BIODIVERSITY OF KINGDOM ANIMALIA AT THE SONGJI RIVER IN SACHEON-CI, KOREA

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ABSTRACT

This study is to investigate the biodiversity of animal kingdoms at four regions on the SongjiRiver in Korea during 2015 season.Although this area was not wide, but the fauna were very diverse and the fauna at the Songji River during 2015 season was identified with a total of 153 taxa, representing six classes; Mammalia (mammals), Actinopterygii (bony fish), Aves (birds), Amphibia (amphibians), Reptilia (reptiles), and Cnidaria (invertebrates). Shannon-Weaver indices (H´) for birds and invertebrates at upper region were higher than those of low region.Berger-Parker's index (BPI) for reptiles/amphibianswas varied from 0.242 (Station D) to 0.333 (Station C). The values of ß-diversity for animals were varied from 0.210 for birdsto 0.250 for mammals. 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 ($p< 0.05$). For the community as a whole, the values of ß-diversity were the low (from 0.161 for St. D to 0.215 for St. A). Many artificial actions reduced the water's natural filtration action and eliminated the habitat of many animals.

Keywords: Animal kingdoms, biodiversity, richness indices,Shannon-Weaver indices, Songji River.

INTRODUCTION

Ecosystem services are the benefits provided to people, both directly and indirectly, by ecosystems and biodiversity. Rivers have been a focus of human activity throughout ancient and modern times. So important to humanity are the benefits obtained from rivers, and so necessary is the protection against floods and other river disasters, that pursuit for knowledge of riverine systems has advanced in leaps and bounds.Many of the services provided by inland water ecosystems are supported by natural variability in spatial and temporal patterns in the distribution, abundance, and quality of water and the interaction between the basin, climate, geology, topography, and vegetation of which they are a product (King and Brown, 2003).

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. The river continuum concept posited that the physical variables in river systems, from headwaters to mouth, presented a continuous gradient of physical conditions that drive the biological strategies and river system dynamics (Vannote et al., 1980).

Biodiversity refers to variation in the organic world.The diversity of species in ecological communities affects the functioning of these communities. Biodiversity defines the diversity of plant and animal life in a particular habitat or in the world as a whole.Biodiversity encompasses the variety of all living forms on the planet, extending from genes to species to

ecosystems (Wilson, 1988).Most biologists agree that national or international reserve systems will be central to biodiversity conservation in an era of increasing human environmental impacts (Kerr, 1997). Central to the success of reserve strategies is an understanding of regional biodiversity patterns (Scott et al., 1987).

Alpha (α), beta (β), and gamma (γ) diversities are among the fundamental descriptive varieties of ecology, but their quantitative definition has been controversial (Jost, 2007).Species evolution and diffusion, inter-specific competition, and environmental changes commonly influence the α, β and γ diversity of plant communities, but the response of species diversity pattern to these biological and environmental changes and the mechanisms for the response differ among the three species diversity measures (Zhang et al., 2014). Though large scales such as global warming and stratosperic ozone depletion are considered to be the main factors affecting species diversity pattern,the local ecological processes and regional species pool are considered to be important at a small scale (Wiersma and Urban, 2005).

River systems are very important zones of Earth's highest biological diversity and also of our most intense human activity. The Songji River is started at the mountains and ends at the Pacific Ocean. The most floodplains of the river have been converted to agricultural or horticultural fields, housing, restricting the river bed to a small channel.

People rely on biodiversity in their daily lives, often without realizing it. Biodiversity contributes to many aspects of people's livelihoods and well-being, providing products, such as food and fibres, whose values are widely recognized. However, biodiversity underpins a much wider range of services, many of which are currently undervalued. The purpose of this study is to investigate the fauna on the Songji River at four regions during four. Then, based on these diversity patterns and relationships, it is to be used primarily to assess changes in biodiversity over time.

METHERALS AND METHODS

Surveyed regions

This study was carried out on the Songji River, located at Yonghyeon-myeon province (upper region: 35°011′014″N/128°100′014″E, low region: 35°012′794″N/128°049′459″E), Sacheon-ciin Korea (Fig. 1). The areas of this river are located at low altitude (30 m above sea level) and consist of a mosaic of agricultural fields and farming houses. Mean annual temperature ranges from -0.1 (January) to 25.7 °C (August) with 13.1°C, and mean annual precipitation ranges from 19.2 (December) to 316.9 mm (August) with 1512.8 mm.

