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SPATIAL AND TEMPORAL ANALYSIS FOR BIOLOGICAL DIVERSITY OF KINGDOM ANIMALIA AT THE MASSANG RIVER, UIRYEONG-GUN IN KOREA

Man Kyu Huh
Division of Applied Bioengineering
/Dong-eui University
S. KOREA

ABSTRACT

Spatial and temporal analyses were performed to study the spatial pattern of the temporal dynamics of the animal species for four stations at the Massang River in Korea during four seasons. Although this area was not wide, the fauna community at the Massang River on 2016 was identified with 64 taxa, representing five classes. Shannon-Weaver indices (H´) of diversity for mammals was varied from 1.860 to 2.231. H´ for birds was varied from 2.136 to 2.455. Reptiles/amphibians, fish, and invertebrates also varied among the stations and seasons. The values of ß-diversity for animals were varied from 0.182 for reptiles/amphibians to 0.311 for invertebrates. The estimate of Bray-Curtis' distances ranged from 0.096 between Station C and Station D to 0.264 between Station A and Station C. Similarity in animal community composition often decreases with both increasing geographic distance and environmental dissimilarity between localities.

Keywords: Biodiversity, Massang River, richness indices, Shannon-Weaver indices, spatial and temporal analyses.

INTRODUCTION

It is common practice among ecologists to complete the description of a community by one or two numbers expressing the "diversity" or the "evenness" of the community (Heip 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. In practice, however, diversity indices have been applied mostly to collections or communities of species or other taxonomic units. When this is the case, two different aspects are generally accepted to contribute to the intuitive concept of diversity of a community: species richness and evenness (Peet, 1974). Species richness is a measure of the total number of species in the community (but note already that the actual number of species in the community is usually unmeasurable). Evenness expresses how evenly the individuals in the community are distributed over the different species. Magurran (2004) gives a comprehensive account of methods for measuring biodiversity. She defines biodiversity to be the variety and abundance of species in a defined unit of study (emphasis added) (Buckland et al., 2005).

A river is a natural flowing watercourse, usually freshwater. During ancient times, human settlements were usually located near a river, with utilization of water for both agricultural purposes and raising livestock (Zhang et al., 2015). Rivers are often a rich source of fish and other edible aquatic life, and are a major source of fresh water, which can be used for drinking and irrigation. The Massang River is started at the mountains and ends at the wide Yang River within Uiryeong-gun in Korea, and its adjacent waters and wetlands do provide important habitats for birds, and are also used by certain mammals, reptiles and amphibians. The organisms in the riparian zone respond to changes in river channel location and patterns of flow. Animal species distributions in space and time tend to vary in importance from place to place and vary with the scale of inquiry; and, species respond to these factors in a range of ways. In this paper several biodiversity indices at the Massang River were measured different spaces and seasons if it is to be used to quantify change over time.

METHODOLOGY

Surveyed regions

This study was carried out on the Massang River (upper region: 35°363′182″N/128°136′369″E, low region: 35°368′347″N/128°089′874″E), located at Massang-ri, Uiryeong-gun, Gyeongsangnam-do province in Korea (Fig. 1). Lowlands are usually no higher than 100 m (328.1 ft.), while uplands are somewhere around 120 m (393.7 ft.) to 130 m (426.5 ft.). It is estimated that 80-90% of the Massang-River water has be used for irrigation. These human modifications traditionally focused on terracing hill slopes and controlling water via irrigation as well as reclaiming marginal land. The building of terraces on slope land not only creates level land but also provides a means of "managing" rainwater by controlling its runoff. 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. It has a temperate climate with a little hot and long summer. In this region the mean annual temperature is 13.0℃ with the maximum temperature being 25.4℃ in August and the minimum -0.5℃ in January. Mean annual precipitation is about 1275.6 mm with 15.2 (December) to 294.5 mm (August). The river is fed principally by the monsoon rains that fall in summer and autumn. In the field, each region was further divided by the three or four major geographic sites. The plots were randomly located within each sampling site for a total of 14 sampling transects.

