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Research Article

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Biological Diversity of Kingdom Animalia at the Backcheon River in Sacheon-ci, Korea

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Abstract The study was the ecological biodiversity of animals at the Backcheon River in Korea during 2015 season. Although this area was not wide, but the fauna were very diverse with 61 taxa, representing five kingdoms. Mammals accounted for 9 taxa for four seasons within the studied areas. Birds (Aves) exhibited the greatest species diversity with 18 taxa identified, followed by invertebrates (16 taxa). Reptiles/amphibians (Sauropsida/Amphibia) were the most poorly represented of the terrestrial vertebrate groups, accounting for only 8 taxa. Fish represented by 10 taxa. Shannon-Weaver indices (H´) for mammals, birds, and fish at upper region were higher than those of low region. Low region of river was high H´ for Reptiles/amphibians and invertebrates. Richness indices for animal taxa were also varied among the stations and seasons. The values of ß-diversity for animals were varied from 0.195 for reptiles/amphibians to 0.298 for birds. The Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among four stations at the Backcheon River.

Keywords Biodiversity, Fauna, spatial patterns, Backcheon River

Introduction

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 at the species is most applied by ecologists and conservation biologists, although high levels classification (genera, families, orders) are sometimes also considered [1].

In the last decade, a great many studies have examined the effects of biodiversity on ecosystem processes by directly manipulating the former in model systems such as grasslands [2]. Alpha (α), beta (β), and gamma (γ) diversities are among the fundamental descriptive varieties of ecology, but their quantitative definition has been controversial [3]. Whittaker [4] proposed measuring β as the ratio between regional diversity or γ and αsuch that $H\gamma = H\alpha \times H\beta$. An alternative approach consists in measuring β-diversity with an additive model such as $H\gamma = H\alpha + H\beta$ [3, 5]. In addition, extensive data of many species as well as many diversity parameters are needed to insure a stable supply of ecosystem goods and services as spatial and temporal variability increases, which typically occurs as longer time periods and larger areas are considered.

River systems are the zone of Earth's highest biological diversity – and also of our most intense human activity. Freshwater biodiversity is in a state of crisis, a consequence of decades of humans exploiting rivers with large dams, water diversions and pollution. Many river-water species, particularly those near cities, have been polluted by human activities. Waterways often carry toxic loads of nutrients, heavy metals, pesticides and contaminants from previous activities that involved sewage plants, chemical factories, refineries and industry. Many river or stream biomes are severely threatened though. Most humans fail to realize just how beneficial they are to the environment [6].

The Backcheon River is started at the mountains and ends at the Pacific Ocean. The floodplains of the Backcheon River have been converted to agricultural or horticultural fields, housing or industrial areas, restricting the river bed to a small channel. In addition, the river has been shared with other users and maintain the environmental and social benefits of water systems.

The purpose of this study is to investigate the fauna on the Backcheon River at four regions during four. I suggest appropriate criteria for a biodiversity measure when that measure is to be used primarily to assess changes in biodiversity over time. This provides an objective means of choosing between possible measures.

Materials and Methods

Surveyed regions

This study was carried out on the Backcheon River, located at Yonghyeon-myeon province (upper region: 34°977′088″N/128°083′815″E, low region: 35°055′262″N/128°042′942″E), Sacheon-ci in Korea (Fig. 1). The areas of this river is located at low altitude (250 m above sea level) and consists of a mosaic of agricultural fields and farming houses. In this region the mean annual temperature is 13.1℃ with the maximum temperature being 19.5℃ in August and the minimum 7.6℃ in January. The annual average precipitation of this region is approximately 1,512.8 mm, and sometimes, intensive rainfall such as 100 mm in an hour or 250 to 400 mm in a day can be recorded.

