BIODIVERSITY OF KINGDOM ANIMALIA AT THE SHINJEON RIVER IN HAPCHEON-GUN, KOREA

Man Kyu Huh
Division of Applied
Bioengineering /Dong-eui
University
S. KOREA
mkhuh@deu.ac.kr

ABSTRACT

Biodiversity provides people with basic ecosystem goods and services. This study is to investigate the biodiversity of animal kingdoms at four regions on the Shinjeon River in Korea. Animal groups included mammals, birds, herpetology, fish, and invertebrates. A diversity index is a mathematical measure of species diversity in a given community. Mammals accounted for eleven taxa for four seasons within the studied areas. Invertebrates exhibited the greatest species diversity with 20 taxa identified, followed by birds (Aves) (16 taxa). There were ten taxa of reptiles/amphibians (Sauropsida/Amphibia) at four sites for four seasons. Shannon-Weaver index (H´) for mammals at the upper region (A) was higher than those of low region (D). The values of ß-diversity for animals were varied from 0.209 for Herpetology to 0.218 for fish. For the community as a whole, the values of ß-diversity were the low (from 0.163 for St. D to 0.221 for St. B). Neighboring stations such as St. B and St. C had the similar species composition (94.8%) and the highest remote populations (St. A and St. D) did not share any species (51.1%). It is usually assumed that habitat quality and the biological characters are based on their ability in the heterogeneous environments.

Keywords: Animal kingdoms, biodiversity, Shinjeon River, richness indices, ß-diversity.

INTRODUCTION

Streams and rivers are among the most fascinating and complex ecosystems on Earth. Ecotones (transition zones between adjacent patches) and connectivity (the strength of interactions across ecotones) are structural and functional elements that result from and contribute to the spatial-temporal dynamics of riverine ecosystems (Ward et al., 1999). In flood plain rivers, ecotones and their adjoining patches are arrayed in hierarchical series across a range of scales.

Describing the diversity of major groups of organisms represents an enormous undertaking. Large institutions and scientists undertake biological surveys of entire countries or regions, which work includes specimen collection in the field, identification of species, and descriptions of fauna). Free-living species are typically estimated from units of defined area, which allows units to be treated as equivalent. According to process of community, priority effects, caused by variation in the sequence and timing of species arrival, are responsible for a large part of the variation in species composition between communities (Grman and Suding, 2010). The number of species in an assemblage is the most basic and natural measure of diversity. Biodiversity refers to variation in the organic world. Biodiversity encompasses the variety of all living forms on the planet, extending from genes to species to ecosystems (Wilson, 1988).

To precisely estimate diversity we would have to collect every individual of every species in the entire habitat, which is neither practical nor desirable (Dove and Cribb, 2006). Animals inhabit a wide variety of habitats such as water or riparian within a river. River fauna has also varied considerably among and within drainages. Geomorphological characteristics of rivers provide the setting for the establishment of distinct faunal assemblages.

Whittaker (1960) introduced the term beta diversity (β) together with alpha diversity (α) and gamma diversity (γ). Both α and γ represent species diversity, but α is the mean species diversity at the local, within-site or within-habitat scale, whereas g is the total species diversity at the regional or landscape scale (Tuomioto, 2010). Cody (1975) redefined beta diversity as the rate of compositional turnover along a habitat gradient within one geographical region, and gamma diversity as the rate of compositional turnover with geographical distance within one habitat.

The length of the Shinjeon River is 3.7 km long, flows across the countryside, and locates at Hapcheon-gun, Gyeongsangnam-do in South Korea. To suggest appropriate criteria for a biodiversity measure when that measure is to be used primarily to assess changes in biodiversity over four season (spring, summer, fall and winter). This provides an objective means of choosing between possible measures. I assume that three aspects of biodiversity are of primary interest: number of species, overall abundance, and species evenness at the Shinjeon River.

METHODOLOGY

Surveyed regions

This study was carried out on the Shinjeon River (upper region: 35°381′217″N/128°189′579″E, low region: 35°409′344″N/128°122′393″E), located at Hapcheon-gun, Gyeongsangnam-do province in Korea (Fig. 1). Lowlands are usually no higher than 120 m, while uplands are somewhere around 430 m to 450 m. The relatively low level land can be developed either as agricultural fields or sites for habitation or business. Flood plains of this river are usually very fertile agricultural areas and out sides of this river consist of a mosaic of agricultural fields and farming houses.