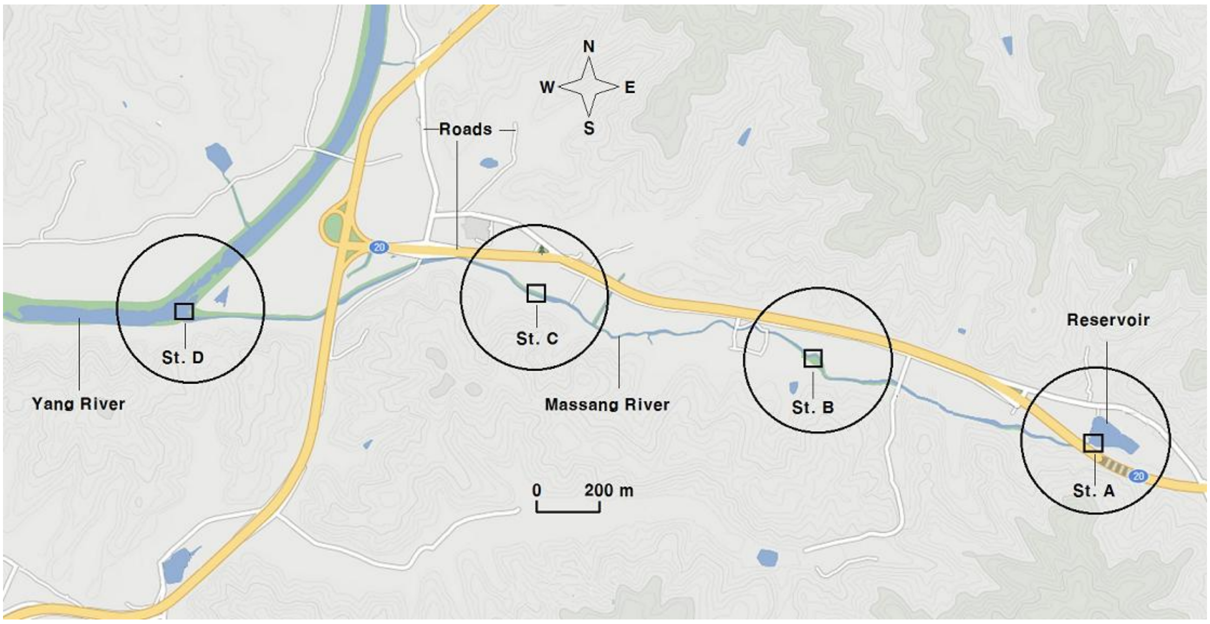

Figure 1. The four stations (St. A~D) for fish and invertebrates (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at the Massang River in Korea.

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Identification of animals

Several methods can be used to identify animals. At one extreme is a complete census of individually identifiable organisms. 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. (2005). Identifications of herpetology were based on Lee et al. (2012), respectively. Identifications of fishes were based on Choi (2001). Identifications of invertebrates were based on Kim et al. (2013) and Merritt and Cummins (1996). The periods of animal samplings were January, April, July, and October 2016.

Biotic indices

Shannon diversity index (H') is $H' = -\Sigma\, p_i \ln p_i$ (Shannon and Weaver, 1963). The p_i is the proportion of important value of the ith species ($p_i = n_i / N$, n_i is the important value index of ith species and N is the important value index of all the species). Biological diversity can be quantified in many different ways.

$N1 = e^{H'}$

$N2 = 1/\lambda$

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

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

Species richness is the number of species of a particular taxon that characterizes a particular biological community, habitat or ecosystem type (Colwell, 2011). 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. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present. 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 $ß = \gamma/\alpha$. 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.