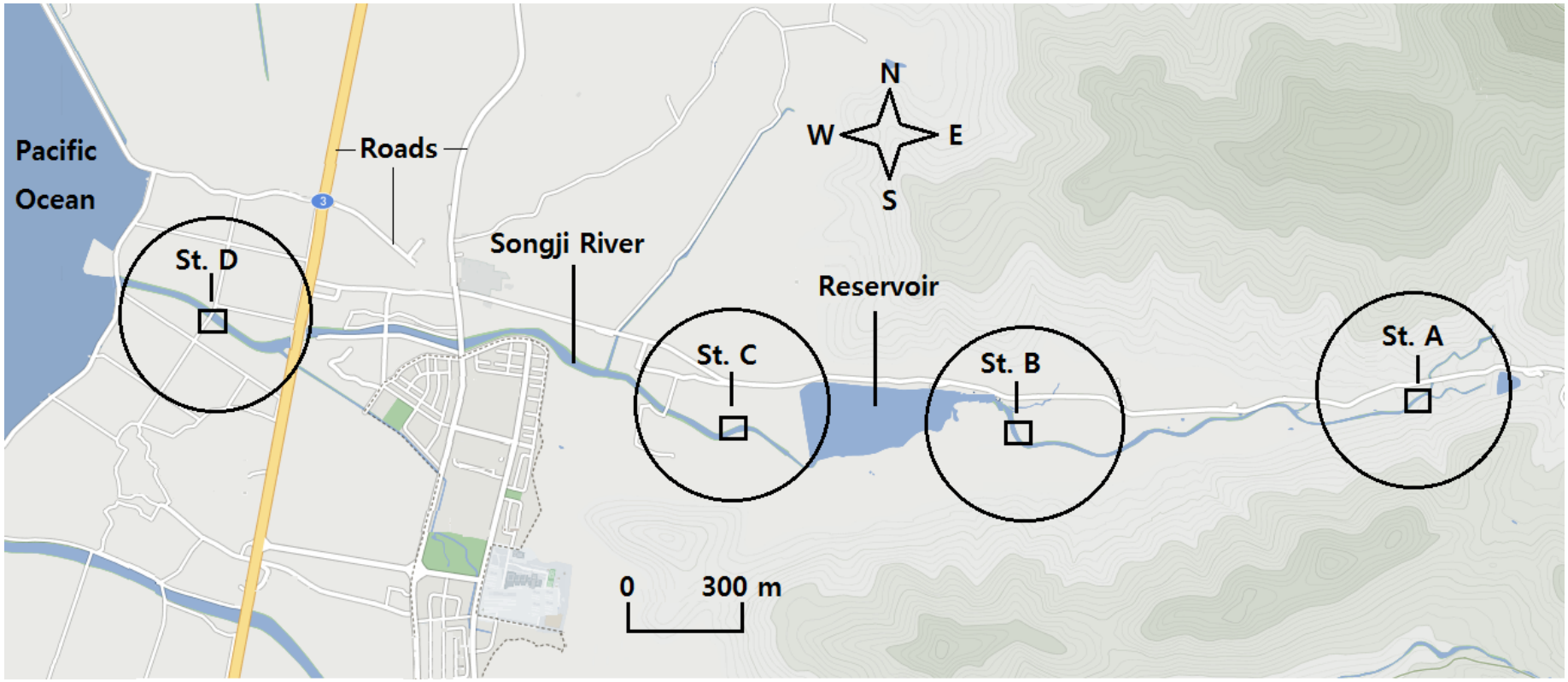

Fig. 1: The four stations (St. A-D) for fish and invertebrates (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at the Songji River, Korea.

Identification of animals

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. (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 2015.