Identification of animals

Animal groups included mammals, birds, herpetology, fish, and invertebrates. To understand how different physical or biological factors influence the distribution or abundance of species, it usually need to measure changes in population abundances over space or time. At one extreme is a complete census of individually identifiable organisms. Animal identification using a means of marking is a process done to identify and track specific animals. A small dredge is also used to collect sediments from the bottom of the river to determine the numbers and kinds of invertebrates present. 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. (2005). Identifications of fishes were based on Choi (2001). Identifications of invertebrates were based on Kim et al. (2013). The periods of animal samplings were February, May, August, and October 2016.

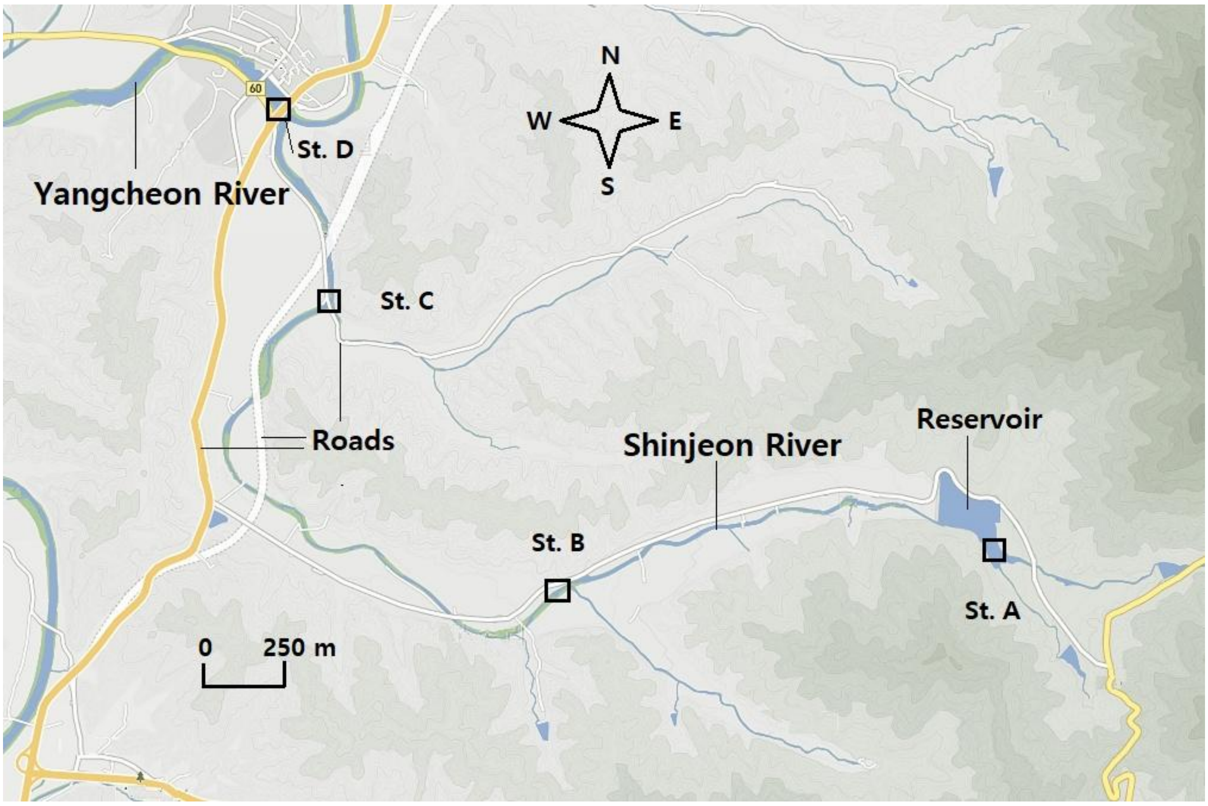

Figure 1. The four stations (St. A~D) for fish and invertebrates (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at the Shinjeon River in Korea.