RESULTS AND DISCUSSION

Spatial and temporal analyses were performed to study the spatial pattern of the temporal dynamics of the animal species for four stations at the Massang River in Korea during four seasons. The animals' spatial patterns for four seasons indicated relatively high differences in abundance from one location to another (Tables 1 and 2). Although this area was not wide, the fauna community at the Massang River on 2016 was identified with 64 taxa, representing five classes. Birds (Aves) exhibited the greatest species diversity with 17 taxa identified, followed by invertebrates (15 taxa); mammals with 10 taxa, reptiles/amphibians (Sauropsida/Amphibia) with 10 taxa, and fish represented by 12 taxa. Mammals, birds, and reptile /amphibian were shown with the relative high individual density or abundance in upper region (station A) of river across areas (Table 1). Fish and invertebrate animals were also shown with the relative high individual density or abundance in upper region (Table 2). The total numbers of species were 58 taxa within the St. A, 44 taxa within the St. B, 43 taxa within the St. C, and 45 taxa within the St. D. In order to assess macro-scale spatial variability of the animal community at the Massang River, I analyzed distributions of species richness, diversity, and evenness of large taxonomic groups as well as four station compositions along geographic distances (Tables 1 and 2). Shannon-Weaver indices (H´) of diversity for mammals was varied from 1.860 to 2.231. H´ for birds was varied from 2.136 to 2.455. Reptiles/amphibians, fish, and invertebrates also varied among the stations and seasons. They were shown high H´ values at the A region of river for all animals. Whereas, the low H´ values were shown at low region (D) of river for mammals and birds. Middle regions (B and C) was considerable low in reptiles/amphibians and fish. Upper region (A) was considerable high richness in mammals, birds and invertebrates. Low region (D) was considerable low richness in most animals. Although evenness indices for five animal kingdoms were different from each other, there were not shown significant differences ($p < 0.05$). BPI for birds was lower than those of other animals (Fig. 2). BPI for reptiles/amphibians was higher than those of other animals. BPI values for four kingdoms and four stations had not any trends, meaning dominant species were different according to stations or seasons. The 'average spatial patterns' indicated relatively high differences in abundance from one location to another (Fig. 3). The values of ß-diversity for animals were varied from 0.182 for reptiles/amphibians to 0.311 for invertebrates (Fig. 2). For the four community positions as a whole, the values of ß-diversity were the low (from 0.170 for St. D to 0.206 for St. B) (Fig. 4). They indicated that heterogeneity in species compositions among the replicates were high. When the parameters paired similarity between season and stations testified, there was high taxonomic heterogeneity of the fauna community in between four seasons. The Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among four stations at the Massang River (Table 3). The estimate of Bray-Curtis' distances ranged from 0.096 between Station C and Station D to 0.264 between Station A and Station C. Clustering of stations was performed based on the matrix of calculated distances (Fig. 5). The phenetic tree showed two distinct groups (A-B and C-D). Similarity in animal community composition often decreases with both increasing geographic distance and environmental dissimilarity between localities (Fig. 6).

Biodiversity indices are principally useful for providing empirical measures in environmental conditions for assessing change. There is much discussion in the theoretical ecology study of the relative merits of measures in terms of an underlying biological process model (Buckland et al., 2004). If the objective is to monitor biodiversity across a large region that includes

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several habitats, the existence of ß-diversity is a principal reason why measuring changes in unsatisfactory, even if they have wide geographical and habitat coverage. In order to prevent rapid loss of biodiversity, the deforestation caused by agricultural expansion and overharvesting of riparian and forests must be controlled so as to reverse the serious environmental consequences of lost plant cover and downstream impacts on river areas. For sustainable land use, the remaining riparian areas of most small rivers or streams developing countries require urgent attention, including possible reorganization of the entire logging industry sector. Deforestation on upper regions of rivers must be monitored and minimized through a coordinated policy for effective use and conservation. In erosion-prone areas, farmers must be encouraged to adopt appropriate agro-forestry practices, which also should become an established component of integrated rural development. For example the Massang River valley--along with its rich diversity of habitats--provides birds with those important resources. The upper region of the Massang River provide some of the most important habitat for around 13 species of birds. It is much more efficient to specify clearly the objectives of a proposed monitoring program for species biodiversity. The general recommendation for those interested in establishing many monitoring programs is that substantial thought should be devoted to the basic questions of ‘how’, ‘what’ and ‘why’ (Yoccoz et al., 2000).

