BIODIVERSITY OF KINGDOM ANIMALIA AT THE JUNGCHEON RIVER IN UIRYEONG-GUN, KOREA

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ABSTRACT

This study is to investigate the biodiversity of animal kingdoms at four regions on the Jungcheon River in Korea. Ecosystems are essentially to understand functional systems and characterized by their dynamic within environments and organisms. Biodiversity is changing over time. The number of mammal species accounted for ten taxa for only four seasons within the studied areas. Invertebrates exhibited the greatest species diversity with 20 taxa identified, followed by birds (Aves) (17 taxa). There were twelve taxa of reptiles/amphibians (Sauropsida/Amphibia) at four sites for four seasons. Fish was represented by 13 taxa. Shannon-Weaver index (H´) for mammals at upper region was higher than those of low region. 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 2.548 (St. D) to 2.742 (St. B). St. B was considerable high H´ in birds, reptiles/amphibians, fish, and invertebrates. Berger-Parker's index (BPI) for mammals was varied from 0.172 (Station B) to 0.294 (Station D). St. A was considerable high BPI in reptiles/amphibians (0.323) and fish (0.333). The values of ß-diversity for animals were varied from 0.164 for birds to 0.321 for fish. For the community as a whole, the values of ß-diversity were the low.

Keywords: Berger-Parker's index, biodiversity, Jungcheon River, richness indices, ß-diversity.

INTRODUCTION

River ecosystems are among the most species-rich in temperate regions due to their naturally high habitat heterogeneity and connectivity (Ward and Stanford, 1995). Lakes, reservoirs, and other wetlands have an important function for river ecosystems by influencing water quality and quantity within the catchment area. Rivers themselves transport water and sediments downstream, thus preventing flooding of adjacent settlements and infrastructure within their natural river beds, and providing the structural, and nutrition background for downstream freshwater habitats. Thus, freshwater ecosystems provide many important goods and services including the provision of food, clean water, building materials, and flood and erosion control. An ecosystem is defined as a community of living organisms, together with the physical environment they occupy at any given time. Many important theories in community ecology, including island biogeography, intermediate disturbance, keystone and foundational species effects, neutral theory, and meta-community dynamics make quantitative predictions about species number that can be tested with field observations and experiments in community ecology (Gotelli and Chao, 2013). According to process of community, priority effects, caused by variation in the sequence and timing of species arrival, are responsible for a large part of the variation in species composition between communities (Grman and Suding, 2010). Many authors have reported similar trait composition in different communities under equal environmental conditions, and classified it under the concept of *community* texture convergence (Matsui et al., 2002; Bello et al., 2009; Matthews and Spyreas, 2010). The number of species in an assemblage is the most basic and natural measure of diversity. Biodiversity refers to variation in the organic world. Biodiversity encompasses the variety of all living forms on the planet, extending from genes to species to ecosystems (Wilson, 1988).

Whittaker (1960) introduced the term beta diversity (β) together with alpha diversity (α) and gamma diversity (γ). Both α and γ represent species diversity, but α is the mean species diversity at the local, within-site or within-habitat scale, whereas g is the total species diversity at the regional or landscape scale (Tuomioto, 2010). Cody (1975) redefined beta diversity as the rate of compositional turnover along a habitat gradient within one geographical region, and gamma diversity as the rate of compositional turnover with geographical distance within one habitat. 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. A healthy ecosystem can be buffered to some extent, mitigating change. Over time, the composition of species may change but the ecosystem will still function to sustain life. The change may be caused by new species moving into the environment, by existing species increasing or decreasing, or by evolution over time.

