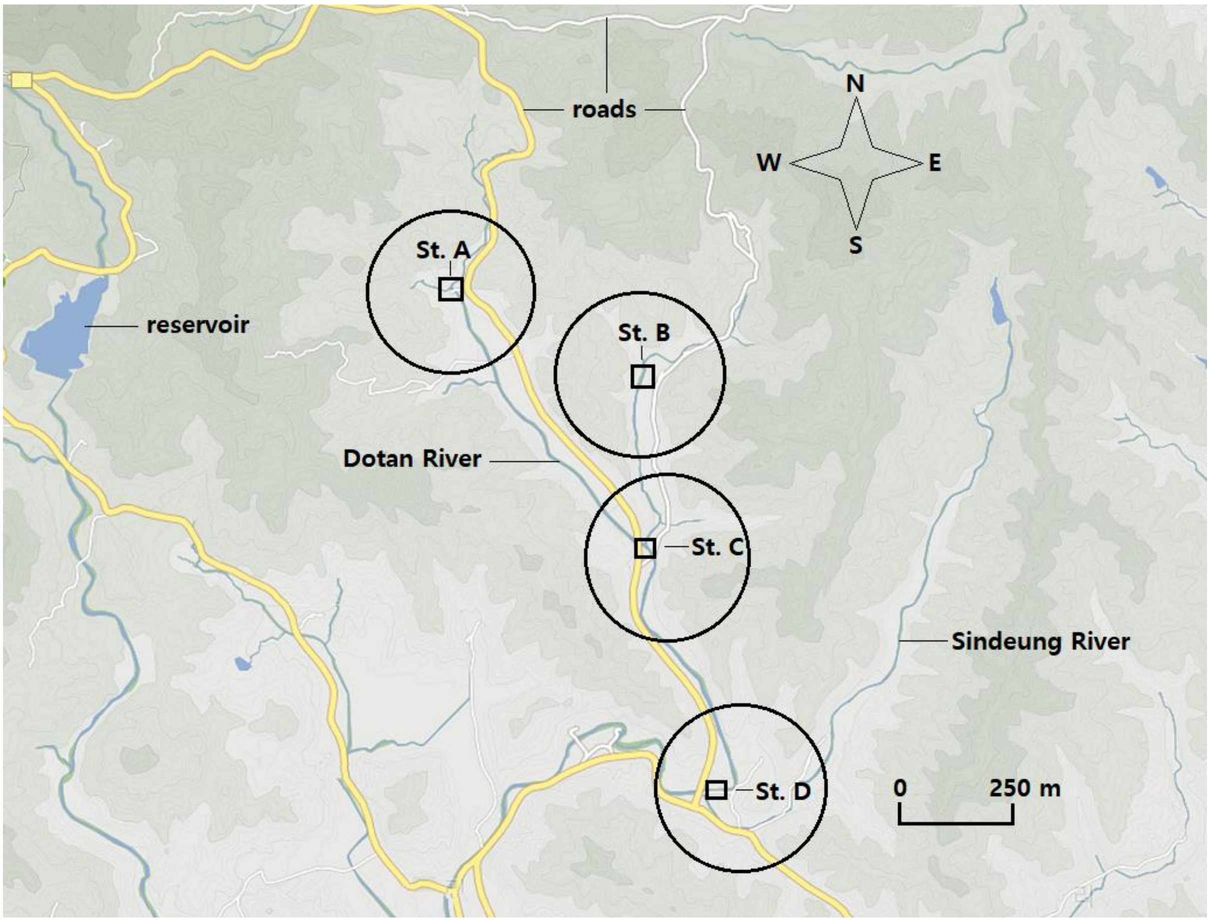

Figure 1. The four stations (St. A~D) for fish (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at Dotan River in Korea.

