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Research Article

Alpha and Beta Diversity of Kingdom Animalia at the Gayeon River, Haman-gun, Korea

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Abstract

Biodiversity and water quality were widely used in river ecology and natural animal fauna. I assume that the primary question underlying monitoring is to ask whether biodiversity is changing over time for sites. The study was described in the spatial patterns of animals for four stations at the Gayeon River in Korea during four seasons. The fauna were very diverse with 47 taxa, representing five kingdoms. Birds (Aves) exhibited the greatest species diversity with 15 taxa identified, followed by mammals (11 taxa), reptiles/amphibians (Sauropsida/Amphibia) and invertebrates with nine taxa, and fish represented by seven taxon. Shannon-Weaver indices (H´) of diversity for mammals was varied from 1.036 to 1.913. H´ for birds also varied among the stations and season. Low region of river was high H´ for fish and invertebrates. Upper region was considerable high richness in four kingdoms except invertebrates. Although evenness indices for five animal kingdoms were different from each other, there were not shown significant differences ($P<0.05$). The Gayeon River has a pH up to 7.54. The average values of BOD and COD were 4.99 mg/ l and 5.17 mg/l, respectively. The portion of BOD and COD in the river increased exponentially along the upper-down gradient. Total nitrogen and phosphate were also accumulated downward. Thus there was decreased the number of species in this river. Many artificial actions reduced the water's natural filtration action and eliminated many species at their habitat in the Gayeon River.

Introduction

Both the magnitude and the urgency of the task of assessing global biodiversity require the use of estimation and extrapolation for all levels of organism at same location or region. Likewise, future biodiversity inventories need to be designed around the use of effective sampling and estimation procedures. Most studies in terrestrial systems examine patterns of biodiversity through a number of indices based on species richness and evenness (Magurran 2004; Bevilacqua, et al., 2009). Also, the number of species and their relative abundances express only one facet of biodiversity (Vane-Wright et al. 1991; Harper and Hawksworth 1994).

Species diversity is the variety of species within a habitat or a region. Species richness is the number of species of a particular taxon that characterizes a particular biological community, habitat or ecosystem type (Colwell, 2011). Species evenness is a measure of biodiversity which quantifies how equal the community is numerically. Most diversity indices may be considered generalized measures of uncertainty (Taneja, 1989; Keylock, 2005).

During the last century, human impacts on our planet have led to an increasing and alarming loss of biodiversity. Scientists estimate that current extinction rates exceed those of prehistoric mass extinctions. Loss of biodiversity also means loss of genetic diversity and loss of ecosystems.

Water Pollution has taken toll of all the surviving species of the earth. Almost 60% of the species live in water bodies. Water pollution in Korea has been greatly increased over the last 40 years, acid rain, pesticides, and fertilizers still alter the chemical balance of Korean's reservoirs and rivers to the detriment of fish and other aquatic life.

The Gayeon River is started at the mountains and ends at the Youngdong River. Vegetation of Gayeon River is the site of the distribution of fish, birds, amphibians, reptiles, etc and is very important to build food networks.

The purpose of this study is to investigate the fauna on the Gayeon River at four regions during four seasons. Therefore, this survey recorded material significance for the future appears in the environment to restore or improve the problem may be. 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 Gayeon River (upper region: 35°337′744″N/128°553′085″E, low region: 35°336′484″N/128°525′448″E) which located at Haman province in Korea (Fig. 1). The areas of this river is located at low altitude (60~80 m above sea level) and consists of a mosaic of agricultural fields and farming houses. The upper regions are surrounded by forests dominants by *Pinus densiflora and Phyllostachys nigra* var. *henonis*. The slopes of river are very low (average < 5°). In this region the mean annual temperature is 14.9℃ with the maximum temperature being 23.6℃ in August and the minimum -1.0℃ in January. The annual average precipitation of this region is approximately 1,545.4 mm, and sometimes, intensive rainfall such as 100 mm in an hour or 200 to 300 mm in a day can be recorded.

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. Identifications of mammals and herpetology were based on Weon (1967). Identifications of birds were based on Lee et al. (2005). Identifications of herpetology were based on Lee et al. (2012). 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 March, June, September, and December 2014.