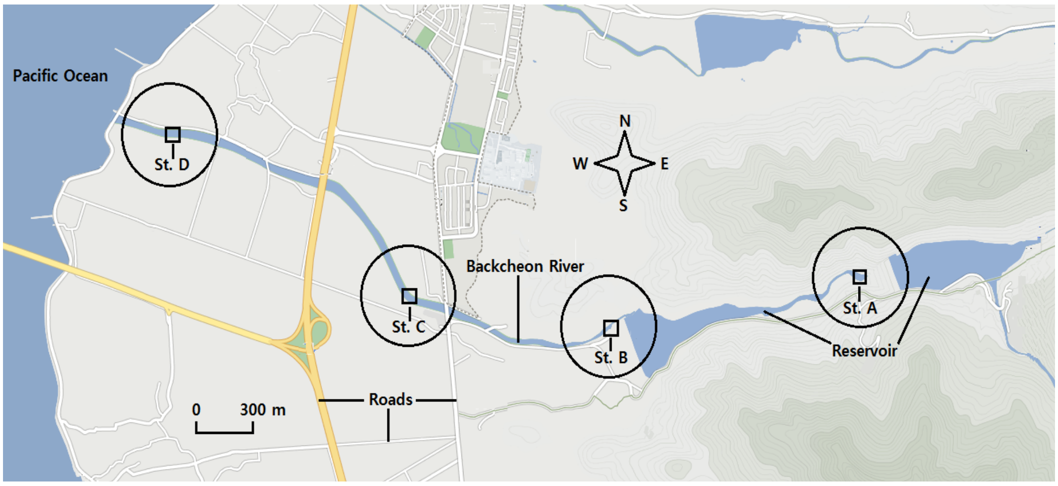

Figure 1: The four stations (St. A~D) for fish and invertebrates (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at the Backcheon River, Korea.

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 [7]. Identifications of birds were based on Lee *et al.* [8]. Identifications of herpetology were based on Lee *et al*. [9], respectively. Identifications of fishes were based on Choi [10]. Identifications of invertebrates were based on Kim *et al*. [11] and Merritt and Cummins [12]. The periods of animal samplings were March, June, September, and December 2015.

Biotic indices

Diversity is defined as the measure of the number of different species in a biotic community. I assume that three aspects of biodiversity are of primary interest: number of species, overall abundance, and species evenness.

Shannon–Weaver index of diversity [13]: 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 ($pi = ni / N$, *ni* 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 [14].

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 [15].

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 [16, 17].

ß-diversity index was calculated using the method of Tuomisto [18] 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 [19]. Except where stated otherwise, statistical analyses were performed using the SPSS software (Release 21.0) [20].

Cluster analyses

A dendrogram was constructed by the neighbor joining (NJ) method using the NEIGHBOR program in PHYLIP version 3.57 [21].

Results and Discussion

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	6	6	5	13	10	9	8	7	8	6	6
Diversity												
H'	2.071	1.753	1.714	1.544	2.506	2.246	2.130	2.027	1.750	1.921	1.678	1.745
N1	7.935	5.774	5.552	4.682	12.261	9.445	8.415	7.590	5.753	6.825	5.357	5.725
N2	8.881	7.241	7.500	5.714	15.221	11.667	10.357	9.450	5.407	6.759	5.449	6.283
Richness												
BPI	0.201	0.238	0.267	0.313	0.130	0.171	0.200	0.179	0.326	0.245	0.308	0.216
R1	2.250	1.642	1.846	1.443	3.134	2.531	2.352	2.101	1.828	1.605	1.346	1.285
R2	1.521	1.309	1.549	1.250	1.917	1.690	1.643	1.512	1.180	1.080	0.937	0.857
Evenness												
E1	0.943	0.979	0.957	0.959	0.977	0.975	0.969	0.975	0.899	0.924	0.937	0.974
E2	0.882	0.962	0.925	0.936	0.943	0.945	0.935	0.949	0.822	0.853	0.893	0.954
E3	0.867	0.867	0.910	0.921	0.938	0.938	0.927	0.941	0.792	0.832	0.871	0.945
E4	1.119	1.254	1.351	1.220	1.241	1.235	1.231	1.245	0.940	0.990	1.017	1.097
E5	1.136	1.307	1.307	1.280	1.263	1.263	1.263	1.282	0.927	0.989	1.021	1.118

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	10	9	7	7	13	14	11	10
Diversity								
H'	2.137	2.013	1.800	1.812	2.500	2.549	2.355	2.234
N1	8.470	7.487	6.049	6.125	12.185	12.791	10.534	9.335
N2	8.538	7.727	6.519	6.364	15.366	16.245	13.837	11.757
Richness								
BPI	0.270	0.229	0.242	0.272	0.111	0.143	0.143	0.200
R1	2.492	2.250	1.716	1.674	3.349	3.478	2.813	2.646
R2	1.644	1.521	1.219	1.167	2.167	2.160	1.859	1.826
Evenness								
E1	0.928	0.916	0.925	0.931	0.975	0.966	0.982	0.970
E2	0.847	0.832	0.864	0.875	0.937	0.914	0.958	0.933
E3	0.830	0.811	0.842	0.854	0.932	0.907	0.953	0.926
E4	1.008	1.032	1.078	1.039	1.261	1.270	1.314	1.259
E5	1.009	1.037	1.093	1.047	1.284	1.293	1.346	1.291

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

Station	St. A	St. B	St. C	St. D
St. A	-	0.016	0.421	0.597
St. B	1.372	-	0.097	0.487
St. C	2.556	1.184	-	0.051
St. D	4.151	2.779	1.595	-

The fauna community at the Backcheon River during 2015 season was identified with a total of 69 taxa, representing five classes (Table 1). Although this area was not wide, but the fauna were very diverse with 61 taxa, representing five kingdoms. Mammals accounted for 9 taxa for four seasons within the studied areas. Birds (Aves) exhibited the greatest species diversity with 18 taxa identified, followed by invertebrates (16 taxa). Reptiles/amphibians (Sauropsida/Amphibia) were the most poorly represented of the terrestrial vertebrate groups, accounting for only 8 taxa. Fish represented by 10 taxa. The mean numbers of species were 52 taxa within the St. A, 47 taxa within the St. B, 39 taxa within the St. C, and 36 taxa within the St. D.