Identification of animals

Animal identification using a means of marking is a process done to identify and track specific animals. Whenever a visual contact was established with any other species, the identification was confirmed by using binoculars and/or acoustic records, and the species' name, date, time, and sighted place were recorded (geographical coordinates obtained by GPS). Several mammals have nocturnal habits and many of them use the interior of the forest and canopy stratum. Whenever possible, the observed species were filmed and/or photographed for subsequent confirmation of the identification. Identifications of mammals and herpetology were based on Weon (1967). The identification of birds followed Lee et al. (2012). Identifications of herpetology were based on Lee et al. (2013). Identifications of fishes were based on Choi (2001). The periods of animal samplings were February (winter), May (spring), August (summer), and October (fall) 2018.

Biotic indices

For determination of diversity indices random samples of animals were taken from four stations for each season. Total number of species, total number of individuals in a sample and total number of individuals of a species were determined every seasons. A diversity index is a mathematical measure of species diversity in a given community. Three categories of biodiversity were used to primary interest: number of species, overall abundance, and species evenness. From these data Shannon–Weaver (S-W) species diversity index (Shannon and Weaver, 1963), Evenness index (E1~E5) (Pielou, 1966; Hill, 1973) and richness (R1 and R2) (Magurran, 1988). were determined. Berger-Parker's index (BPI) is a measure of the evenness

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of evenness (Cody & Diamond, 1975). BPI = *N*max/N where *N*max is the number of individuals of the most abundant species, and N is the total of individuals of sample. ß-diversity, defined as the differences in species composition among plots as a region, is calculated using the method of Tuomisto (2010) as ß = γ/α. Here γ is the total species diversity of a landscape, and α is the mean species diversity per habitat. The homogeneity of variance or mean values to infer whether differences exist among the stations samples or seasons was tested (Zar, 1984). Except where stated otherwise, statistical analyses were performed using the SPSS software (Release 21.0).

Cluster analyses

The degree of similarity among animal communities and classification of sites was calculated on the basis of Ward's method and a hierarchical cluster analysis (Bis et al., 2000). A dendrogram was constructed by the neighbor joining (NJ) method using the NEIGHBOR program in PHYLIP version 3.57 (Tamura et al., 2011).

RESULTS AND DISCUSSION

Examination of all samples resulted in a total number of 52 taxa, representing six classes; Mammalia (Mammals), Actinopterygii (Bony Fish), Chondrichthyes (Cartilaginous Fish), Aves (Birds), Amphibia (Amphibians) and Reptilia (Reptiles) (Table 1). Mammals accounted for eight taxa for only four seasons within the studied areas. They were the most poorly represented of the terrestrial vertebrate groups. Fish exhibited the greatest species diversity with 16 taxa identified, followed by birds (Aves) (14 taxa). There were thirteen taxa of reptiles/amphibians (Sauropsida/Amphibia) at four sites for four seasons. The mean numbers of species were 32 taxa within the St. A and St. B, 31 taxa within the St. C, and 34 taxa within the St. D. Mammals and Birds were shown with the relative high individual density or abundance in upper region (stations A and B) of river across areas (Table 2). Fish was shown with the relative high individual density or abundance in low region (station D) of river across areas. Many individuals were found in this area because the abundant water supply by two joining rivers.

In order to assess macro-scale spatial variability of the animal community at the Dotan River, I analyzed distributions of species richness, diversity, and evenness of large taxonomic groups as well as four station compositions along a geographic distances (Tables 1 and 2). Shannon-Weaver index (H´) for mammals at upper region was higher than those of low region. This area is a forest area and is good for mammals. Significant variability was recorded both between seasons and between sites. H´ for birds also varied among the stations and season. Mean H´ of diversity for birds was varied from 1.980 (St. D) to 2.387 (St. A). St. C and St. D were considerable high H´ in reptiles/amphibians and fish. Berger-Parker's index (BPI) for mammals was varied from 0.200 (Station A) to 0.333 (Station D). St. A was considerable high BPI in fish (0.286). BPI values for mammals were low at upper region, meaning dominant species were different according to stations or seasons. St. B was also considerable high richness in birds and reptiles/amphibians. Richness indices for animal taxa were also varied among the stations and seasons. Although richness indices (R1-R2) for animal kingdoms during seasons were different from each other (data not shown), there were not shown significant differences ($p < 0.05$). Evenness indices (E1-E5) for animal kingdoms were different from each other, however there were not shown significant differences ($p < 0.05$).
The values of ß-diversity for animals were varied from 0.225 for fish to 0.242 for mammals (Fig. 2). For the community as a whole, the values of ß-diversity were the low (from 0.149 for St. D to 0.191 for St. B) (Fig. 3). Those results indicated that heterogeneity in species