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 (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 a measure of the number of species found in a sample. 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.

Evenness indices (E1~E5) was calculated using important value index of species (Pielou, 1966; Hill, 1973).

ß-diversity index was 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) (IBM Corp. Released, 2012).

Environmental factors

Laboratories and equipment were used to measure a range of water quality parameters including pH, suspended solids (SS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total phosphate, and total nitrate. The change in DO concentration is measured over a given period of time in water samples at a specified temperature. The test for BOD is a bioassay procedure that measures the oxygen consumed by bacteria from the decomposition of organic matter (Sawyer and McCarty, 1978). The method for BOD was used to a standard method of the American Public Health Association (APHA) and is approved by the U.S. Environmental Protection Agency (USEPA). COD is a widely known parameter used to measure water quality using the 910 colorimeter (YSI Incorporated, Ohio, USA). It is a measure of water pollution resulting from organic matter. Total phosphorus and nitrogen in river were evaluated the use of alkaline peroxodisulfate digestion with low pressure microwave, autoclave or hot water bath heating (Maher et al., 2002). Total suspended solids (SS) were determined by membrane filtration (0.1 um polycarbonate filters).

An ecological distance describes the difference in species composition (Kindt and Coe, 2005). The relationship between a distance matrix and a quantitative environmental variable can be analysed with Mantel test.

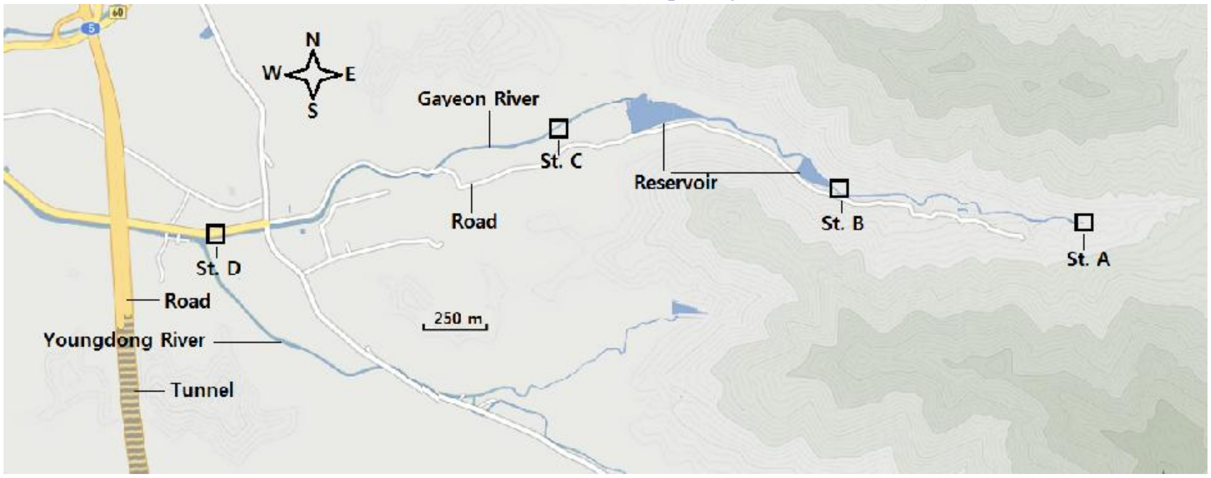

Figure 1: The four stations at the Gayeon River, Haman-gun, Korea.

Results and Discussion

The fauna community at the Gayeon River on 2013 was identified with 46 taxa, representing five classes (Table 1). The mean numbers of species were 34 taxa within the St. A, 32 taxa within the St. B, 35 taxa within the St. C, and 39 taxa within the St. D. Although this area was not wide, but the fauna were very diverse with 47 taxa, representing five kingdoms. Birds (Aves) exhibited the greatest species diversity with 15 taxa identified, followed by mammals (11 taxa); reptiles/amphibians (Sauropsida/Amphibia) and invertebrates with nine taxa, and fish represented by seven taxon. 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 1). 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 Gayeon 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´) of diversity for mammals was varied from 1.061 to 1.913. H´ for birds also varied from 1.590 to 2.213. H´ for reptiles/amphibians varied from 1.830 to 2.147. Upper region of river was high H´ for mammals, birds, fish and reptiles/amphibians. H´ for fish and invertebrates among the stations and season. Low region of river was high H´ for fish and invertebrates. Upper region was considerable high richness in mammals and reptiles/amphibians. Although evenness indices for five animal kingdoms were different from each other, there were not shown significant differences (P<0.05). BHI values for four kingdoms except invertebrates were low at high region, meaning dominant species were different according to stations or seasons.