Mammals, birds, reptiles/amphibians, and fish were shown with the relative high individual density or abundance in upper region (station A) of river across areas (Table 2). Reptiles/amphibians and invertebrate animals were shown with the relative high individual density or abundance in low region (station B).

In order to assess macro-scale spatial variability of the animal community at the Backcheon 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 mammals, birds, and fish at upper region were higher than those of low region. Mean H´ of diversity for mammals was varied from 1.544 to 2.071. H´ for mammals also varied among the stations and season. Low region of river was high H´ for Reptiles/amphibians and invertebrates. St. B was considerable high richness in mammals and birds. Although evenness indices for five animal kingdoms were different from each other, there were not shown significant differences (P < 0.05). Berger-Parker's index (BPI) for mammals was varied from 0.201 (Station A) to 0.313 (Station D). BHI values for four kingdoms except fish were low at high 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 evenness indices for five animal kingdoms during seasons were different from each other, there were not shown significant differences ($p < 0.05$).

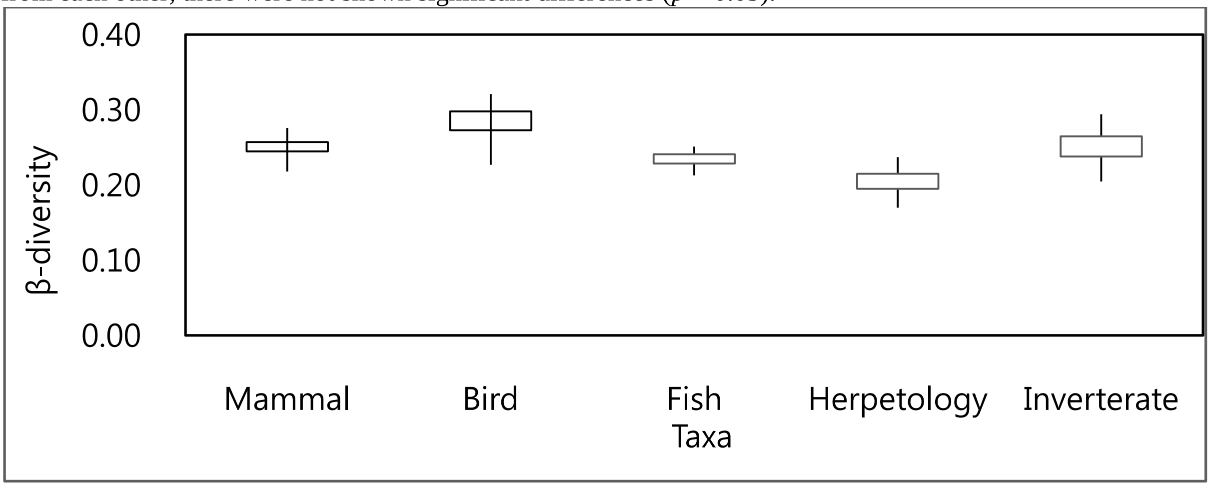

Figure 2: Occurrence index (β-diversity) for five animal kingdoms at four stations.