Agriculture is a dominant component of the global economy. It is well known that agriculture is the single largest user of freshwater resources, using a global average of 70% of all surface water supplies (FAO, 1996). Existing knowledge indicates that agricultural operations can contribute to water quality deterioration through the release of several materials into water: sediments, pesticides, animal manures, fertilizers and other sources of inorganic and organic matter. The Jungcheon River is started at the mountains. The most floodplains of the river have been converted to agricultural or horticultural fields, housing, restricting the river bed to a small channel. The purpose of this study is to investigate the fauna on the Jungcheon River at four regions during four seasons on 2016. 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 Jungcheon River (upper region: 35°296′851″N/128°234′679″E, low region: 35°297′285″N/128°259′047″E), located at Uiryeong-gun, Gyeongsangnam-do province in Korea (Fig. 1). Lowlands are usually no higher than 100 m (328 ft.), while uplands are somewhere around 130 m (427 ft.) to 160 m (525 ft.). Rivers provide both a natural transportation network and source of water for irrigation and industry. The relatively level land can be developed either as agricultural fields or sites for habitation or business. Flood plains of this river are usually very fertile agricultural areas and out sides of this river consist of a mosaic of agricultural fields and farming houses. Mean annual temperature ranges from -0.5 (January) to 25.4 °C (August) with 13.0°C, and mean annual precipitation ranges from 15.2 (December) to 294.5 mm (August) with 1275.6 mm.

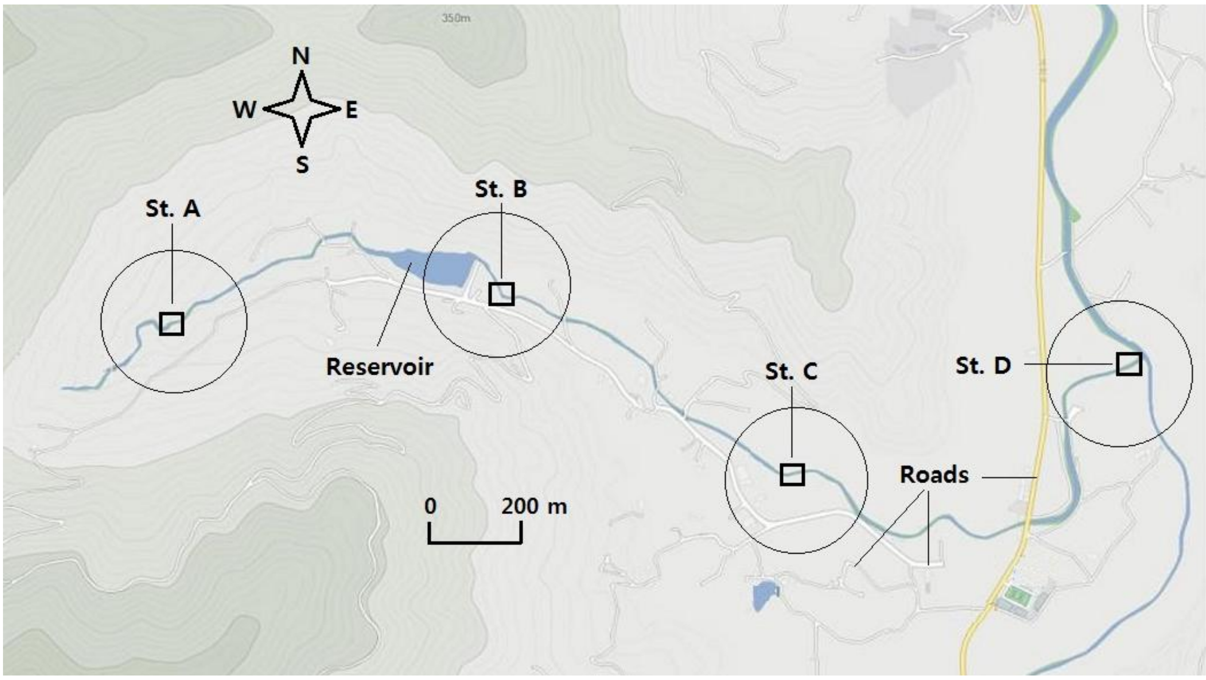

Figure 1. The four stations (St. A~D) for fish and invertebrates (small quadrangles) and four areas (large circles) for mammals, birds, and herpetology at the Jungcheon River in Korea.

