Available online at www.ijpab.com

International Journal of Pure & Applied Bioscience

ISSN: 2320 – 7051
Int. J. Pure App. Biosci. **3 (2):** 1-7 (2015)

INTERNATIONAL JOURNAL OF PURE & APPLIED BIOSCIENCE

Research Article

OPEN ACCESS

Spatial Distribution and Biological Diversity of Kingdom Animalia at the Sosa River, Jinhae-city, Korea

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ABSTRACT

The study was described in the spatial patterns of animals for four stations at the Sosa River in Korea during four seasons. Although this area was not wide, but the animal communities were very diverse with 54 taxa, representing four kingdoms. Invertebrate animals exhibited the greatest species diversity with 21 taxa identified, followed by birds (Aves, 14 taxa); reptiles/amphibians (Sauropsida/Amphibia) with ten taxa, and fishes represented by nine taxa. BOD for all the samples was found to above 4.0 ppm except the station A. So the depletion of DO is continuously occurring due the discharge of agriculture water such as pesticides or by the contamination added by the city civilization. The portion of COD, total suspended solids (SS), total nitrogen (N) and phosphate (P) in the river increased exponentially along the upper-down gradient. Total nitrogen and phosphate were also accumulated downward. Many cement blocks were creating instead river grasslands by the Direct-stream Rivers Project. 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 this river.

Keywords: *Animal community, BOD, COD, Sosa River*

INTRODUCTION

Water of sufficient quality and quantity is critical to all life. Healthy and self-sustaining river systems provide ecological and services of critical importance to human societies everywhere[18]. The biogeochemical processes and diverse aquatic species that regulate freshwater quantity and quality are not sufficiently acknowledged nor appreciated, as exemplified by pervasive degradation of the world's freshwater resources[1,15]. Increasing human population and growth of technology require human society to devote more and more attention to protection of adequate supplies of water[19]. Humans can compromise their health by coming in contact with poor water or ingesting it. Other effects include an imbalance in healthy natural ecosystems, harm to the food chain, and impaired populations of fish and other wildlife. Reduced recreation potential and economic loss are possible[16].

The Sosa River is started at the Sosa Reservoir and ends at the Daejang River. Vegetation of Sosa River provides water purification and flow rate of deceleration, and fish habitat. In addition, vegetation is the site of the distribution of fish, birds, amphibians, reptiles, etc and is very important to build food networks.

The structure of the Sosa River was changed during the so-called Direct-stream Rivers Project. The principal factor controlling the distribution of aquatic plants is the depth and duration of flooding. However, other factors may also control their distribution and abundance, including nutrients, disturbance from waves, grazing, and human activity.

The purpose of this study is to investigate the fauna on the Sosa River at four regions during four seasons before secondary indirect damages occur in this river by construct of beams. Therefore, this survey recorded material significance for the future appears in the environment to restore or improve the problem may be.