Biotic indices

Diversity is defined as the measure of the number of different species in a biotic community. Three categories of biodiversity were used to primary interest: number of species, overall abundance, and species evenness.Shannon–Weaver index of diversity (Shannon and Weaver, 1963): the formula for calculating the Shannon diversity index (H') is

$H' = -\Sigma\, pi \ln pi$

*p*i is the proportion of important value of the *i*th species (*p*i = *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).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 22.0) (IBM Corp. Released., 2013).

Cluster analysis

A dendrogram was constructed by the neighbor joining (NJ) method using the NEIGHBOR program in PHYLIP version 3.57 (Tamura et al., 2011).

RESULTS

Although this area was not wide, but the fauna were very diverse and the fauna community at the Songji River during 2015 season was identified with a total of 153 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 Cnidaria (invertebrates) (Table 1). Mammals accounted for eight taxa for four seasons within the studied areas. Birds (Aves) exhibited the greatest species diversity with 14 taxa identified, followed by invertebrates (12 taxa). Reptiles/amphibians (Sauropsida/Amphibia) were the most poorly represented of the terrestrial vertebrate groups, accounting for only seven taxa. Fish represented by 10 taxa.The mean numbers of species were 46 taxa within the St. A, 39 taxa within the St. B, 33 taxa within the St. C, and 30 taxa within the St. D.Mammals, birds, and reptiles/amphibians were shown with the relative high individual density or abundance in upper region (station A) of river across areas (Table 2). Fish and invertebrate animals were shown with the relative high individual density or abundance in low region (station D).In order to assess macro-scale spatial variability of the animal community at the Songji 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 2 and 3).Shannon-Weaver indices (H´) for birds and invertebrates at upper region were higher than those of low region.H´ for mammals also varied among the stations and season.Mean H´ of diversity for mammals was varied from 1.574 (St. C) to 2.048 (St. A). St. A was considerable high H´ in mammals, birds, fish, and invertebrates.Berger-Parker's index (BPI) for reptiles/amphibianswas varied from 0.242 (Station D) to 0.333 (Station C).St. D was considerable high BPI in mammals, birds, fish, and invertebrates.BHI values for four kingdoms except fish and reptiles/amphibians were low at upper region, meaning dominant species were different according to stations or seasons. St. A was also considerable high richness in mammals, birds, fish, and invertebrates.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 0.210 for birdsto 0.250 for mammals (Fig. 2).For the community as a whole, the values of ß-diversity were the low (from 0.161 for St. D to 0.215 for St. A) (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 Songji River (Table 4). Neighboring stations such as St. A and St. B had the similar species composition (93.9%) and the highest remote populations (St. A and St. D) did not share any species (42.5%).Clustering of four stations, using the NJ algorithm, was performed based on the matrix of calculated distances (Fig. 4). Four stations of the Songji River were well separated each other. The dendrogram showed two distinct groups; St. A and St. B cladeand the other stations (St. C and St. D).

The results of ecological diversity and richness of animalsat the Songji River showed a spatial variability according to sites. This heterogeneous spatial distribution of animals across the studied sites is according with biotic environments. The Songji River is started at the low mountains and ends at the Pacific Ocean (Fig. 1). Many cement blocks has been substitute riparian areas for the

purpose of protecting the soil erosion in banks by intensive rainfall such as 100 mm in an hour or 250 to 400 mm in a day. Artificial disturbances such as roads or house construction are increasing at St. D (Fig. 1). This artificial action reduced the water's natural filtration action and eliminated the habitat of many animals. Thus there was decreased the number of species in St. C and St. D.

Thus, monitoring of this river is necessary for an adaptive management approach and the successful implementation of ecosystem management. Although this study was based on observations of changes in diversity at small spatial scales and only one year, this design provides insight into how actual patterns of change in species abundances, species richness, and species evenness can affect ecosystem processes (Zavaleta and Hulvey, 2007).

CONCLUSIONS

The fauna community at the Songji River during 2015 season was identified with a total of 153 taxa, representing six classes. The results of ecological diversity and richness of animalsat the Songji River showed a spatial variability according to sites. This heterogeneous spatial distribution of animals across the studied sites is according with biotic environments.

