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Fish Fauna and Community Structure in Yulcheon Stream of South Korea

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ABSTRACT In this study, nine major sites of Yulcheon stream, a principal tributary of the Seomjingang River, were surveyed from April 2020 to October 2020, and their fish fauna and community structure were analyzed. A total of five families and 19 species of fish were identified. Among the 19 species, seven species were found to be endemic to Korea: *Rhodeus uyekii*, *Squalidus gracilis majimae*, *Microphysogobio yaluensis*, *Odontobutis interrupta*, *Cobitis tetralineata*, *Zacco koreanus*, and *Squalidus chankaensis tsuchigae*. Among five families, the family Cyprinidae had the largest number of species (15), whereas the rest of the four families: Gobiidae, Odontobutidae, Cobitidae, and Osphronemidae, had one species each. The two dominant species in the family Cyprinidae were identified as *Z. platypus* and *Z. temminckii*. The community index of nine major sites of Yulcheon stream was 0.499 dominance, 2.279 diversity, 0.774 evenness, and 2.594 species richness. The number 3 site had 14 species, the largest number of species among all sites, and the dominance rate (0.480) was low, whereas diversity (2.173), and species richness (2.701) were the highest. As a result of cluster analysis, clusters matched according to the structure of the river types, but St. 9, which confirmed a relatively small number of populations, showed a structure similar to that of the upstream section. In the case of St. 5, a separate cluster was formed by a large number of species and populations.

Key words: Fish fauna, freshwater fish, Yulcheon stream, Korea, fish community

INTRODUCTION

The Yulcheon stream flows through Namwon-si, Imsil-gun, and Jeollabuk-do provinces, and is a principal tributary of Osucheon stream that subsequently joins Seomjingang River (Fig. 1). Many other streams such as Doryongcheon, Dasancheon, Goyangcheon, Maenaecheon, and Suoecheon also join Yulcheon to form a highly fertile river basin. There is a vast agricultural land around it, which is mainly irrigated by Seomjingang watershed. Over the last few decades, climate change has become highly pronounced owing to enhanced global warming. As a result, various changes have been observed in natural habitats and their inhabitants worldwide, including Korea (ISK, 2003). Aquatic ecosystems, in particular, is disturbed by many factors such as floods, sediment runoff, and concentrated rainfall, which in turn will have a huge impact on its community size and population (Chae, 2000; Park *et al*., 2009). In addition, inconsiderate man-made constructions on river basins can severely affect fish habitats. There have been many changes in the distribution of fish species due to the frequent introduction of alien species and the movement of other fish species between water systems (ISK, 2003; Chae, 2007). Therefore, holistic research on fish fauna and community structure is very important because not only does it identify variations in the number of freshwater fish and provides basic data necessary for species restoration, but also calculates the impact of geological

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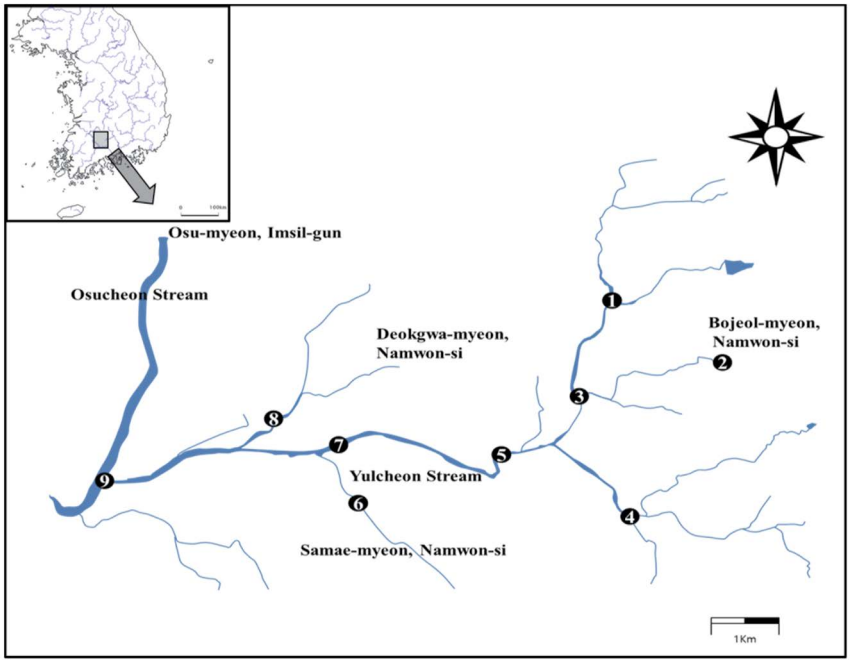