MATERIALS AND METHODS

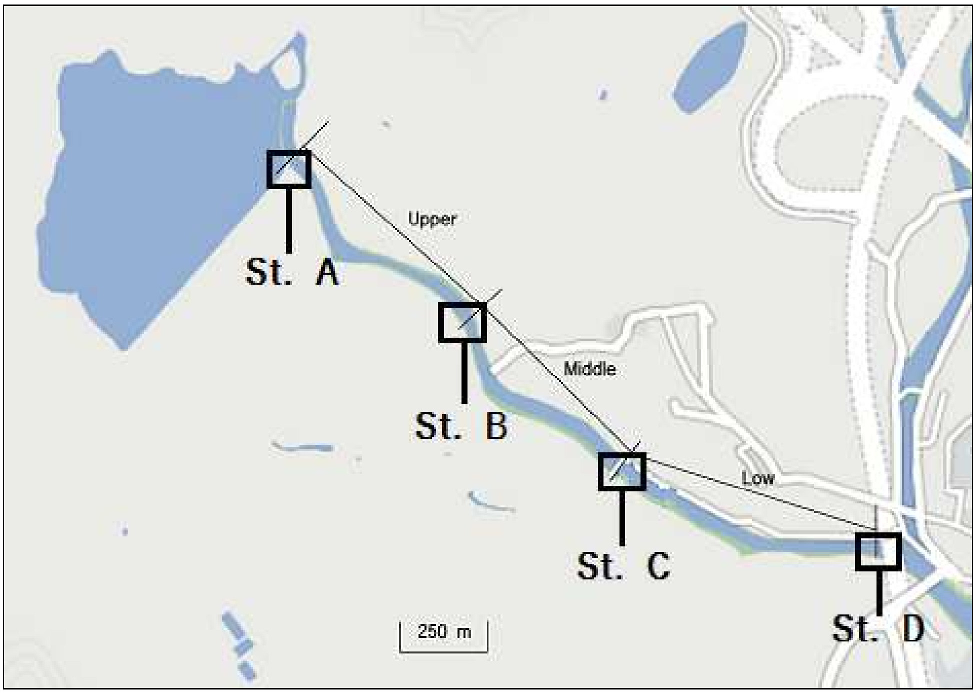
Surveyed regions

Animal samplings were conducted at four stations at the Sosa River, Jinhae-city, Gyeongsangnam-do (Fig. 1). Geographical ranges of the Sosa River were a total length of 2.1 kilometers from the Sosa Reservoir to the confluence of the Daejang River. Sampling periods were 02 February, 10 May, 10 August, and 10 November 2014.

Identification of animals

Animal identification using a means of marking is a process done to identify and track specific animals. Identifications of birds and herpetology were based on Lee *et al.*[10] and Lee *et al.*,[9] respectively. Identifications of fishes and invertebrates were based on Choi[2] and Kim et al.,[8,13] respectively.

Fig. 1: The four stations at the Sosa River, Jinhae-city, Korea



Biotic indices

Shannon–Weaver index of diversity[20]: the formula for calculating the Shannon diversity index (H') is

$$H' = -\sum p_i \ln p_i$$

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).

$$N1 = e^{H'}$$

$$N2 = 1/\lambda$$

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

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

The species richness of animals was calculated by using the method, Margalef's indices (R1 and R2) of richness[11].

$$R1 = \frac{S-1}{\ln(n)}$$

$$R2 = \frac{S}{\sqrt{n}}$$

S is the total number of species in a community and *n* is the total number of individuals observed. Evenness index was calculated using important value index of species[4,17].

$$E1 = \frac{H'}{\ln(S)}$$

$$E2 = \frac{e^{H'}}{S}$$

$$E3 = \frac{e^{H'}-1}{S-1}$$

$$E4 = \frac{1/\lambda}{e^{H'}}$$

$$E5 = \frac{(1/\lambda) - 1}{e^{H'} - 1}$$

ß-diversity index was calculated using the method of Tuomisto[21]

$ß = \gamma/\alpha$

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[22]. Except where stated otherwise, statistical analyses were performed using the SPSS software (Release 21.0)[6].

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[14]. 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) [3]. 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[12]. Total suspended solids (SS) were determined by membrane filtration (0.1 um polycarbonate filters).

RESULTS AND DISCUSSION

The fauna community at the Sosa River on 2013 was identified with 54 taxa, representing four classes (Table 1). Invertebrate animals exhibited the greatest species diversity with 21 taxa identified, followed by birds (Aves, 14 taxa); reptiles/amphibians (Sauropsida/Amphibia) with ten taxa, and fish (Mammalia) represented by nine taxa.

Except invertebrate animals, upper regions of river were shown with the relative high individual density or abundance across areas (Table 1).