Table 1. Diversity index for mammals, birds, and reptile/amphibians in four studied areas at the Massang River

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	10	8	8	7	13	12	10	9	10	8	8	9
Richness												
R1	2.474	2.079	2.175	1.971	3.052	2.873	2.408	2.308	2.364	2.002	1.924	2.140
R2	1.622	1.486	1.600	1.528	1.820	1.769	1.543	1.591	1.491	1.393	1.298	1.389
Diversity												
H'	2.231	1.993	2.023	1.860	2.455	2.423	2.219	2.136	2.115	1.884	1.877	2.062
N1	9.312	7.340	7.564	6.426	11.651	11.284	9.195	8.466	8.289	6.578	6.533	7.865
N2	11.159	8.638	9.677	8.077	12.879	13.618	10.373	10.333	8.250	6.286	6.167	8.278
Evenness												
E1	0.969	0.959	0.973	0.958	0.957	0.975	0.964	0.972	0.919	0.906	0.903	0.939
E2	0.931	0.917	0.945	0.918	0.896	0.940	0.920	0.941	0.829	0.822	0.817	0.874
E3	0.924	0.906	0.938	0.904	0.888	0.935	0.911	0.933	0.810	0.797	0.790	0.858
E4	1.198	1.177	1.279	1.257	1.105	1.207	1.128	1.221	0.995	0.956	0.944	1.053
E5	1.222	1.205	1.322	1.304	1.115	1.225	1.144	1.250	0.995	0.948	0.934	1.060

Table 2. Diversity index for fishes and invertebrates in four studied areas at the Massang River

Indices	Fish				Invertebrates			
	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
No. of species	12	7	7	10	13	9	10	10
Richness								
R1	2.798	1.782	1.747	2.492	3.171	2.288	2.531	2.408
R2	1.681	1.300	1.257	1.644	1.960	1.567	1.690	1.543
Diversity								
H'	2.325	1.833	1.879	2.213	2.327	2.120	2.196	2.064
N1	10.229	6.188	6.550	9.142	10.242	8.333	8.991	7.881
N2	10.537	6.656	7.500	10.406	9.185	9.778	10.085	7.297
Evenness								
E1	0.936	0.937	0.966	0.961	0.907	0.965	0.954	0.897
E2	0.852	0.884	0.936	0.914	0.788	0.926	0.899	0.788
E3	0.839	0.865	0.925	0.905	0.770	0.917	0.888	0.765
E4	1.030	1.076	1.145	1.138	0.897	1.173	1.122	0.926
E5	1.033	1.090	1.171	1.155	0.886	1.197	1.137	0.915

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

Station	St. A	St. B	St. C	St. D
St. A	-	0.105	0.212	0.176
St. B	0.998	-	0.264	0.209
St. C	1.989	0.981	-	0.096
St. D	3.384	2.386	1.405	-