Fig. 1. Map showing the surveyed sites of Yulcheon stream, Korea.

Table 1. The nine sites of Yulcheon stream, Korea

Sites	Aministrative district	N	E
St.1	Bojeol-myeon, Namwon-si, Jeollabuk-do, Korea	35.524599	127.396813
St.2	Bojeol-myeon, Namwon-si, Jeollabuk-do, Korea	35.516545	127.412149
St.3	Deokgwa-myeon, Namwon-si, Jeollabuk-do, Korea	35.511671	127.391635
St.4	Bojeol-myeon, Namwon-si, Jeollabuk-do, Korea	35.495320	127.398116
St.5	Deokgwa-myeon, Namwon-si, Jeollabuk-do, Korea	35.503466	127.379101
St.6	Samae-myeon, Namwon-si, Jeollabuk-do, Korea	35.497119	127.358837
St.7	Samae-myeon, Namwon-si, Jeollabuk-do, Korea	35.504608	127.355988
St.8	Osu-myeon, Imsil-gun, Jeollabuk-do, Korea	35.507970	127.346743
St.9	Osu-myeon, Imsil-gun, Jeollabuk-do, Korea	35.499831	127.321074

changes on the fish population. The South Korean Ministry of Environment (ME) has already carried out extensive studies on freshwater fish at the following locations: Namwon (2008), Jeongsong (2007), Imsil (2006a), Sinchang (2006b), Sinchang (2013), and downstream of the Yocheon basin. In our study, we aim to compare the available data with the fish fauna and community of nearby streams. Hence, we selected nine major sites in Yulcheon stream.

This study further intends to analyze the impact such as environmental change of the downstream and mainstream sections through extensive surveys of fish fauna and community structure in the water systems of Yulcheon stream.

MATERIALS AND METHODS

In this study, a total of nine major sites of Yulcheon stream were surveyed three times from April 2020 to October 2020, and their fish fauna and community structure were analyzed. The investigation of fish fauna was carried out by collecting fish at 9 sites (Table 1) by either using a throwing net or kick net (Kim and Park, 2002). For fish community analysis, the dominance index was calculated by McNaughton (1967), Pielou (1966), Pielou (1975), and the abundance index was calculated according to Margalef (1958). The riverbed materials were modified according to the Cummins (1962) method using Mud (M: <0.1 mm),

Table 2. Details of river structure of nine sites of Yulcheon stream, Korea

Stream	Sites	Width of stream (m)	Width of flowing water (m)	Depth of water (m)	Composition of substratum (%)*					River type**
					R	B	P	S	M	
	1	30−50	10−25	0.2−1	10	10	30	30	20	Aa
	2	10−15	1−2	0.2−0.5	20	30	30	10	10	Aa
	3	40−50	15−20	0.5−1	10	10	10	40	30	Aa
	4	30−45	5−15	0.2−1	−	10	10	50	30	Aa
Yulcheon	5	50−60	5−12	0.2−0.5		10	10	50	30	Aa
	6	30−50	5−10	0.2−0.5	10	10	10	30	20	Aa
	7	100−110	40−60	0.5−1	10	10	10	30	20	Aa-Bb
	8	30−40	2−5	0.2−0.5		10	10	50	20	Aa
	9	80−100	15−20	0.5−1	10	10	20	40	20	Bb

*Kani (1944), **R: Rock (＞256 mm), B: Boulder (64−256 mm), P: Pebble (2−64 mm), S: Sand (0.1−2 mm), M: Mud (~0.1 mm) - modified Cummins method (1962).