Biotic indices

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. The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled (Shannon and Weaver, 1963): the formula for calculating the Shannon diversity index (H') is

$$H' = -\sum pi \ln pi$$

pi is the proportion of important value of the *i*th species (*pi* = *n*i / N, *n*i is the important value index of *i*th species and N is the important value index of all the species).

$$N1 = e^{H'}$$

$$N2 = 1/\lambda$$

Where λ (Simpson's index) for a sample is defined as

$$\lambda = \sum \frac{ni(ni-1)}{N(N-1)}$$

Species richness is the number of species of a particular taxon that characterizes a particular biological community, habitat or ecosystem type (Colwell, 2011). Species richness was also calculated for all derived emergent groups separately. The species richness of animals was calculated by using the method, Berger-Parker's index (BPI) and Margalef's indices (R1 and R2) of richness (Magurran, 1988). 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. Species evenness is a measure of biodiversity which quantifies how equal the community is numerically. Evenness indices (E1~E5) was calculated using important value index of species (Pielou, 1966; Hill, 1973). 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 current study examines the performance of cluster analysis with dichotomous data using distance measures based on response pattern similarity. 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

As expected, the diversity of vertebrates is well known, with fishes being the most species-rich group and perhaps the most important for the functioning of riverine ecosystems.
Although the length of the Shinjeon River was not long (about 3.6 km), but the fauna were very diverse and the fauna community at the Shinjeon River region during 2017 season was identified with a total of 69 taxa, representing six classes; Mammalia (Mammals), Actinopterygii (Bony Fish), Chondrichthyes (Cartilaginous Fish), Aves (Birds), Amphibia (Amphibians) and Reptilia (Reptiles) Mammalia (Mammals), Actinopterygii (Bony Fish), Aves (Birds), Amphibia (Amphibians) and Reptilia (Reptiles) and invertebrates (Tables 1 and 2). Mammals accounted for eleven taxa for four seasons within the studied areas. Invertebrates exhibited the greatest species diversity with 20 taxa identified, followed by birds (Aves) (16 taxa). There were ten taxa of reptiles/amphibians (Sauropsida/Amphibia) at four sites for four seasons. They were the most poorly represented of the terrestrial vertebrate groups. Fish represented by twelve taxa. The mean numbers of species were 61 taxa within the St. A, 53 taxa within the St. B, 51 taxa within the St. C, and 53 taxa within the St. D. All classes were shown with the relative high individual density or abundance in upper region (station A) of river across areas (Tables 1 and 2). Many individuals were found in this area because the abundant food supply by one large reservoir. The area has many good habitats including forests. Invertebrate animals were shown with the relative high individual density or abundance in low region (station D). It is the junction of two rivers in this area. The area is abundant in quantity and provides good food and habitat for fish. Theory and small-scale experiments predict that biodiversity losses can decrease the magnitude and stability of ecosystem services such as production and nutrient cycling (France and Duffy, 2006). In order to assess macro-scale spatial variability of the animal community at the Shinjeon River, I analyzed distributions of species richness, diversity, and evenness of large taxonomic groups as well as four station compositions along a geographic distances (Table 3).

Shannon-Weaver index (H´) for mammals at the upper region (A) was higher than those of low region (D). This area A is a forest area and is good for mammals. H´ for fauna varied among the stations and season. Mean H´ of diversity for mammals was varied from 1.837 (St. D) to 2.153 (St. A). St. A was also considerable high H´ in birds, reptiles/amphibians, fish, and invertebrates. Berger-Parker's index (BPI) for mammals was varied from 0.176 (Station A) to 0.263 (Station D). St. B was considerable high BPI in reptiles/amphibians (0.344). BPI values for mammals, birds, and invertebrates were low at upper region, meaning dominant species were different according to stations or seasons. Richness indices for animal taxa were also varied among the stations and seasons. Although richness indices (R1-R2) for five animal kingdoms during seasons were different from each other, there were not shown significant differences ($p < 0.05$). Evenness indices (E1-E5) for five 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 0.209 for Herpetology to 0.218 for fish (Fig. 2). For the community as a whole, the values of ß-diversity were the low (from 0.163 for St. D to 0.221 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 Shinjeon River (Table 4). Neighboring stations such as St. B and St. C had the similar species composition (94.8%) and the highest remote populations (St. A and St. D) did not share any species (51.1%).

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

The importance of the order of species loss also raises questions as to how best to prioritise funding for biodiversity and ecosystem services protection. The importance of systemic thinking and multi-functionality is not a side issue when it comes to considering the links between biodiversity and ecosystem services. In fact, the true significance of biodiversity may only be revealed when the whole system, across the full spectrum of ecosystem services, including different locations and across many years, is considered. Indeed, evidence is now mounting to show that higher biodiversity is needed to maintain multiple ecosystem services in the long term and under environmental change (Balvanera et al., 2014; Cardinale et al., 2011).

