BIODIVERSITY OF THE FAUNA AT THE UNAM STREAM IN UIRYEONG-GUN, KOREA

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ABSTRACT

Biodiversity is changing over time. The objectives of this study were to identify the fauna and biological species diversity at a small regional scale. This study was carried out on the Unam Stream, located at Uiryeong-gun, Gyeongsangnam-do province in Korea. I surveyed at four sampling stations (Stations A, B, C, and D). This study is to investigate the biodiversity of animal kingdoms. For the kingdom Animalia, 71 taxa have been described in five phyla at four regions on the Unam Stream in Korea. Among these, invertebrates exhibited the greatest species diversity with 17 taxa identified, followed by birds (Aves) (14 taxa). Mammals accounted for nine taxa for only four seasons within the studied areas. Shannon-Weaver index (H′) for animals at upper region was higher than those of low and middle regions. Mean H′ of diversity for birds was varied from 1.837 (St. D) to 2.153 (St. A). The values of ß-diversity for animals were varied from 0.209 for reptiles/amphibians to 0.226 for birds. The dendrogram showed two distinct groups; St. B and St. C clade and the other stations were sistered with St. A and St. D. The distribution of species of animals at the Unam Stream in Korea may also be related to patch size and the distance between neighboring patches, on a smaller spatial scale.

Keywords: Biodiversity, kingdom Animalia, Unam Stream, ß-diversity.

INTRODUCTION

Each reference river or stream within a region will have a distribution of values for each defining flow variable/metric derived from the historic flow record. These distributions are likely to vary from one river to another but when combined represent the natural range of spatial and temporal variation for all revers in the region. If some rivers are un-gauged, statistical modeling can be used to estimate the flow metrics relevant to the regional classification by using nearby gauges in combination with drainage basin, climatic, and other types of landscape information (Snelder et al., 2005; Sanborn & Bledsoe, 2005; Henriksen et al., 2006). The hyporheic zone, the interstitial habitat penetrated by riverine animals, is characterized as being spatially limited to no more than a few metres, in most cases centimetres, away from the river channel.

The discovery and recognition of animals such as mammal, bird, amphibian, and reptile species with geographical distributions limited to a particular landmass like a small region is compelling evidence for the importance of historical events. Species are distributed according to their ecological requirements and behaviour.

Biomonitoring, or biological monitoring, is commonly defined as “the systematic use of living organisms or their responses to determine the condition or changes of the environment” (Rosenberg, 1998; Gerhardt, 1999; Oertel & Salánki, 2003). Indeed, biological indices or parameters (endpoints) used for river ecosystems may be selected from any level of biological organization (suborganismal, organismal, population, community, and ecosystem). However, the historical focus has been on ecological methods and higher levels of organization, e.g. populations, communities, and ecosystems. Therefore, the term of biomonitoring used in this paper tends to follow Markert et al. (1998): Biomonitoring is a method of observing the impact of external factors on ecosystems and their development over a period, or of ascertaining differences between one location and another. Compared to the former definition, the latter is considered to reflect the ecological content of biomonitoring better (Li et al., 2010).

Species diversity is a synthetic concept that is inextricably linked to other ecological constructs such as succession, ecotones, and draws upon related disciplines such as biogeography, polulaton genetics and evolution (Ward et al., 1999). Biodiversity is much more than species diversity and genetic diversity. It also in cludes functional (process) diversity and, in the broadest sence, even habit diversity is encompassed within biodiversity. Biodiversity is a crucial part of nature's precious assets that provide many human needs and insures against environmental disasters. Many biodiversity studies have focused on species diversity, but biodiversity has a more comprehensive aspect. For example, due to the extinction of plant and animal species, climate change, air pollution, advances in technology and industry, development of agricultural and urban lands, and changing human attitudes toward species, ecosystems, and landscapes, biodiversity has become a more attractive topic for researchers over the last decade (Heydari et al., 2020). Understang the factors that structure diversity patterns of local species assemblages requires knowledge of processes that species richness at the regionl level and the rates of spatial turnover of species (Caley & Schluter, 1977).
The Unam Stream is started at the Jagulsan Mountain (897 m) in South Korea. The total length of the stream is 1.627 km. Eventually, the land becomes flatter and the water flow slows down, causing the Stream to drop its stones and pebbles onto the stream bed. The purpose of this study is to investigate the fauna on the Unam Stream at four regions during four seasons on 2021. 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 Unam Stream (upper region: 35.35040251346756N, 128.22086350451E, low region: 35.32923380995035N, 128.2251213481324E), located at Uirjeong-gun, Gyeongsangnam-do province in the South Korea. I surveyed at four sampling stations (Fig. 1). Lowlands of law regions are usually no higher than 100 m (328 ft.), while uplands are somewhere around 350 m (1,148 ft.). This Stream orginates from high Jagulsan Mountain (897 m, 2,942 ft.) in the upper stream of the Stream.