Table 3. List and number of species of freshwater fish collected from Yulcheon stream, Korea

Fish family and sp.	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	Total	RA (%)
CYPRINIFORMES											
CYPRINIDAE											
Carassius auratus			3	3	2	5	12			25	2.42
**Rhodeus uyekii*			24		13	8	15			60	5.81
Rhodeus notatus			8			9	18			35	3.39
Acheilognathus lanceolata intermedia			2					4	5	11	1.07
Acheilognathus rhombeus					15					15	1.45
Pseudorasbora parva			5			5		9		19	1.84
**Squalidus gracilis majimae*	6		8				14			28	2.71
**Squalidus chankaensis tsuchigae*			5		8				14	27	2.62
Hemibarbus labeo			1		5				8	14	1.36
Pseudogobio esocinus			5				21		21	47	4.55
**Microphysogobio yaluensis*					25				6	31	3.00
Rhynchocypris oxycephalus			35	5				56		96	9.30
Zacco temminckii			15		31	78	4	45		173	16.76
**Zacco koreanus*	13			14						27	2.62
Zacco platypus				78	125	25	56		58	342	33.14
COBITIDAE											
**Cobitis tetralineata*					6					6	0.58
PERCIFORMES											
ODONTOBUTIDAE											
**Odontobutis interrupta*			1				3			4	0.39
GOBIIDAE											
Rhinogobius brunneus	6	12	9	6	21			16		70	6.78
OSPHRONEMIDAE											
Macropodus ocellatus			2							2	0.19
Total number of fish	25	12	123	106	251	130	143	130	112	1,032	
Total number of species	3	1	14	5	10	6	8	5	6	19	

*: endemic species of Korea

Table 4. The community index of the Yulcheon stream

	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	Total
Dominance	0.76	–	0.480	0.868	0.622	0.792	0.538	0.777	0.705	0.499
Diversity	1.025	0.000	2.173	0.901	1.680	1.231	1.763	1.280	1.399	2.279
Evenness	0.933	–	0.823	0.560	0.730	0.687	0.848	0.795	0.781	0.774
Species richness	0.621	0.000	2.701	0.858	1.629	1.027	1.410	0.822	1.060	2.594

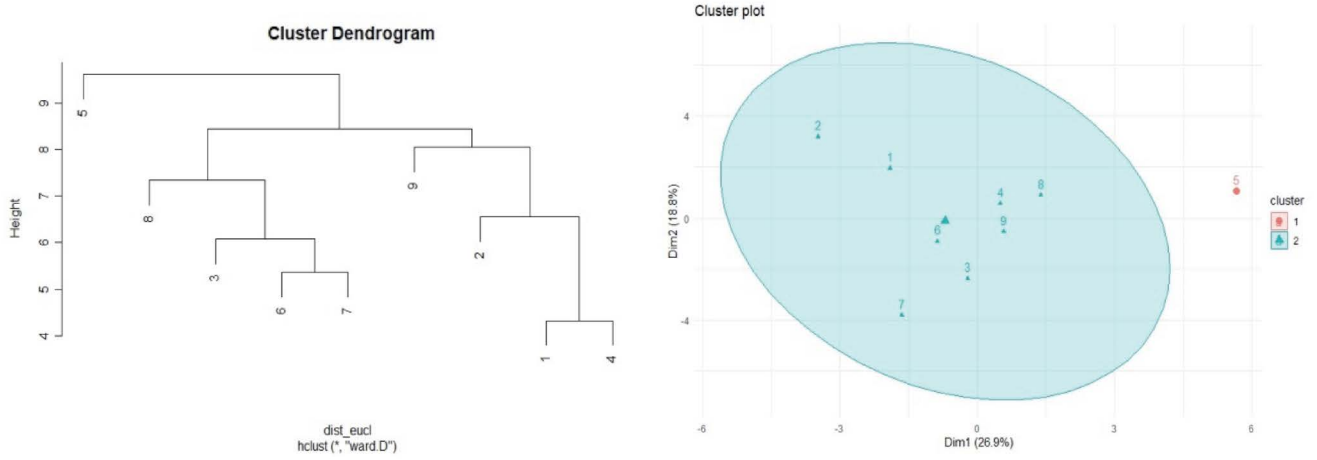

Fig. 2. The results of cluster similarity analysis using the fish population and community structure of Yulcheon stream.

sand (S: 0.1–2 mm), pebble (P: 2–64 mm), and Cobble (C: 64–256 mm), Boulder (B: >256 mm), and rock (R: large stone and bedrock), and the required ratio was obtained by visual examination. The river types were classified according to Kani (1944).