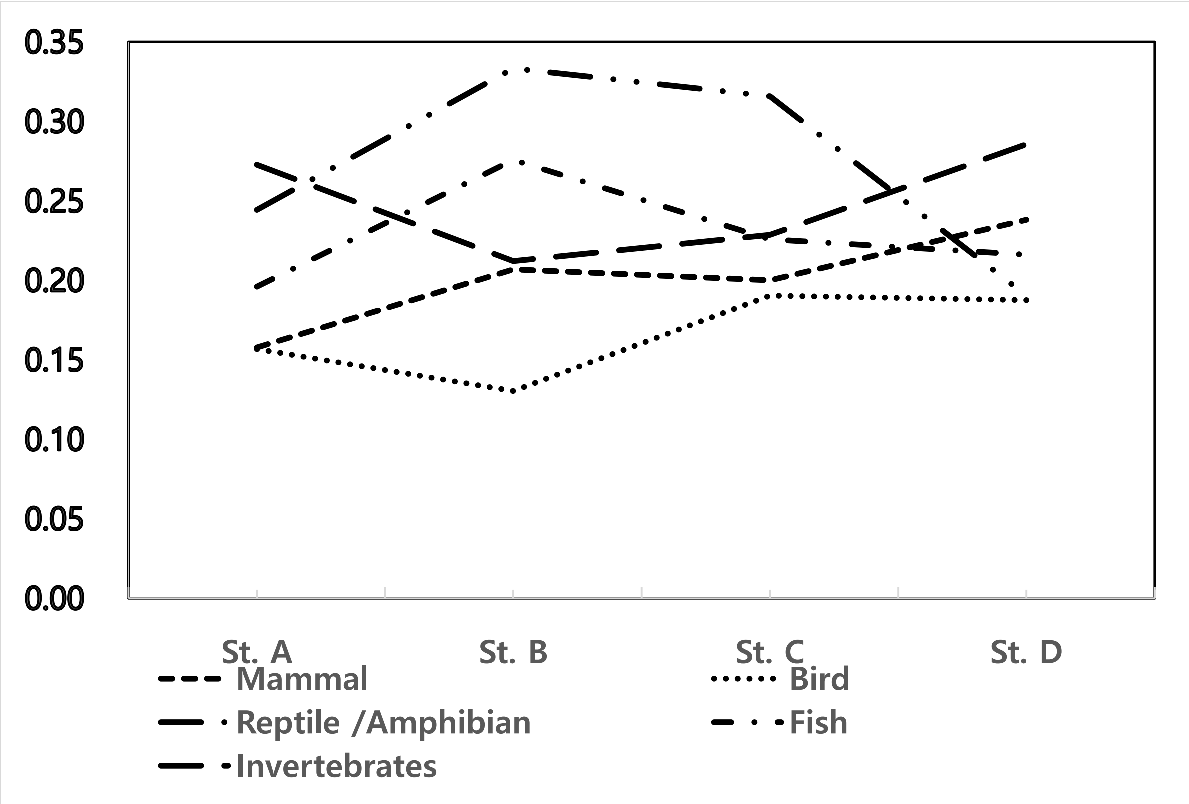

Figure 2. Berger-Parker's index (BPI) for five animal kingdoms at four stations.