Identification of animals

To understand how different physical or biological factors influence the distribution or abundance of species, it usually need to measure changes in population abundances over space or time. At one extreme is a complete census of individually identifiable organisms. 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. (2012). Identifications of herpetology were based on Lee et al. (2013). Identifications of fishes were based on Choi (2001). Identifications of invertebrates were based on Kim et al. (2013). The periods of animal samplings were February, May, August, and October 2016.

Biotic indices

A diversity index is a mathematical measure of species diversity in a given community. Three categories of biodiversity were used to primary interest: number of species, overall abundance, and species evenness. The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled (Shannon and Weaver, 1963): the formula for calculating the Shannon diversity index (H') is

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

pi is the proportion of important value of the ith species ($pi = ni / N$, ni 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

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

Species richness is the number of species of a particular taxon that characterizes a particular biological community, habitat or ecosystem type (Colwell, 2011). Species richness was also calculated for all derived emergent groups separately. 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 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., 2011).

RESULTS AND DISCUSSION

Although the studied area was not wide, but the fauna were very diverse and the fauna community at the Jungcheon River during 2016 season was identified with a total of 72 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 ten 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 20 taxa identified, followed by birds (Aves) (17 taxa). There were twelve taxa of reptiles/amphibians (Sauropsida/Amphibia) at four sites for four seasons. Fish represented by 13 taxa. The mean numbers of species were 52 taxa within the St. A, 70 taxa within the St. B, 59 taxa within the St. C, and 60 taxa within the St. D. Birds, fish and reptiles/amphibians were shown with the relative high individual density or abundance in upper region (station B) of river across areas (Table 2). 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 rivers in this area. 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). In order to assess macro-scale spatial variability of the animal community at the Jungcheon 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 index (H´) for mammals at upper region was higher than those of low region. 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 2.548 (St. D) to 2.742 (St. B). St. B was considerable high H´ in birds, reptiles/amphibians, fish, and invertebrates. Berger-Parker's index (BPI) for mammals was varied from 0.172 (Station B) to 0.294 (Station D). St. A was considerable high BPI in reptiles/amphibians (0.323) and fish (0.333). BPI values for mammals and invertebrates were low at upper region, meaning dominant species were different according to stations or seasons. St. B was also considerable high richness in birds, reptiles/amphibians, 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 (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 0.164 for birds to 0.321 for fish (Fig. 2). For the community as a whole, the values of ß-diversity were the low (from 0.167 for St. D to 0.219 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 Jungcheon River (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 Jungcheon River were well separated each other. The dendrogram showed two distinct groups; St. C and St. D clade and the other stations were sistered with St. C and St. A. The results of ecological diversity and richness of animals at the Jungcheon River 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.

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	10	9	7	6	15	17	16	14	7	12	9	10
Richness												
BPI	2.208	2.137	1.862	1.677	2.646	2.742	2.641	2.548	1.791	2.287	2.018	2.187
R1	9.100	8.472	6.434	5.348	14.091	15.520	14.029	12.778	5.995	9.848	7.526	8.908
R2	10.012	10.684	7.667	6.476	18.679	18.162	15.798	15.452	6.039	9.697	7.222	9.167
Diversity												
H'	0.214	0.172	0.208	0.294	0.111	0.109	0.145	0.125	0.323	0.194	0.300	0.214
N1	2.408	2.376	1.888	1.765	3.678	3.847	3.743	3.358	1.747	2.665	2.169	2.236
N2	1.543	1.671	1.429	1.455	2.236	2.125	2.157	2.021	1.257	1.524	1.423	1.336
Evenness												
E1	0.959	0.973	0.957	0.936	0.977	0.968	0.953	0.965	0.920	0.920	0.919	0.950
E2	0.910	0.941	0.919	0.891	0.939	0.913	0.877	0.913	0.856	0.821	0.836	0.891
E3	0.900	0.934	0.906	0.870	0.935	0.908	0.869	0.906	0.832	0.804	0.816	0.879
E4	1.101	1.261	1.192	1.211	1.326	1.170	1.126	1.209	1.007	0.985	0.960	1.029
E5	1.113	1.296	1.227	1.260	1.351	1.182	1.136	1.227	1.009	0.983	0.953	1.033