compositions among the replicates were high. It is usually assumed that habitat quality and the biological characters are based on their ability in the heterogeneous environments. Alternatively, isolation would be a game of chance, where stochastic principles would favor the isolation of more abundant community members and sample heterogeneity would determine seasonal migration (migratory birds) for favor habitat (Huh, 2015). The Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among four stations at the Dotan River (Table 4). Neighboring stations such as St. C and St. D had the similar species composition (95.8%) and the highest remote populations (St. A and St. D) did not share any species (52.9%).

Clustering of four stations, using the NJ algorithm, was performed based on the matrix of calculated distances (Fig. 4). Four stations of the Dotan River were well separated each other. The dendrogram showed two distinct groups; St. A and St. B clade, St. C and St. D clade and they were sistered with each other.

Species diversity has two primary components: species richness (the number of species in a local community) and species composition (the identity of the species present in a community). While most research on the relationship between ecosystem diversity and stability has focused on species richness, it is variation in species composition that provides the mechanistic basis to explain the relationship between species richness and ecosystem functioning. Species differ from one another in their resource use, environmental tolerances, and interactions with other species, such that species composition has a major influence on ecosystem functioning and stability. Habitat diversity (spatial heterogeneity within and between habitat patches in a landscape) is often invoked as a driver of species diversity at small spatial scales (Lengyel et al., 2006). Heterogeneity is a prominent feature of most ecosystems. As a result of environmental heterogeneity the distribution of many soil organisms shows a temporal as well as horizontal and vertical spatial patterning (Berg & Bengtsson, 2007). In spite of this, food webs are usually portrayed as static networks with highly aggregated trophic groups over broader scales of time and space.

Table 1. Biological diversity index for mammals, birds, and reptile/amphibians in the studied areas

Indices	Mammal				Bird			
Station	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
No. of species	8	7	5	5	12	12	9	8
Diversity								
H'	2.029	1.860	1.553	1.490	2.387	2.363	2.025	1.980
N1	7.608	6.426	4.726	4.436	10.884	10.624	7.575	7.242
N2	9.255	8.077	5.667	5.250	14.025	12.857	8.017	8.591
Richness								
BPI	0.200	0.238	0.278	0.333	0.233	0.344	0.324	0.222
R1	2.058	1.971	1.384	1.477	3.119	3.070	2.330	2.101
R2	1.461	1.528	1.179	1.291	2.058	2.001	1.616	1.512
Diversity								
H'	2.029	1.860	1.553	1.490	2.387	2.363	2.025	1.980
N1	7.608	6.426	4.726	4.436	10.884	10.624	7.575	7.242
N2	9.255	8.077	5.667	5.250	14.025	12.857	8.017	8.591
Evenness								

E1	0.976	0.956	0.965	0.926	0.961	0.951	0.922	0.952
E2	0.951	0.918	0.945	0.887	0.907	0.885	0.842	0.905
E3	0.944	0.904	0.931	0.859	0.899	0.875	0.822	0.892
E4	1.217	1.257	1.199	1.184	1.289	1.210	1.058	1.186
E5	1.249	1304	1.253	1.237	0.318	1.232	1.067	1.216

Table 2. Biological diversity index for reptile/amphibians and fishes in the studied areas