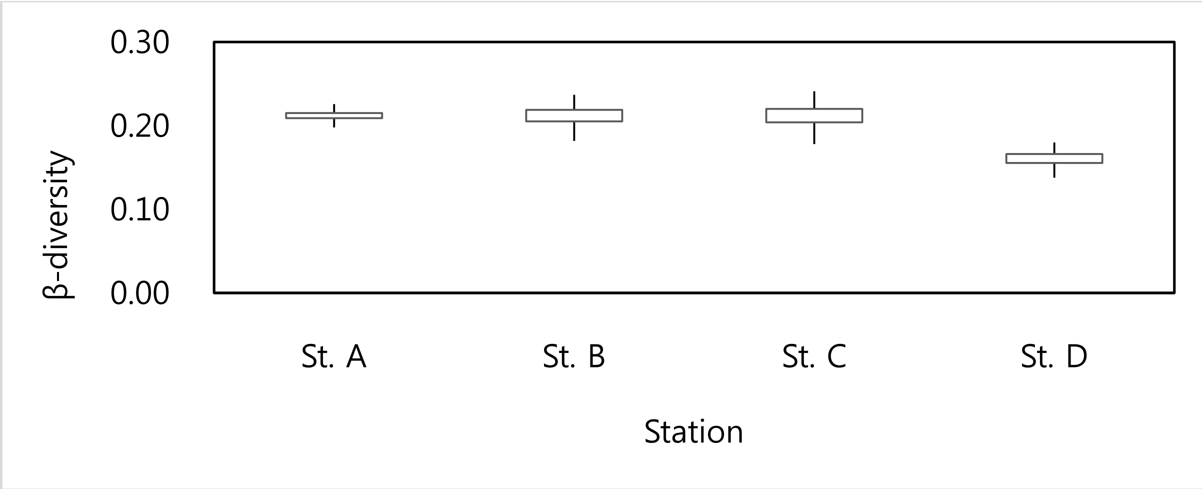

Figure 3: Occurrence index (β-diversity) of four stations for five animal kingdoms.

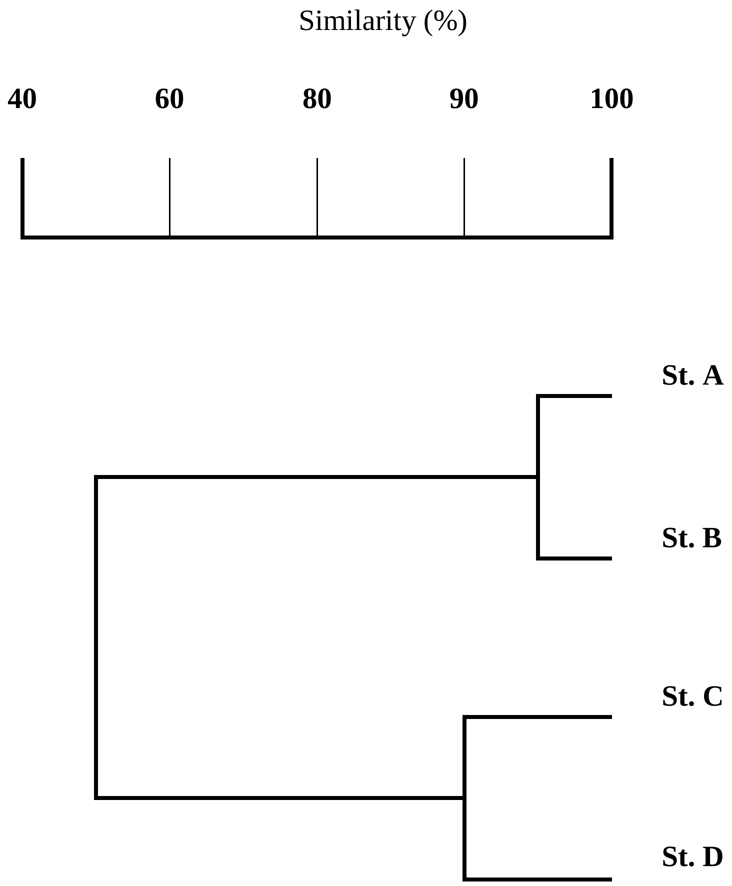

Figure 4: A phenogram showing the animal distribution relationships among four stations at the Backcheon River.

The values of ß-diversity for animals were varied from 0.195 for reptiles/amphibians to 0.298 for birds (Fig. 2). For the community as a whole, the values of ß-diversity were the low (from 0.156 for St. D to 0.209 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 Backcheon River. Neighboring stations such as St. A and St. B had the similar species composition (98.4%) and the highest remote populations (St. A and St. D) did not share any species (40.3%).

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

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 [22]. Various indices of diversity are used for estimating the amount of environmental change. For an index to be useful, it should be applicable to a variety of situations and at multiple temporal and spatial scales. The literature is mixed on whether richness, evenness or diversity indices are more sensitive to changes in the environment such as nutrient enrichment or pollution [23]. The Backcheon River is started at the low mountains and ends at the Pacific Ocean (Fig. 1). For the past years, riparian areas of this river have often been converted to cropland because of soil fertility and convenient access to irrigation water. Recently many riparian areas of this river have been lost or degraded for commercial and industrial developments. 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 [2].

Conclusions

The fauna community at the Backcheon River during 2015 season was identified with a total of 69 taxa, representing five classes. Recently many riparian areas of this river have been lost or degraded for commercial and industrial developments. Thus, monitoring for biological diversity of kingdom Animalia of this river is necessary for an adaptive management approach and the successful implementation of ecosystem management.

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