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	7	13	10	12	13	19	17	20
Richness								
BPI	1.785	2.465	2.182	2.317	2.496	2.733	2.745	2.857
R1	5.960	11.761	8.861	10.148	12.135	15.372	15.568	17.402
R2	5.959	12.759	9.674	9.936	15.136	15.590	18.584	19.324
Diversity								
H'	0.333	0.141	0.190	0.232	0.108	0.147	0.148	0.136
N1	1.764	2.885	2.408	2.732	3.323	4.169	4.011	4.535
N2	1.278	1.625	1.543	1.604	2.137	2.194	2.313	2.462
Evenness								
E1	0.917	0.961	0.948	0.933	0.973	0.928	0.969	0.954
E2	0.851	0.905	0.886	0.846	0.933	0.809	0.916	0.870
E3	0.827	0.897	0.873	0.832	0.928	0.798	0.911	0.863
E4	1.003	1.085	1.092	0.979	1.247	1.014	1.194	1.111
E5	1.001	1.093	1.103	0.977	1.270	1.015	1.207	1.117

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

Station	St. A	St. B	St. C	St. D
St. A	-	0.271	0.314	0.353
St. B	0.863	-	0.194	0.242
St. C	1.805	0.942	-	0.114
St. D	3.058	2.195	1.253	-

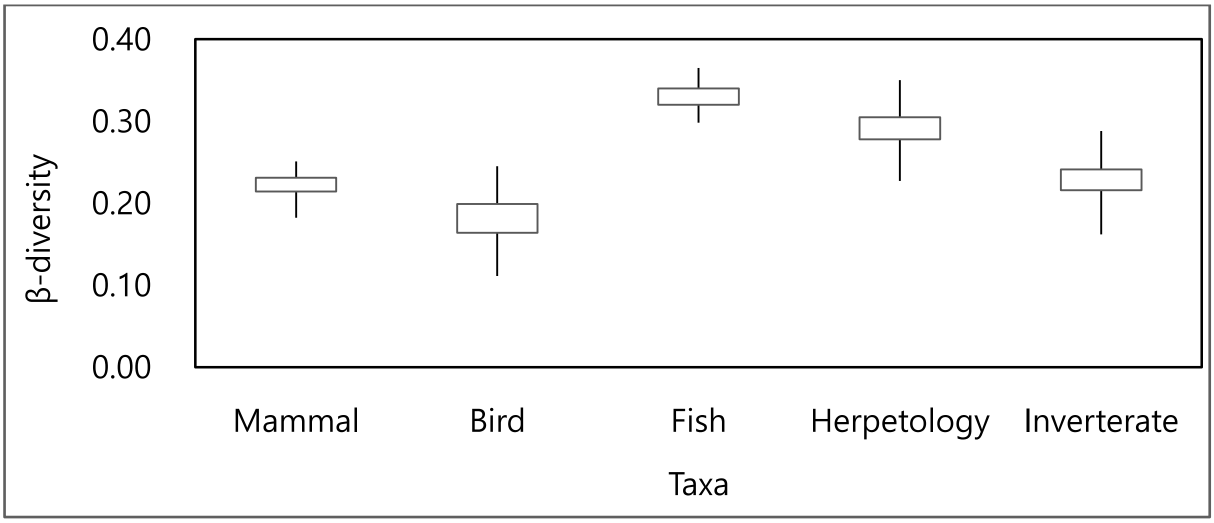

Figure 2. Occurrence index (β-diversity) for five animal kingdoms at four stations.