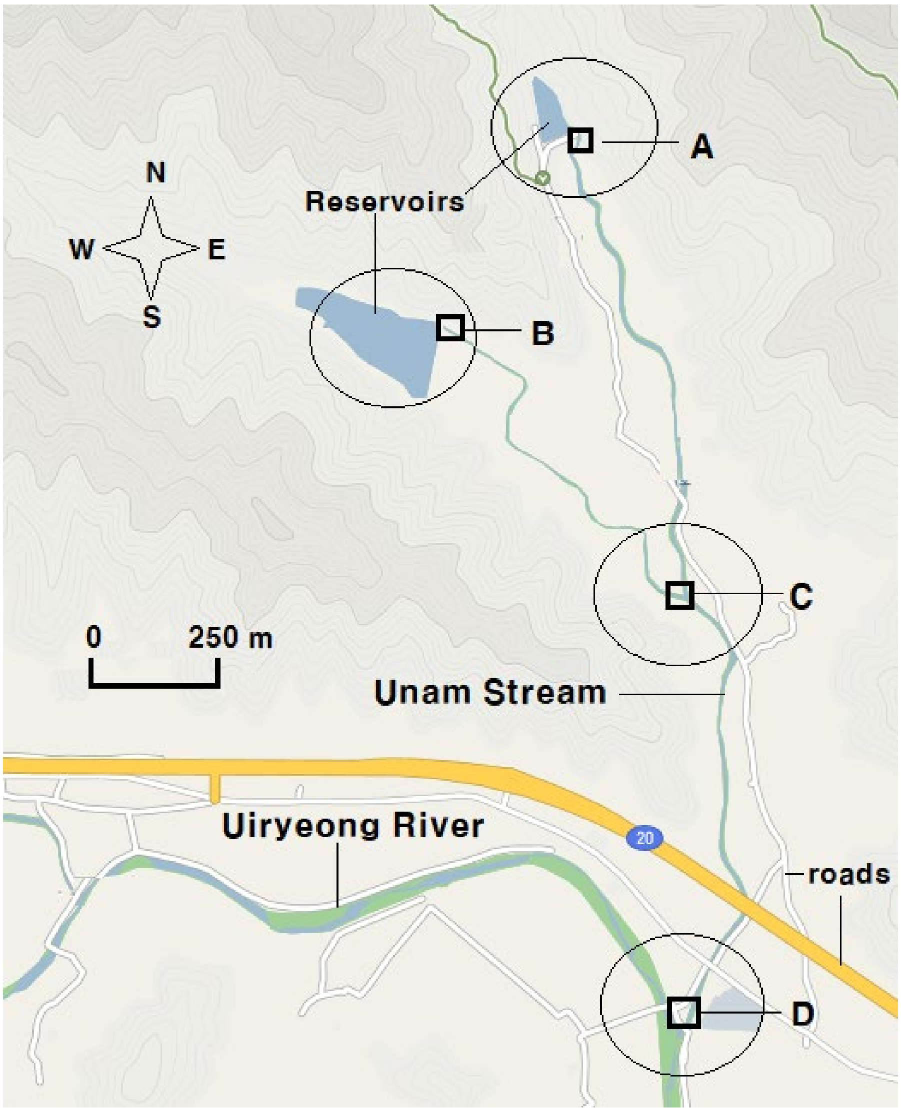

Figure 1. The four stations (St. A~D) for fish and invertebrates (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at the Unam Stream in Korea.