CONCLUSION

The results of ecological diversity and richness of animals at the Shinjeon River showed a spatial variability according to sites. Many forests and agricultural lands were converted into industrial sites. This artificial action reduced the water's natural filtration action and eliminated the habitat of many animals.

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

Indices	Mammal				Bird				Reptile /Amphibian			
	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
No. of species	9	8	8	7	14	13	11	10	9	8	8	9
Richness												
BPI	0.176	0.185	0.185	0.263	0.119	0.150	0.211	0.182	0.233	0.344	0.324	0.222
R1	2.269	2.123	2.124	2.038	3.478	3.253	2.749	2.574	2.127	2.020	1.939	2.102
R2	1.544	1.539	1.540	1.606	2.160	2.055	1.784	11.000	1.372	1.414	1.315	1.342
Diversity												
H'	2.153	2.026	2.004	1.837	2.572	2.473	2.278	2.207	2.379	1.354	1.828	2.089
N1	8.607	7.580	7.415	6.276	13.093	11.863	9.758	9.090	10.793	3.874	6.222	8.080
N2	10.585	9.487	9.000	7.773	17.220	14.717	10.815	11.000	8.135	5.976	6.343	8.534
Evenness												
E1	0.980	0.974	0.963	0.944	0.975	0.964	0.950	0.959	1.083	0.651	0.879	0.951
E2	0.956	0.948	0.927	0.897	0.935	0.913	0.887	0.909	1.199	0.484	0.778	0.898
E3	0.951	0.940	0.916	0.879	0.930	0.905	0.876	0.899	1.224	0.411	0.746	0.885
E4	1.230	1.252	1.214	1.239	1.315	1.241	1.108	1.210	0.754	1.542	1.019	1.056
E5	1.260	1.289	1.247	1.284	1.341	1.263	1.121	1.238	0.729	1.731	1.023	1.064

Table 2. Biological diversity index for fishes and invertebrates in the studied areas

Indices	Fish				Invertebrates			
	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
No. of species	12	10	10	11	17	14	14	16
Richness								
BPI	0.164	0.167	0.195	0.245	0.080	0.150	0.178	0.170
R1	2.564	2.325	2.424	2.519	4.090	3.524	3.415	3.778
R2	1.404	1.443	1.562	1.511	2.404	2.214	2.087	2.198
Diversity								
H'	2.361	2.222	2.153	2.243	2.772	2.508	2.542	2.628
N1	10.599	9.221	8.615	9.419	15.984	12.282	12.698	13.840
N2	10.771	10.255	9.318	9.248	22.685	15.001	14.776	15.143
Evenness								
E1	0.950	0.965	0.935	0.935	0.978	0.950	0.963	0.948
E2	0.883	0.922	0.861	0.858	0.940	0.877	0.907	0.865
E3	0.873	0.913	0.846	0.842	0.937	0.868	0.900	0.856
E4	1.016	1.112	1.082	0.982	1.419	1.221	1.164	1.094
E5	1.018	1.126	1.092	0.980	1.447	1.241	1.178	1.101

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

Station	St. A	St. B	St. C	St. D
St. A	-	0.081	0.382	0.489
St. B	1.155	-	0.052	0.408
St. C	2.509	1.354	-	0.127
St. D	3.664	1.842	0.488	-