RESULTS AND DISCUSSION

Most of the sites of Yulcheon stream were of the Aa type, characterized by more sand flowing downstream, but few sites of Bb type were also observed (St. 7 and St. 9; Table 2). The depth of the stream was found to be 0.2 m at the shallowest area and 1 m at the deepest area. The width of the stream was small and stayed within the range of 10–110 m. St. 7, where the two streams- Yulcheon and Maenaecheon converge, was the widest (100–110 m) because of the presence of a downstream weir (Table 2).

In this study, the analysis of fish fauna and community structure in Yulcheon stream resulted in the identification of five families and 19 species of freshwater fish. A total of 1,032 fish, belonging to either one or 14 species, were collected from nine sites (individual fish collection from each site varied from 12–251) (Table 3). We next compared our findings with those of neighboring streams using available ME data. Data showed that there were 1,313 fish representing seven families and 26 fish species from 12 sites of Yocheon (ME, 2013); and 1,302 fish classified in four families and 14 species from 10 sites of Namwon (ME, 2014). We found that 13 out of 26 species were common between Yulcheon and Yocheon stream, whereas only 6 out of 14 species were common between Yulcheon stream and Namwon. Therefore, the species of fish in Yulcheon stream were more similar to those of Yocheon stream than Namwon.

Furthermore, seven species that are endemic to Korea were identified in Yulcheon stream: *Rhodeus uyekii*, *Squalidus gracilis majimae*, *Microphysogobio yaluensis*, *Odontobutis interrupta*, *Cobitis tetralineata*, *Zacco koreanus*, and *Squalidus chankaensis tsuchigae* (Table 3). Among the 19 species isolated from Yulcheon stream, *Zacco platypus*, which is resistant to water pollution (ME/NIER, 2014), had the highest dominance rate of 33%. The only other fish species that exceeded the 10% dominance rate was *Z. temminckii*. Out of nine sites, only two sites – St. 3 and St. 5 harbored more than 10 different fish species. From St. 2, only one species (*Rhinogobius brunneus*) was collected, whereas, at St. 1, three different species were identified

(Table 3). Thus, various habitats for fish species to inhabit were not identified. In addition, among the 19 species, *C. tetralineata*, which belongs to the family 'Cobitidae' was identified only at St. 5. *C. tetralineata* is a kind of sardine fish endemic to Korea and is well known to live in the water system of Seomjingang River (Kim *et al*., 2006). *C. tetralineata* usually inhabits the sandy bottom of clear rivers with the sluggish flow in the middle. Most of the sites we surveyed had high turbidity at the time of sample collection, except St. 5, which had negligible turbidity and a sandy bottom that helped us to identify *C. tetralineata*. As the water of the stream twists and turns around the large obstructions, the pools and riffles are formed in a repetitive sequence. This type of environment makes the preferred habitat for *Z. platypus*. Consistent with these habitat characteristics, *Z. platypus* constituted almost 50% of total fish collection at St. 5 and was also the most abundant species at all other surveyed sites. The endemic species were mainly collected from the upper and middle courses of the river which had clear water. Their habitat may rapidly deteriorate because of its sensitivity to changes in the aquatic environment. There is a tendency for the population of endemic species to decrease rapidly (Choi *et al*., 2000), as most of their habitats are located upstream and also due to the lack of proper identification.