Identification of animals

The species abundance distribution describesthe full distribution of commonness and rarity in ecological systems. It is one of the most fundamental and ubiquitous patterns in ecology, and exhibits a consistent general form with many rare species and few abundant species occurring within a community. 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). Identifications of fishes were based on Choi (2001). Identifications of invertebrate stations or sites were based on Kim et al. (2013). The periods of animal samplings were January (winter) , June (spring), August (summer), and October (autumn) 2021.

Biotic indices

It is generally understood that diversity can be divided into three components: richness, evenness, and disparity (Jost, 2006). Namely, t**hree** categories of biodiversity were used to primary interest: number of species, overall abundance, and species evenness. A much more balanced estimate of diversity is provided by the *Shannon diversity index* (H'), also known as the Shannon–Wiener index, the Shannon–Weaver index and the Shannon entropy. It measures the uncertainty in the outcome of a sampling process (Shannon & Weaver, 1963), and is given by:

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

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

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

The absolute number of species present in the population of interest is referred to as its *richness*. 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.

Aside from the total number of species in a community, the distribution of their abundances is also an important component of diversity. If a species is represented by only a few individuals, it should be clear that it contributes less to the community's diversity than a species represented by several thousand individuals. The equitability of a community's species abundance distribution is referred to as its *evenness*. 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. A dendrogram was constructed by the neighbor joining (NJ) method using the NEIGHBOR program in PHYLIP version 3.57 (Tamura et al., 2021).

RESULTS

Although they have relatively few species in total and the studied area was not wide, but the fauna were very diverse and the fauna community at the Unam Stream during 2021 season was identified with a total of 71 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 (Table 1). Mammals accounted for nine taxa for only four seasons within the studied areas. They were the most poorly represented of the terrestrial vertebrate groups. Invertebrates exhibited the greatest species diversity with 17 taxa identified, followed by birds (Aves) (14 taxa). There were nine taxa of reptiles/amphibians (Sauropsida/Amphibia) at four sites for four seasons. Fish represented by 12 taxa. The mean numbers of species were 61 taxa within the St. A, 53

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taxa within the St. B, 51 taxa within the St. C, and 53 taxa within the St. D. Birds and invertebrates were shown with the relative high individual density or abundance in upper region (station A) of Stream across areas (Table 2). The distribution of birds is uneven. Many individuals were found in this area because the abundant food supply by one large reservoir. Invertebrate animals were shown with the relative high individual density or abundance in low region (station D). It is the junction of two streams in this area. In order to assess macro-scale spatial variability of the animal community at the Unam Stream, 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 index (H´) for mammals at upper region was higher than those of low region. Mean H´ of diversity for birds was varied from 1.837 (St. D) to 2.153 (St. A). This area is a forest area and is good for mammals. H´ for birds also varied among the stations and season. Mean H´ of diversity for birds was varied from 2.207 (St. D) to 2.572 (St. A). St. B was considerable high H´ in reptiles/amphibians. Berger-Parker's index (BPI) for mammals was varied from 0.263 (Station D) to 1.185 (Station B). St. C was considerable high BPI in birds (0.2113). St. B was considerable high BPI in reptiles/amphibians (0.344). BPI values for mammals and invertebrates were low at low region, meaning dominant species were different according to stations or seasons. St. B was also considerable high richness in birds. 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 (data not shown), 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 reptiles/amphibians to 0.226 for birds (Fig. 2). For the community as a whole, the values of ß-diversity for regions were varied from 0.163 for St. D to 0.221 for St. B (Fig. 3). The Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among four stations at the Unam Stream (Table 4). Neighboring stations such as St. C and St. D had the similar species composition (88.6%) and the highest remote populations (St. A and St. D) did not share any species (35.3%).

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

DISCUSSION

Although artifical disturbance may indeed contribute to high diversity, I can explain that maintaining a diversity of disturbanced regions is also of major importance in maximizing the total biodiversity across a floodplain. The upper reaches of this area are thick with forests, making it difficult for people to access. Artificial interference is increasingly high in agricultural land, residential areas, and roads in the midstream and downstream areas. 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). The distribution of species of animals at the Unam Stream in Korea may also be related to patch size and the distance between neighboring patches, on a smaller spatial scale than

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applies to the distribution of the fauna themselves, corresponding to the more limited dispersal ability of the species in many species.