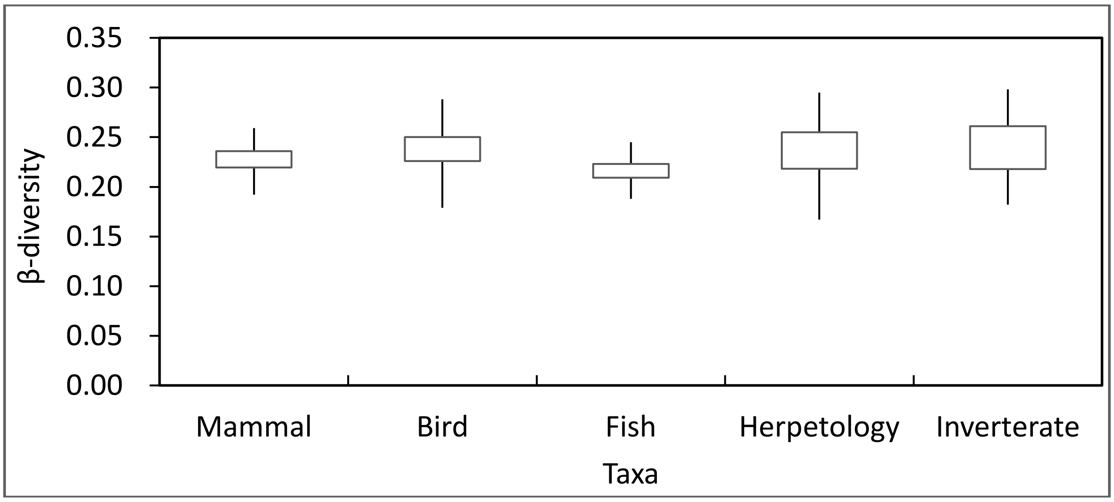

Figure 2. Occurrence index (β-diversity) for five animal kingdoms at four stations.

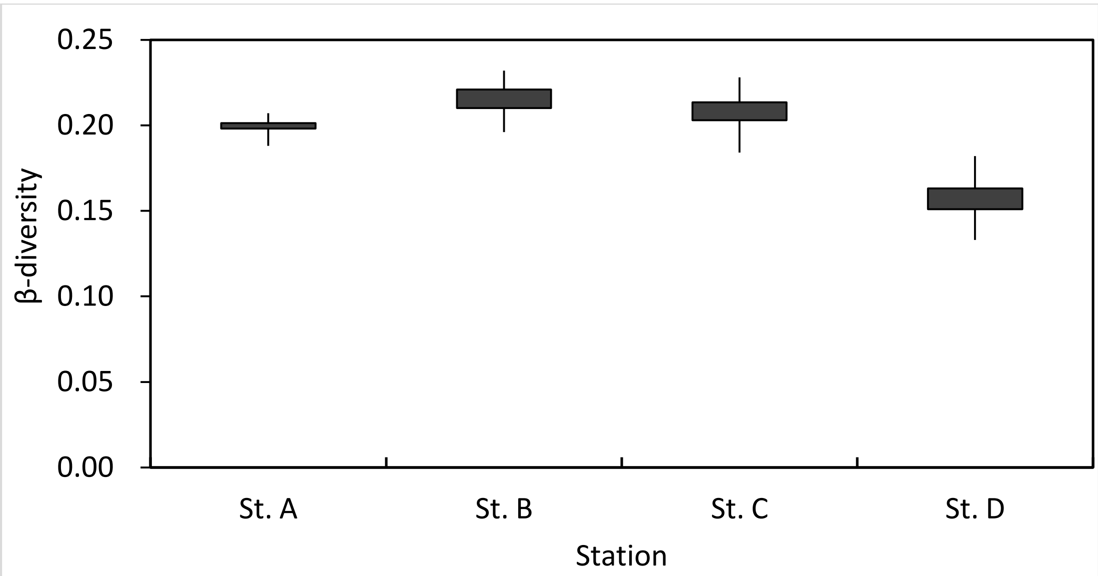

Figure 3. Occurrence index (β-diversity) of four stations for five animal kingdoms.

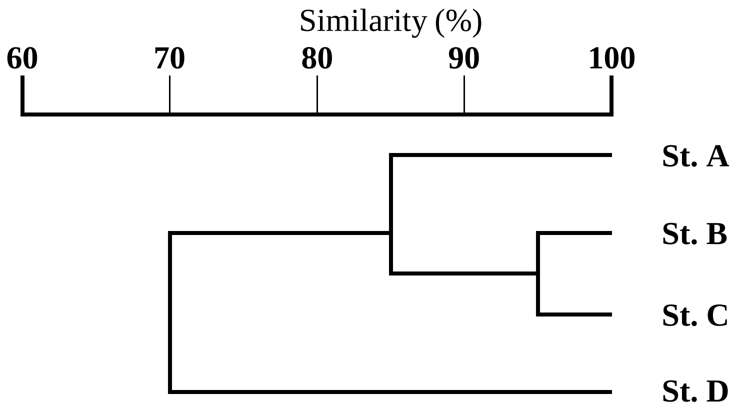

Figure 4. A phenogram showing the animal distribution relationships among four stations at the Shinjeon River.

CONCLUSIONS

The number of species at the Shinjeon River represents one characteristic of an assemblage that can reveal the presence of natural river system and reflect the effect of such change on an assemblage over time. Differences in species richness at a local scale are one of indicators of changes in aquatic habitat. Species richness is also influenced by ecosystem processes and is an important component of monitoring for ecosystem health.

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