In order to assess macro-scale spatial variability of the animal community at the Sosa 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). The mean number of species within the St. A was 38 taxa and other stations varied from 35 to 37. Especially the number of invertebrate species at St. D was high (21 species). Richness indices and Shannon-Weaver indices (H´) of birds for season were not different from each other because a lot of migratory birds were included in these regions. Richness indices (R1 and R2) for reptile/amphibian at station A were different from significantly different from those of the three other stations ($p < 0.05$). H´ of diversity for reptiles/ amphibians and invertebrates were not varied among the stations and seasons. H´ of St. B was similar to those of St. C. Richness indices and evenness indices were same trend. Vertebrate compositions of St. D was less diverse than that of St. A. However, Biological diversity indices for invertebrate at St. D were higher than those of other stations.

For the community as a whole, the values of ß-diversity were the low (from 0.342 for St. A to 0.568 for St. D) (Fig. 2). They indicated that heterogeneity in species compositions among the replicates were not high. The parameters paired similarity between season and stations testified. There were high taxonomic homogeneity of the fauna 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 ($p < 0.05$).

The quality of natural water in rivers and reservoirs depends on a number of interrelated factors. Water is a prerequisite for the existence of life due to its unique physical and chemical properties[7]. BOD for all the samples was found to above 4.0 ppm except St. A. So the depletion of DO is continuously occurring due the discharge of agriculture water such as pesticides or by the contamination added by the city civilization. pH trends were similar to BOD trends in that St. D had a much lower magnitude trend than upper and middle regions (Table 3). The portion of DO and COD in the river increased exponentially along the upper-down gradient. Total nitrogen and phosphate were also accumulated downward.

As a result of an analysis about environmental factors for the numbers of fishes in each surveyed sites, the most effective groups were T-N, T-P, and COD (Table 3). In particular, SS (Suspended solids) has a significant influence on the two points (St. C and St. D). Suspended solids are important as pollutants in water system. Thus both stations remained in suspension in water. 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[3].

Freshwater marsh can be either fresh water mineralized marshes, from groundwater, streams and surface runoff, or poorly mineralized fresh water marshes resulting from direct precipitation. They have their own ecosystems where the pH is usually neutral leading to an abundance of many different types of plants and wildlife. Common species include ducks, geese, swans, songbirds, swallows, coots, and black ducks. Although more shallow marshes do not support many fish, deeper marshes are home to many species, including northern pike and carp. Some of the most common plants are cattails, water lilies, arrowheads, and rushes[5].

Many cement blocks were creating instead river grasslands by the Direct-stream Rivers Project. 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. B and St. C. This decreasing trend for biological indices except invertebrates at from St. A to St. D was supported mainly by an increase of artificial disturbances such as road or house construction.

Table 1: Diversity index for birds and reptile/amphibians at the Sosa River in Korea

Indices	Bird				Reptile /Amphibian			
	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
Richness								
No. of species	13	11	10	8	7	4	4	5
R1	3.323	2.860	2.673	2.337	2.076	1.059	1.137	1.443
R2	2.137	1.915	1.857	1.789	1.650	0.970	1.069	1.250
Diversity								
H'	2.475	2.323	2.173	1.973	1.773	1.201	1.334	1.515
N1	11.883	10.205	8.783	7.192	5.888	3.322	3.795	4.551
N2	14.800	13.200	10.884	9.500	6.652	3.163	4.550	5.217
Evenness								
E1	0.965	0.969	0.944	0.949	0.911	0.866	0.962	0.942
E2	0.914	0.928	0.878	0.899	0.841	0.831	0.949	0.910
E3	0.907	0.921	0.865	0.885	0.815	0.774	0.932	0.888
E4	1.245	1.293	1.216	1.321	1.130	0.952	1.199	1.146
E5	1.268	1.325	1.244	1.373	1.156	0.931	1.270	1.188