The values of ß-diversity for animals were varied from 0.218 for reptiles/amphibians to 0.294 for mammals (Fig. 2). For the community as a whole, the values of ß-diversity were the low (from 0.154 for St. D to 0.204 for St. A) (Fig. 3). They indicated that heterogeneity in species compositions among the replicates were high. The parameters paired similarity between season and stations testified. There was high taxonomic heterogeneity of the fauna community in between four seasons. Especially, species compositions of birds for season were different from each other because a lot of migratory birds were included in those regions. The numbers of individuals of reptiles/amphibians were different from each other between seasons because generally begin hibernation in late fall. There were high taxonomic homogeneity of the mammals and fish community in between four seasons and similar trends in seasonal development of animals at riparian and channels of the same river. However, distribution of biological diversity and richness showed a statistically significant upper-low regions different (p <0.05). This decreasing trend was supported mainly by an increase of artificial disturbances such as road or house construction (Noss, 1990).

The Gayeon River has a pH up to 7.54 (Table 3). The average values of DO was 6.06 mg/ l. The average value of BOD and COD were 4.99 mg/ l and 5.17 mg/l, respectively. The portion of BOD and COD in the river increased exponentially along the upper-down gradient. The portion of suspended solids (SS), total nitrogen (T-N), and phosphate (T-P) in the river increased exponentially along the upper-down gradient. In particular, SS has a significant influence on the two points (St. C and St. D). T-N also has a significant influence at the St. C and St. D. They are important as pollutants in water system. Fertilizer supplies of N and P are the most important impacts on water quality. One of the most important impacts of N on the environment is that on water quality. Because N as well as P are frequently the nutrient most limiting biological productivity in estuaries (Vitousek et al. 1997), inputs of soil and fertilizer N from agricultural land can be a major contributor to N-induced eutrophication.

Table 1: 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	7	4	3	3	11	8	7	6	9	7	7	7
Richness												
BPI	0.211	0.364	0.455	0.444	0.255	0.333	0.389	0.419	0.162	0.194	0.214	0.250
R1	2.038	1.251	0.834	0.910	0.253	1.911	1.674	1.456	2.216	1.747	1.801	1.731
R2	1.606	1.206	0.905	1.000	1.540	1.281	1.167	1.078	1.480	1.257	1.323	1.237
Diversity												
H'	1.913	1.295	1.036	1.061	2.213	1.887	1.729	1.590	2.247	1.906	1.912	1.830
N1	6.775	3.649	2.818	2.889	9.141	6.597	5.635	4.904	8.560	6.726	6.764	6.235
N2	9.500	4.583	3.235	3.600	8.854	6.175	5.040	4.471	10.246	8.017	8.217	6.613
Evenness												
E1	0.983	0.934	0.943	0.966	0.923	0.907	0.888	0.887	0.977	0.979	0.982	0.941
E2	0.968	0.912	0.939	0.963	0.831	0.825	0.805	0.817	0.951	0.961	0.966	0.891
E3	0.963	0.883	0.909	0.944	0.914	0.800	0.772	0.781	0.945	0.954	0.961	0.872
E4	1.402	1.256	1.148	1.248	0.969	0.936	0.894	0.912	1.197	1.192	1.215	1.061
E5	1.472	1.353	1.229	1.377	0.965	0.925	0.872	0.869	1.23	1.226	1.252	1.072