Indices	Reptile /Amphibian				Fish			
Station	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
No. of species	10	11	12	10	12	11	12	14
Diversity								
H'	1.736	1.8555	2.048	2.081	1.735	1.744	2.005	2.024
N1	5.677	6.395	7.754	8.015	5.668	5.718	7.430	7.569
N2	5.979	6.757	7.853	7.984	6.233	6.329	8.283	7.279
Richness								
BPI	0.233	0.344	0.324	0.222	0.286	0.250	0.240	0.255
R1	1.338	1.586	2.045	1.996	1.418	1.406	1.885	2.102
R2	0.929	1.055	1.273	1.214	1.029	1.014	1.249	1.342
Diversity								
H'	1.736	1.8555	2.048	2.081	1.735	1.744	2.005	2.024
N1	5.677	6.395	7.754	8.015	5.668	5.718	7.430	7.569
N2	5.979	6.757	7.853	7.984	6.233	6.329	8.283	7.279
Evenness								
E1	0.969	0.954	0.932	0.947	0.968	0.973	0.964	0.921
E2	0.946	0.914	0.862	0.891	0.945	0.953	0.929	0.841
E3	0.935	0.899	0.844	0.877	0.934	0.944	0.919	0.821
E4	1.053	1.057	1.013	0.996	1.100	1.107	1.115	0.962
E5	1.065	1.067	1.015	0.996	1.121	1.130	1.133	0.956

Table 3. Ecological distance (upper diagonal) based on Bray-Curtis' formulae analysis and geographic distances (km) (low diagonal) among four stations at the Dotan River

Station	St. A	St. B	St. C	St. D
St. A	-	0.086	0.299	0.471
St. B	0.352	-	0.071	0.382
St. C	0.565	0.320	-	0.042
St. D	0.917	0.880	0.500	-

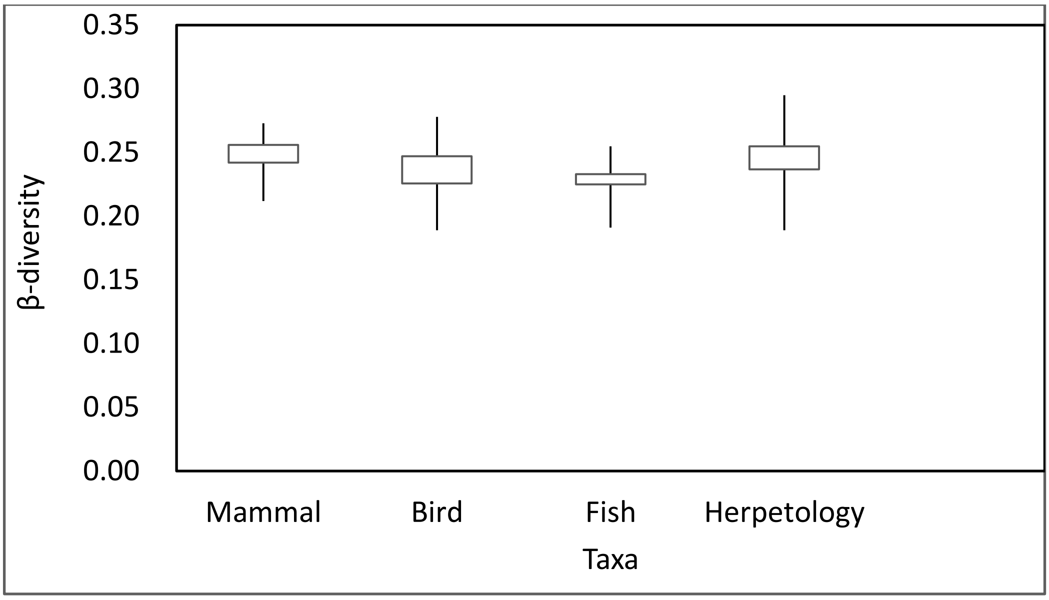

Figure 2. Occurrence index (β-diversity) for five animal kingdoms at four stations.