The results of ecological diversity and richness of animals at the Unam Stream showed a spatial variability according to sites. This heterogeneous spatial distribution of animals across the studied sites is according with biotic environments. Artificial disturbances such as roads or house construction are increasing at St. D (Fig. 1). Recently industrial facilities are being introduced into rural areas in order to utilize the surplus labor force of elderly people living in rural areas. 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.

The water flow in the upstream area at the Unam Stream in Korea is fast, but the middle and lower streams are slow. Disturbance from fluvial dynamics generally exhibits a progressive decline from the channel to the uplands corresponding to declining connectivity (Ward et al., 1999). Floodplain water bodies and riparian assemblages far from the channel are less frequently disturbed by flooding than those situated in close proximity to the active channel. In the event of a flood, interference occurs in the upstream, such as soil erosion due to a large amount of water and rapids.

Today, a major threat to survival of these organisms is deforestation. Much of the land disturbance in the rivers takes place on steep mountain slopes, which are naturally vulnerable to soil erosion. Alteration of natural areas may damage or destroy wildlife habitat and harm surrounding waters. Runoff of human and domestic animal waste is also a problem. Respon sible management of land activities is also needed to help protect streams and rivers. Understanding the role of communication networks can be difficult outside carefully controlled conditions. However, field survey data provide a wealth of relevant data that enable new insights into consumption and engagement with both visual media and associated conservation/environmental messaging (Correia et al., 2021).

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

Indices	Mammal				Bird				Reptile /Amphibian			
Station	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	1.176	1.185	1.182	0.263	0.119	0.150	0.211	0.182	0.233	0.344	0.324	0.222
R1	2.269	2.134	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	2.056	1.784	1.741	1.372	1.414	1.315	1.342
Diversity												
H'	2.153	2.026	2.004	1.837	2.572	2.474	2.278	2.207	2.379	1.354	1.828	2.089
N1	8.607	7.780	7.415	6.276	13.093	11.863	9.758	9.090	10.793	3.784	6.222	8.080
N2	10.585	9.487	9.001	7.773	17.220	14.717	10.815	11.002	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	0.947	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	1.211	0.754	1.542	1.019	1.056
E5	1.260	1.290	1.247	1.284	1.341	1.263	1.121	1.236	0.729	1.731	1.023	1.064

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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	0.171
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	2.198	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	10.770	10.255	9.318	9.248	22.685	15.000	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	0.856	0.940	0.877	0.907	0.865
E3	0.873	0.914	0.846	0.842	0.937	0.867	0.901	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	1.102

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

Station	St. A	St. B	St. C	St. D
St. A	-	0.052	0.382	0.489
St. B	0.425	-	0.081	0.408
St. C	0.892	0.650	-	0.127
St. D	1.627	1.356	0.706	-

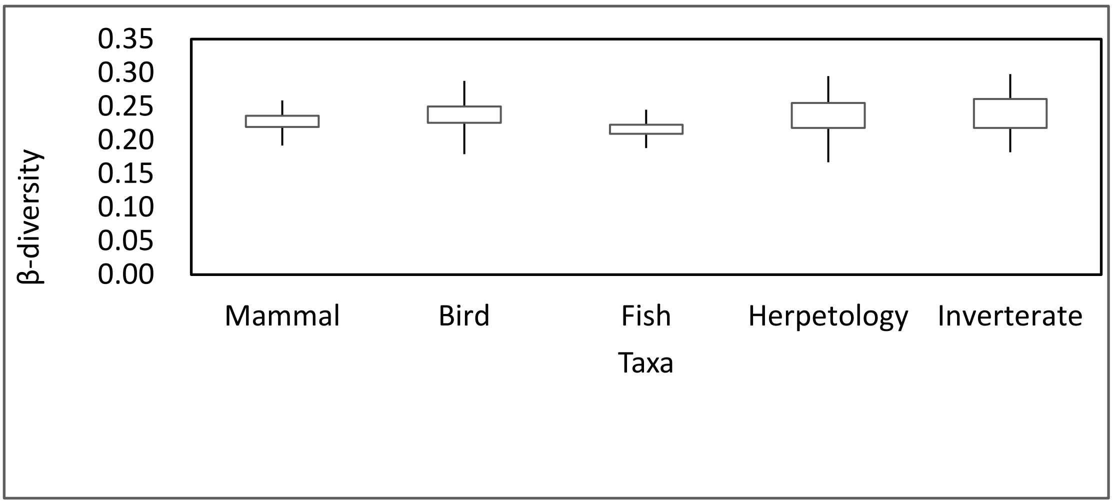

Figure 2. Occurrence index (β-diversity) for five animal kingdoms at four stations.