Table 2: 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	5	6	7	7	6	6	7	9
Richness								
BPI	0.280	0.345	0.241	0.325	0.211	0.300	0.238	0.194
R1	1.243	1.485	1.782	1.627	1.698	1.669	1.970	2.330
R2	1.000	1.114	1.300	1.107	1.373	1.342	1.528	1.616
Diversity								
H'	1.568	1.561	1.818	1.800	1.749	1.687	1.885	2.123
N1	4.799	4.762	6.167	6.052	5.752	5.401	6.589	8.357
N2	5.455	4.667	6.881	5.909	6.577	6.333	8.400	10.109
Evenness								
E1	0.975	0.871	0.935	0.925	0.976	0.941	0.969	0.966
E2	0.960	0.794	0.881	0.865	0.959	0.900	0.941	0.929
E3	0.950	0.752	0.861	0.842	0.950	0.880	0.931	0.920
E4	1.137	0.980	1.116	0.976	1.143	1.173	1.275	1.210
E5	1.172	0.975	1.138	0.972	1.174	1.212	1.324	1.238

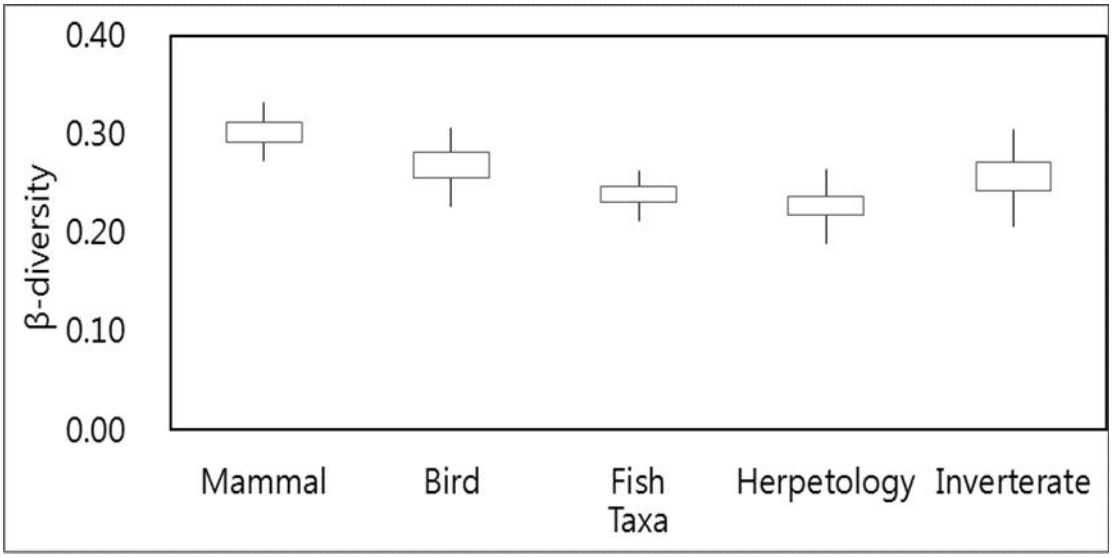

Figure 2: Occurrence index (β-diversity) for five animal kingdoms at four stations.