Since Yulcheon stream water is used for irrigation, we observed that its turbidity increased as it approached Osucheon stream, which is downstream from St. 5. Human activities, such as river construction and domestic sewage pollution, have been observed at some survey sites. Therefore, the total number of fish collected was not large in Yulcheon stream. The community indices of dominance, diversity, evenness, and species richness for all the nine sites were found to be 0.499, 2.279, 0.774, and 2.594, respectively (Table 4). After comparing these indices with those of neighboring areas such as Yocheon stream (0.611, 1.941, 0.598, and 3.482; ME, 2013) and Namwon (0.653, 1.755, 0.665, and 1.812; ME, 2014), we concluded that Yulcheon stream had high diversity whereas Yocheon stream had considerable species richness. As a result of analyzed by NMDS Plot extras in R the similarity between the fish population and the community structure, it was divided into three clusters, and only St. 5 formed a separate cluster, confirming that the similarity of the cluster was different (Fig. 2).

Therefore, the Yulcheon stream showed an intermediate community index in between that of the Yocheon stream and Namwon. In general, the fish community structure is considered good when dominance and evenness indices are low and species richness and diversity indices are high (Lee *et al*., 2009). Hence, the fish community structure of Yocheon stream was found to be better than that of the nearby stream.

Above all, the current survey sites have confirmed the habitat of the largemouth bass, an invasive species, in past surveys (ME, 2006a, 2006b, 2007, 2008). Fortunately, there was no single invasive species found at the sites surveyed in this study.

In the case of Yulcheon stream, the number of fish collected was not large, as Yulcheon stream is located upstream of the river. In addition, the fish population is severely affected by man-made construction, non-point farmland pollution, domestic sewage, and over-fishing. Moreover, Yulcheon stream water system has already been altered by the devastating flood, hence, the riverbed structure and fish fauna of the stream are significantly different now from that of the previous surveys (Lee *et al*., 2009). For example, largemouth bass, which is designated as an invasive species that disturbs the wildlife ecosystem and appeared in the past in currently studied watershed areas, was not found invasive in any of our surveyed sites in this study. In addition, most of the species endemic to Korea live in the riffles of the upper course of the river. Also, 50% of endangered species designated by the ME live upstream. The habitat of each species is different, and their range of distribution is narrow (Yang *et al*., 2006). Therefore, if the upstream habitats are not preserved, there is a high risk of extinction of some of these species. Commendable efforts should be made to preserve the endemic fish species, which are the biological resources of Korea. In addition, with regular monitoring, the spread of invasive species can be prevented and the health of our aquatic ecosystems can be restored.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no conflict of interest.

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율천의 어류상과 어류군집구조의 분석

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요 약 : 본 연구에서는 2020년 4월부터 2020년 10월까지 섬진강의 오수천으로 유입되는 율천의 주요 지점 9곳을 3회에 걸쳐 조사하여 어류상 및 군집구조를 분석하였다. 그 결과 율천 일대에서 5과 19종의 어류가 확인되었다. 한국 고유종은 7종(*Rhodeus uyekii*, *Squalidus gracilis majimae*, *Microphysogobio yaluensis*, *Odontobutis interrupta*, *Cobitis tetralineata*, *Zacco koreanus*, *Squalidus chankaensis tsuchigae*)이 조사되었다. 어류의 과별 종 구성을 살펴보면, 잉어과가 15종으로 가장 많았고, 나머지 어종은 망둑어과, 동사리과, 미꾸리과, 버들붕어과에서 각각 1종씩 나타났다. 우점종은 *Z. platypus*였으며, 아우점종은 *Z. temminckii*로 확인되었다. 군집지수는 우점도 0.499, 다양도 2.279, 균등도 0.774 및 종 풍부도 2.594로 나타났다. 지점 3에서 14종으로 전체 지점 중 가장 많은 종 수를 보였으며 본 지점은 우점도(0.480)가 낮고 다양도(2.173)와 종 풍부도(2.701)는 가장 높았다. 군집분석 결과, 하천의 구조에 따라 군집이 일치하는 경향을 보였으나 비교적 적은 수의 개체수를 확인한 St. 9은 상류구간과 유사한 결과로 확인되었다. St. 5는 많은 종 수와 개체수에 의해 별도의 cluster를 형성하고 있었다.

찾아보기 낱말 : 어류상, 담수어류, 율천, 어류군집