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	8	6	5	5	10	8	7	6	7	7	6	5
Diversity												
H'	2.048	1.754	1.574	1.609	2.221	2.014	1.839	1.736	1.803	1.808	1.672	1.572
N1	7.753	5.778	4.826	4.996	9.216	7.491	6.290	5.676	6.066	6.101	5.321	4.818
N2	9.947	7.650	6.500	6.500	11.478	9.022	7.441	7.125	6.124	6.176	5.339	5.280
Richness												
BPI	0.179	0.222	0.286	0.308	0.152	0.207	0.261	0.263	0.256	0.306	0.333	0.242
R1	2.101	1.730	1.516	1.559	2.574	2.079	1.914	1.698	1.638	1.674	1.395	1.144
R2	1.512	1.414	1.336	1.387	1.741	1.486	1.460	1.376	1.121	1.167	1.001	0.870
Evenness												
E1	0.985	0.979	0.978	0.999	0.965	0.968	0.945	0.969	0.926	0.929	0.933	0.977
E2	0.969	0.963	0.965	0.999	0.922	0.936	0.899	0.946	0.867	0.872	0.887	0.964
E3	0.965	0.956	0.957	0.999	0.913	0.927	0.882	0.935	0.844	0.850	0.864	0.954
E4	1.283	1.324	1.347	1.301	1.245	1.204	1.183	1.255	1.010	1.012	1.003	1.096
E5	1.325	1.392	1.437	1.376	1.275	1.236	1.218	1.310	1.011	1.015	1.004	1.121

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	9	7	6	6	12	10	9	7
Diversity								
H'	2.036	1.758	1.709	1.675	2.415	2.225	2.156	1.862
N1	7.662	5.801	5.522	5.3410	11.185	9.253	8.640	6.434
N2	7.727	5.959	6.039	5.754	13.895	11.535	11.154	7.700
Richness								
BPI	0.286	0.267	0.258	0.296	0.121	0.188	0.167	0.273
R1	2.250	1.764	1.456	1.517	3.146	2.597	2.352	1.941
R2	1.521	1.278	1.078	1.155	2.089	1.768	1.643	1.492
Evenness								
E1	0.927	0.903	0.954	0.935	0.972	0.966	0.981	0.957
E2	0.851	0.829	0.920	0.890	0.932	0.925	0.960	0.919
E3	0.833	0.800	0.904	0.868	0.926	0.917	0.955	0.906
E4	1.008	1.027	1.094	1.077	1.242	1.291	1.291	1.197
E5	1.010	1.033	1.114	1.095	1.266	1.277	1.329	1.233

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

Station	St. A	St. B	St. C	St. D
St. A	-	0.061	0.437	0.575
St. B	1.229	-	0.104	0.461
St. C	1.904	0.675	-	0.023
St. D	3.150	1.921	1.246	-

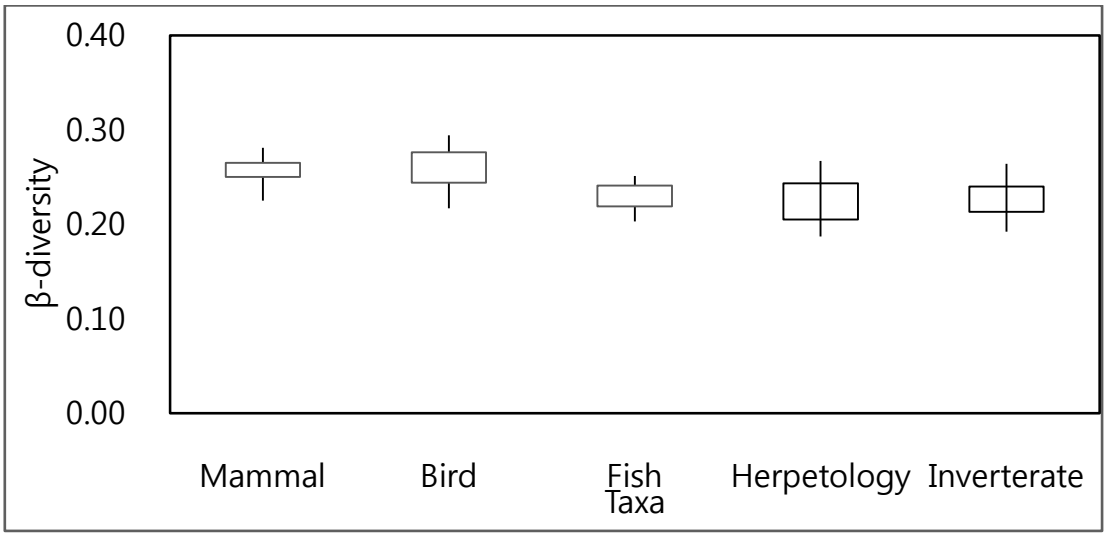

Fig. 2. Occurrence index (β-diversity) for five animal kingdoms at four stations.