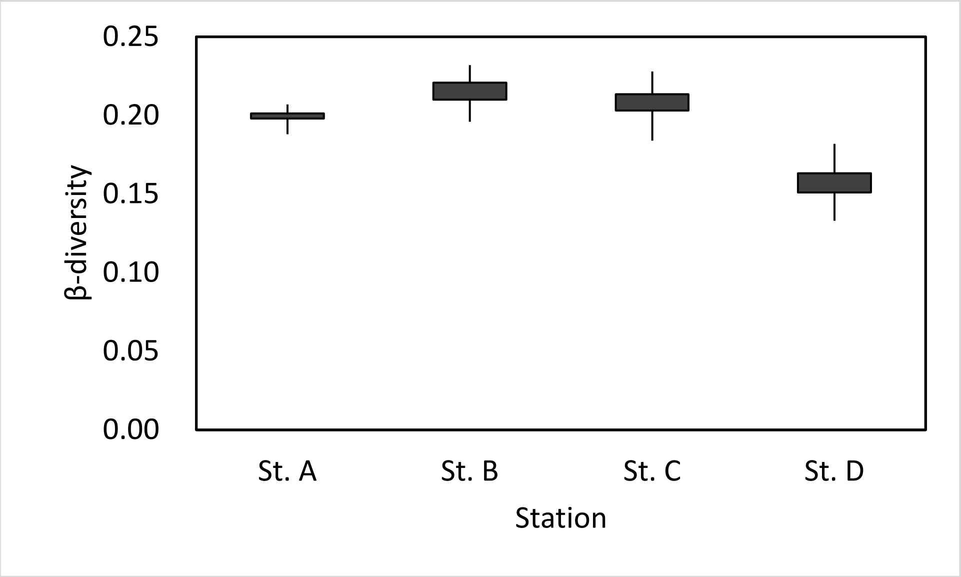

Figure 3. Occurrence index (β-diversity) of four stations for five animal kingdoms.

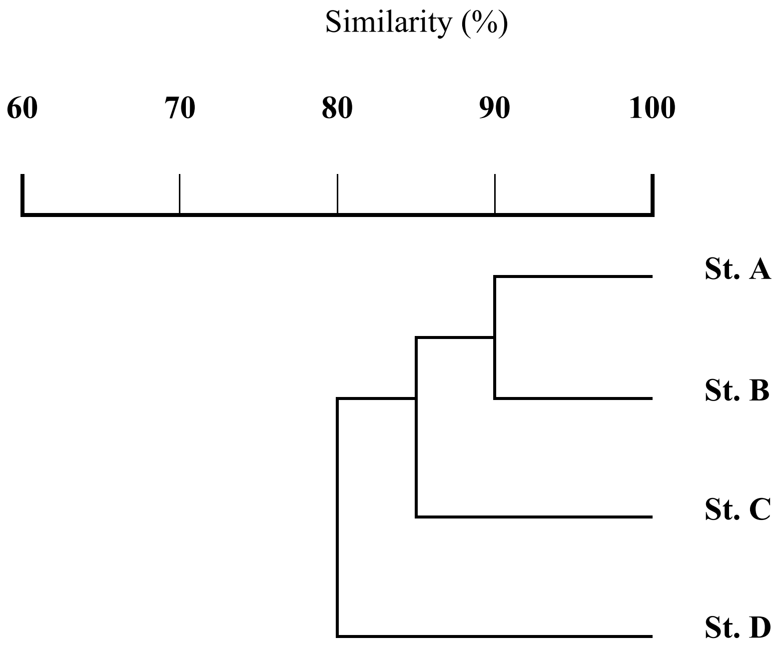

Figure 4. A phenogram showing the animal distribution relationships among four stations at the Unam Stream.

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