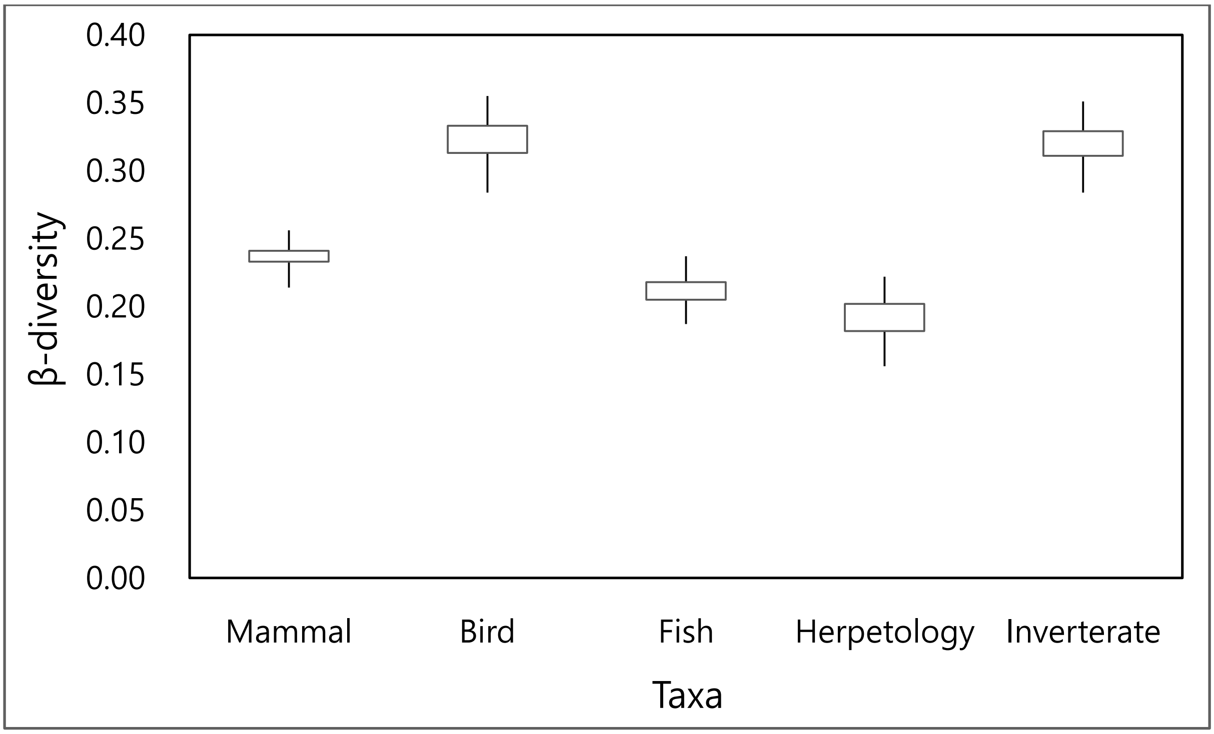

Figure 3. Occurrence index (β-diversity) for five animal kingdoms at four stations.

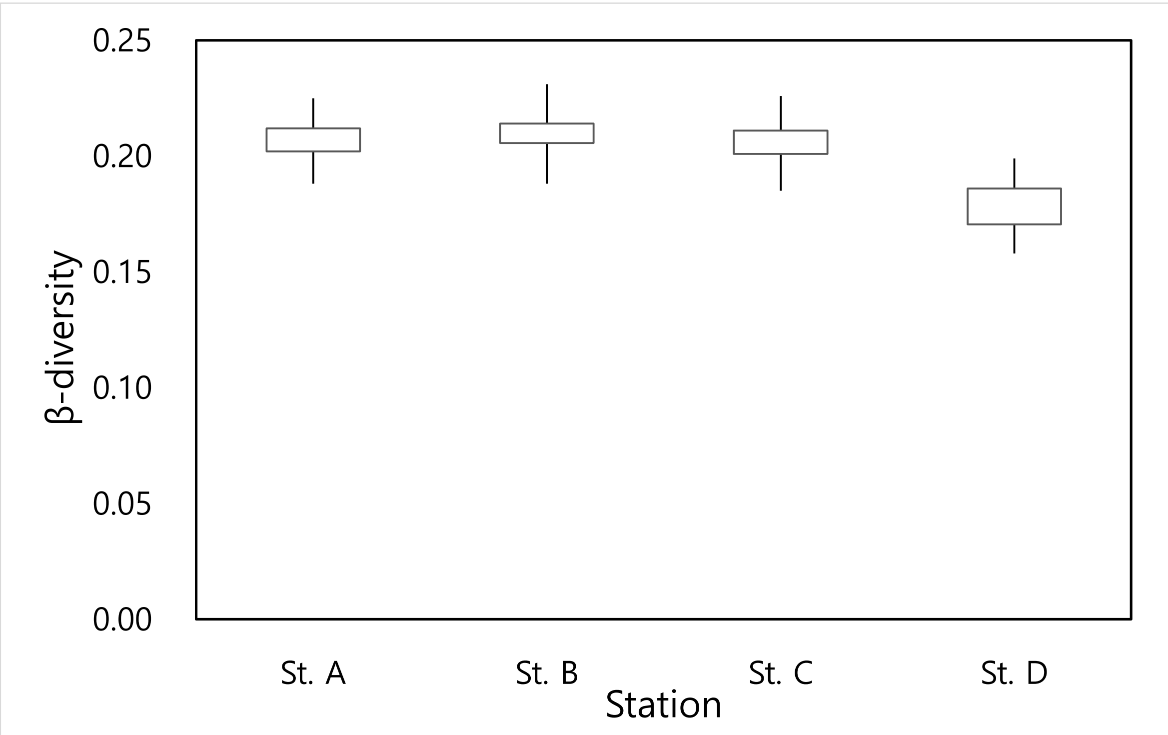

Figure 4. Occurrence index (β-diversity) of four stations for five animal kingdoms.