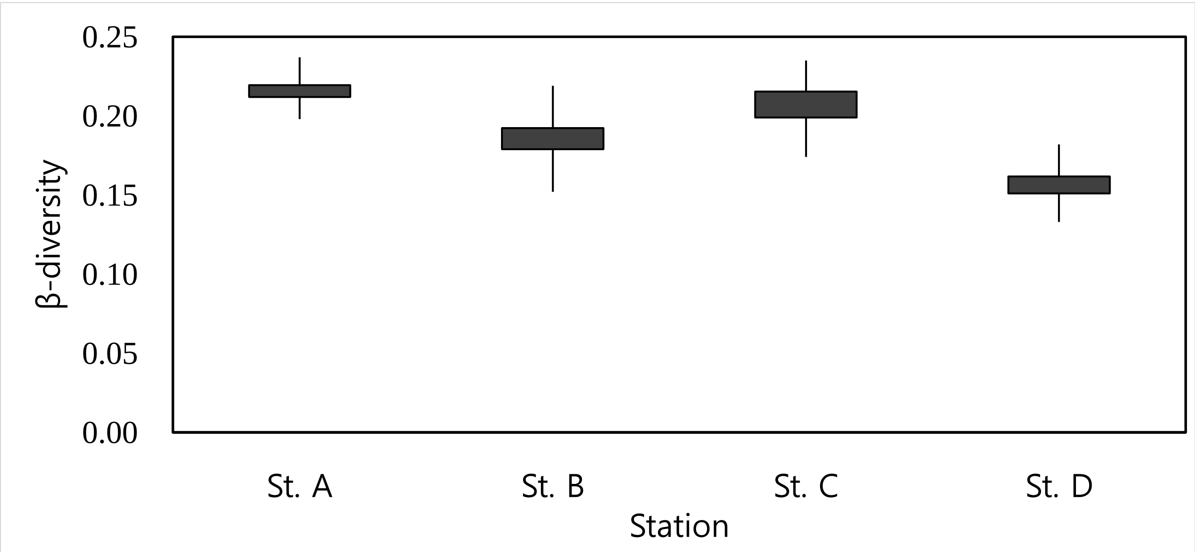

Figure 3. Occurrence index (β-diversity) of four stations for five animal kingdoms

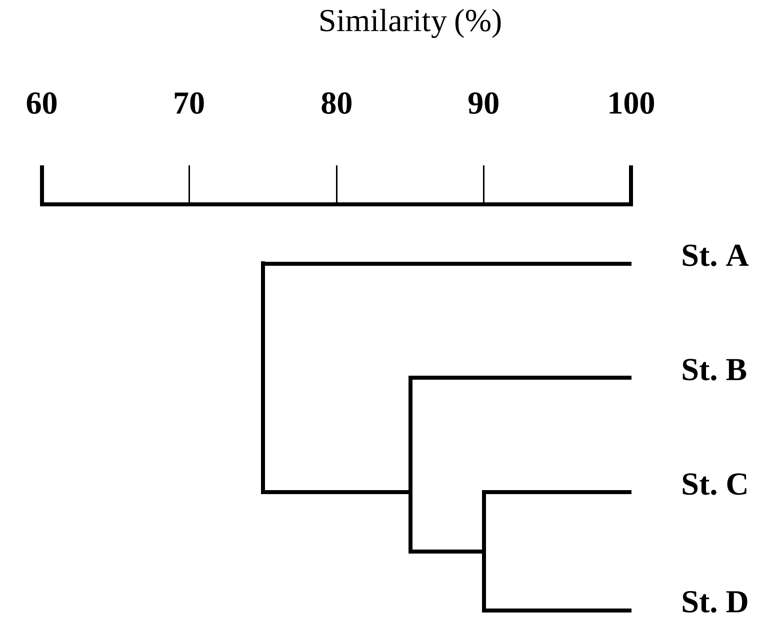

Figure 4. A phenogram showing the animal distribution relationships among four stations at the Jungcheon River.

CONCLUSIONS

The number of species at the Jungcheon River represents one characteristic of an assemblage that can reveal the presence of natural river system and reflect the effect of such change on an assemblage over time. Differences in species richness at a local scale are one of indicators of changes in aquatic habitat. Species richness is also influenced by ecosystem processes and is an important component of monitoring for ecosystem health.

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