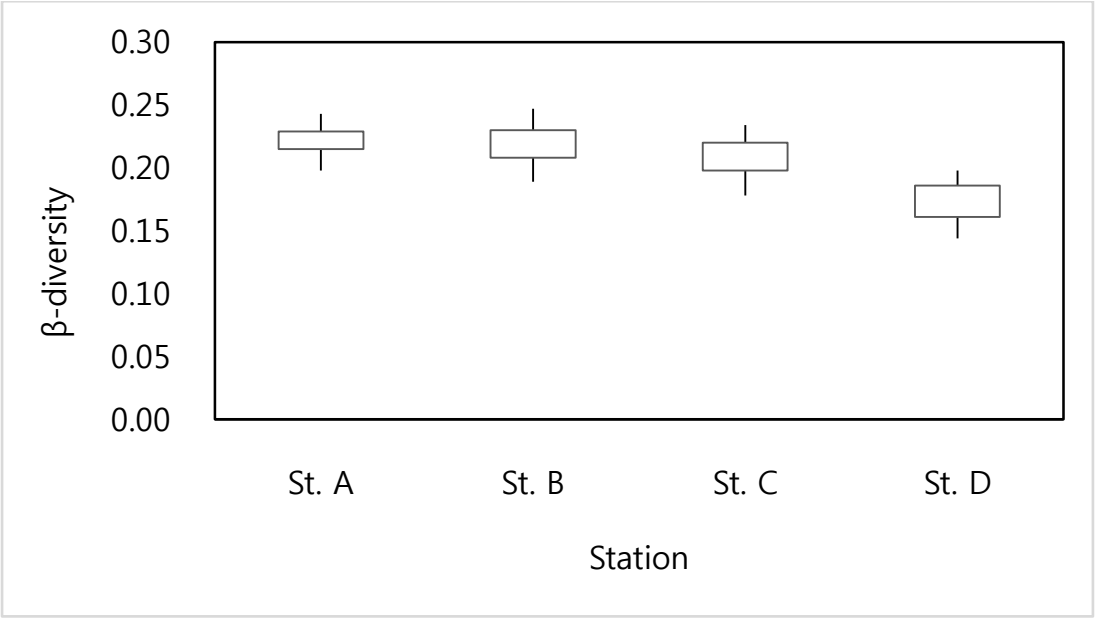

Fig. 3. Occurrence index (β-diversity) of four stations for five animal kingdoms.

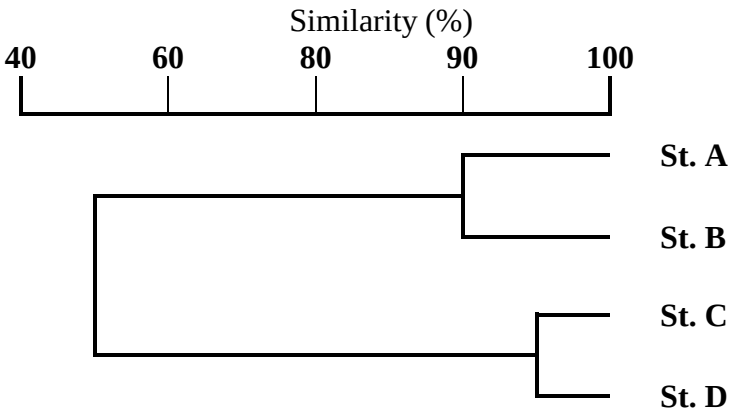

Fig. 4: A phenogram showing the animal distribution relationships among four stations at the Songji River.

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