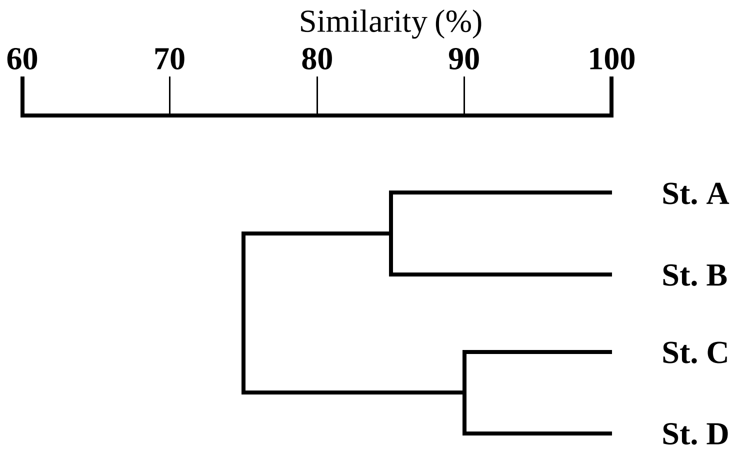

Figure 5. A phenogram showing the animal distribution relationships among four stations at the Massang River.

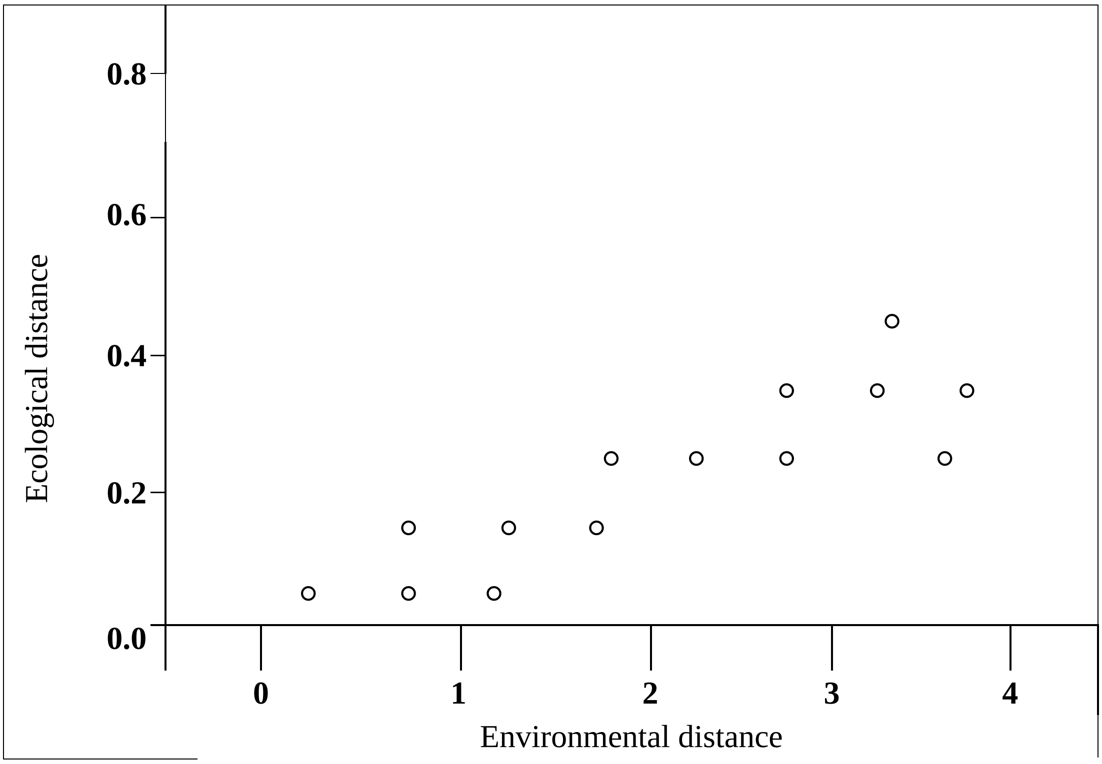

Figure 6. The plot of Bray-Curtis distance in relationship with ecological and environmental distances in Mantel test for five animal kingdoms at the Massang River, Korea.

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