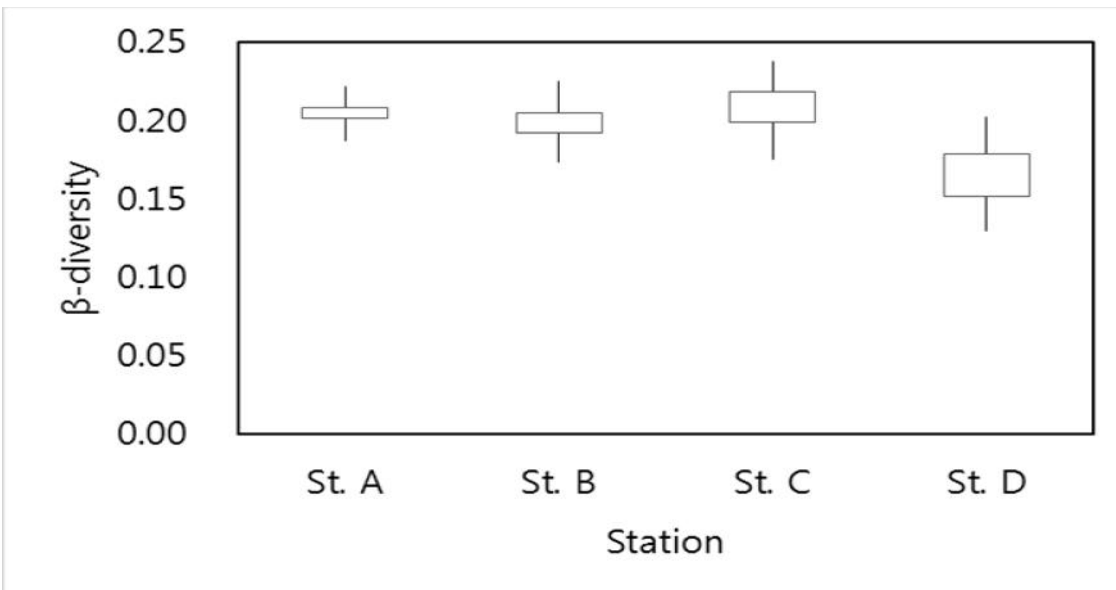

Figure 3: Occurrence index (β-diversity) of four stations for five animal kingdoms.

Table 3: Water quality at four stations in the studied areas

Item	St. A	St. B	St. C	St. D
pH	7.54±0.17	7.42±0.10	7.37±0.12	7.29±0.21
DO (㎎/L)	6.41±0.69	5.53±0.50	4.95±0.54	3.75±0.52
BOD (㎎/L)	3.47±0.54	4.51±0.31	5.83±0.62	6.21±0.60
COD (㎎/L)	4.76±0.51	6.28±0.36	6.85±0.69	7.36±0.89
SS (㎎/L)	19.98±1.61	21.38±2.61	22.88±3.52	23.33±1.44
T-N (㎎/L)	1.935±0.22	2.019±0.09	2.631±0.47	2.807±0.47
T-P (㎎/L)	0.121±0.07	0.229±0.06	0.307±0.11	0.343±0.06

Table 4: Ecological distance (upper diagonal) based on Bray-Curtis' formulae analysis and geographic distances (km) (low diagonal) among four stations at the Gayeon River

Station	St. A	St. B	St. C	St. D
St. A	-	0.047	0.451	0.566
St. B	1.065	-	0.082	0.412
St. C	2.355	1.290	-	0.040
St. D	4.180	3.115	1.825	-

Nitrates and nitrites are common inorganic pollutants of water. Most nitrates in the Gayeon River come from heavily fertilized crops and sewage treatment plants. Some nitrates were discharged from the factories that are operating. Nitrate-related drinking-water methemoglobinemia is principally a disease of young children, with bottle-fed or weaned infants < 4 months of age being the most susceptible (Fewtrell, 2004). The exposure assessment was based on levels of nitrate in drinking water greater than the WHO guideline value of 50 mg/L. Although rare today, nitrite poisonings usually occur in rural areas where drinking water id contaminated by farmyards.

The excessive growth of algae and macrophytes, the resulting oxygen depletion, and the production of a range of substances toxic to fish, cattle, and humans are now major pollution problems worldwide (Howarth et al. 2002). Stone dust was carried on the surface of particles and stone powders might cover the gills of the fish. It could be affected as one indicator of mortality of fishes (EPA, 2002). Thus there was decreased the number of species in this river. Many artificial actions reduced the water's natural filtration action and eliminated many species at their habitat in the Gayeon River.

The Bray-Curtis' distances were calculated from differences in abundance of each species according to geographic distances among four stations at the Gayeon River (Table 4). Neighboring stations such as St. C and St. D had the similar species composition and the highest remote populations (St. A and St. D) had shared a few species.

Different indices of species diversity, richness, and evenness were reflected different aspects of biodiversity. An index based on overall abundance exclusively measures a single component of biodiversity (Buckland et al., 2004). This makes it easy to understand and interpret. However, it should be used together with an index that measures species evenness, such as the Shannon index or Simpson's index. If an index is obtained by averaging relative abundance indices across species, then the geometric mean has much better properties than the arithmetic mean. Conserving as many plants and animals as possible is important for the benefit of humans and of other species. The best way to conserve biodiversity is to save habitats and ecosystems rather than trying to save a single species.

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