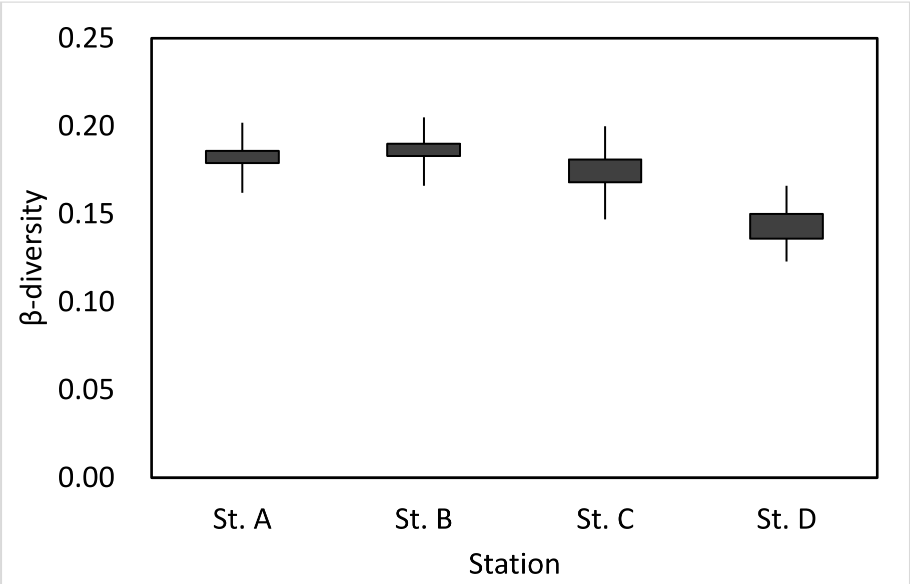

Figure 3. Occurrence index (β-diversity) of four stations for five animal kingdoms.

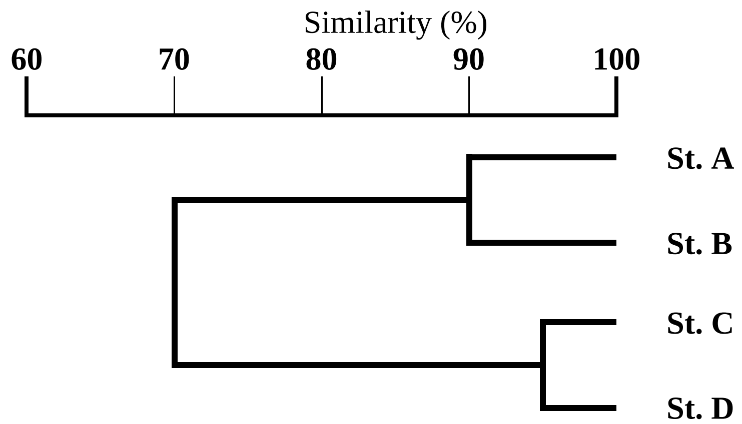

Figure 4. A phenogram showing the animal distribution relationships among four stations at the Dotan River in Korea.

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CONCLUSIONS

Experiments in aquatic ecosystems have also shown that large-scale processes play a significant role in stabilizing ecosystems. Neighboring stations such as St. C and St. D had the similar species composition (95.8%) and the highest remote populations (St. A and St. D) did not share any species (52.9%). Evidence from multiple ecosystems at a variety of temporal and spatial scales, suggests that biological diversity acts to stabilize ecosystem functioning in the face of environmental fluctuation.

REFERENCES

Bis, B., Zdanowitz, A., & Zalewski, M. (2000) Effect of catchment properties on hydrochemistry, habitat complexity and invertebrate community structure in a lowland river. *Hydrobiologia, 422/423,* 369-87.

Berg, M.P., & Bengtsson, J. (2007) Temporal and spatial variability in soil food web structure. *Oikos, 116,* 1789-804.

Chesson, P. (2000) Mechanisms of maintenance of species diversity. *Annual Review of Ecology and Systematics, 31,* 343-66.