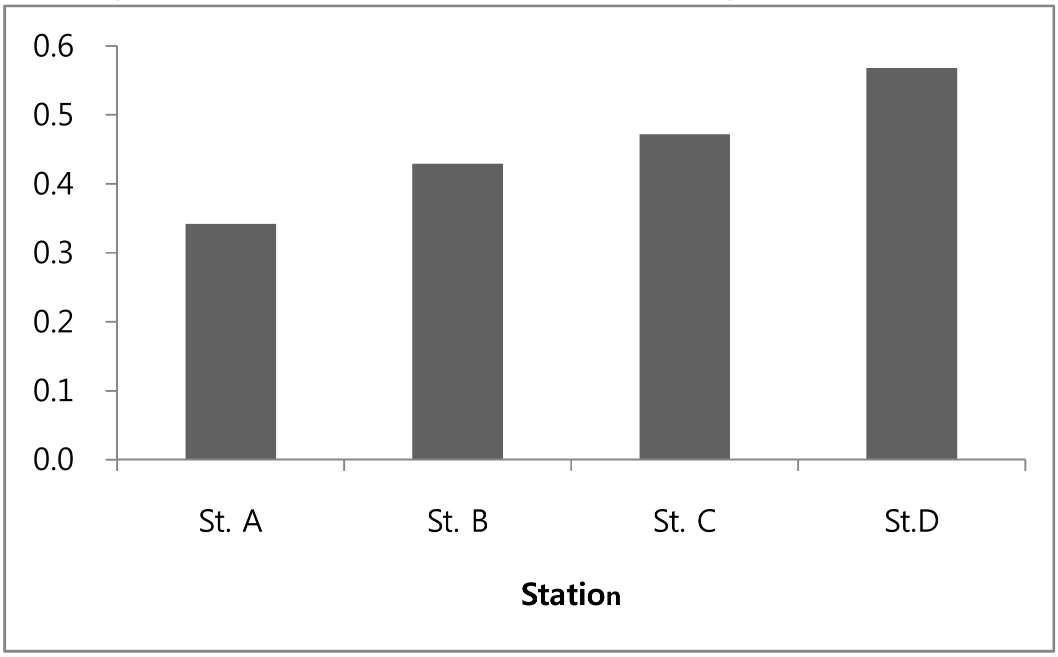
Table 2: Diversity index for fishes and invertebrates at the Sosa River in Korea

Indices	Fish				Invertebrates			
	St. A	St. B	St. C	St. D	St. A	St. B	St. C	St. D
Richness								
No. of species	6	6	5	3	12	15	17	21
R1	1.535	1.243	1.294	0.869	2.841	3.526	3.957	4.791
R2	1.177	1.000	1.066	0.949	1.732	2.060	2.252	2.605
Diversity								
H'	1.668	1.499	1.398	0.930	2.336	2.592	2.716	2.941
N1	5.301	4.4979	4.045	2.535	10.345	13.354	15.114	18.942
N2	5.503	4.762	4.053	3.214	8.356	15.659	17.933	23.636
Evenness								
E1	0.931	0.932	0.868	0.847	0.940	0.957	0.958	0.966
E2	0.883	0.896	0.809	0.845	0.862	0.890	0.889	0.902
E3	0.860	0.870	0.761	0.768	0.850	0.882	0.882	0.897
E4	1.039	1.063	1.002	1.268	0.808	1.173	1.186	1.248
E5	1.048	1.081	1.002	1.442	0.787	1.187	1.200	1.262

Table 3: Water quality for four stations at the Sosa River in Korea. The values are mean of four seasons at each station and standard deviation

Item	St. A	St. B	St. C	St. D
pH	7.82±0.14	8.22±0.11	7.37±0.26	7.08±0.14
BOD (㎎/L)	3.31±0.12	4.89±0.13	5.21±0.15	5.33±0.14
SS (㎎/L)	19.63±2.40	19.31±1.88	25.70±0.73	24.10±0.94
DO (㎎/L)	6.23±0.19	5.93±0.31	5.48±0.15	5.17±0.13
COD (㎎/L)	3.58±0.17	4.12±0.06	4.30±0.04	4.84±0.08
T-N (㎎/L)	2.21±0.05	2.67±0.24	3.35±0.03	4.13±0.02
T-P (㎎/L)	0.11±0.03	0.11±0.02	0.13±0.01	0.14±0.01

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



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