Chiras, D.D. (1998) Environmental science. A systems approach to sustainable development. Fith edition, Wadsworth Publishing Company: Belmont, USA.

Choi, K.C. (2001) Guide of Korean fresh water fish in color (excluded Lepidoptera). Hyeoamsa: Seoul, Korea.

Cody, M., & Diamond, J. (1975) Ecology and evolution of communities. Harvard University Press: Cambridge, Mass.

Collinge, S. (2010) Spatial ecology and conservation. *Nature Education Knowledge, 3*, 69.

Dudgeon, D. (2010) Requiem for a river: Extinctions, climate change and the last of the Yangtze. *Aquatic Conservation: Marine and Freshwater Ecosystems, 20,* 127-31.

Dutta, V., Sharma, U., & Kumar, R. (2017) Assessment of river ecosystems and environmental flows: Role of flow regimes and physical habitat variables. *Climate Change and Environmental Sustainability, 5,* 20-34.

Dziock, F., et al. (2006) Biological indicator systems in floodplains-a review. *International Review of Hydrobiology, 91,* 271-91.

Failing, L., & Gregory, R. (2003) Ten common mistakes in designing biodiversity indicators for forest policy. *Journal of Environmental Management, 68,* 121-32

Fränzle, O. (2006) Complex bioindication and environmental stress assessment. *Ecological Indicators, 6,* 114-36

Heip, C.H.R., et al. (1998) Indices of diversity and evenness. *Oceanis, 24,* 61-87.

Hill, M.O. (1973) Diversity and evenness: a unifying notation and its consequences. *Ecology, 54*, 423-32.

Huh, M.K. (2015) Monitoring change in biodiversity of kingdom animalia at the Cheongok River, Uiryeong-gun, Korea. *International Journal of Engineering and Applied Sciences, 2*, 54-58.

Lee, J.H., Chun, H.J., & Seo, J.H. (2012) Ecological guide book of Herpetofauna. National Institute of Environmental Research: Incheon, Korea.

Lee, U.S., Ku, T.H., & Park, J.Y. (2005) A field guide to the birds of Korea. LG Evergreen Foundation: Seoul, Korea.

Lengyel, S., Deri, E., & Magura, T. (2006) Species richness responses to structural or compositional habitat diversity between and within grassland patches: a multi-taxon approach. *PLoS ONE 11,* e0149662.

Landres, P.B, Verner, J., & Thomas, J.W. (1988) Ecological uses of vertebrate indicator species: a critique. *Conservation Biology, 2,* 316-27.

Magurran, A.E. (1988) Ecological diversity and its measurement. Univ. Press: Cambridge, USA.

Naiman, R.J., et al. (2008) Flow variability and the biophysical vitality of river systems. *Comptes Rendus Geoscience, 340,* 629-43.

Nichols, J.D., et al., (1998) Estimating rates of local species extinction, colonization, and turnover in animal communities. *Ecological Applications, 8,* 1213-25

Pielou, E.C. (1966). The measurement of diversity in different types of biological collection. *Journal of Theoretical Biology*, *13*, 131-144.

Sarkar, S. (2002) Defining ‘‘biodiversity’’: Assessing biodiversity. *The Monist 85,* 131-55.

Treweek, J.R. (1996) Ecology and environmental impact assessment. *Journal of Applied Ecology, 33*, 191-9.

Shannon, C.E., & Weaver, W. (1963) The measurement theory of communication. Univ. of Illinois Press: Urbana.

Tamura, K., et al. (2011) MEGA5: Molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution, 28,* 2731-9.

Tuomisto, H. (2010) A diversity of beta diversities: straightening up a concept gone awry. Part 1. Defining beta diversity as a function of alpha and gamma diversity. *Ecography*, *33*, 2-22.

Weon, B.H. (1967) Mammal species in Korea. Ministry of Education: Seoul, Korea.

Zar, J.H. (1984) Biostatistical analysis. Prentice-Hall Inc.: Englewood Cliffs, New Jersey.