Environ. Eng. Res. Vol. 13, No. 3, pp. 147~154, 2008
Korean Society of Environmental Engineers

An Investigation of Flora and Fauna in Upper streams and Lower streams of Weirs with and without a Fish-Way in Ham-an Stream

Dong Wook Kim, Je Chul Park, and Jae Keun Ryu[1,†]

Department of Environmental Engineering, Kumoh National Institute of Technology, Gumi, Gyeongbuk 730-701, Korea
[1]Department of Environmental Engineering, Chungju National University, Chungju, Chungbuk 380-702, Korea

Received May 2008, accepted September 2008

Abstract

The purpose of this study was, as a preliminary step for understanding the whole aspects of the impacts of a weir on the ecosystems in upper and lower streams, to find out the impacts of the weirs with and without a fish-way. A survey on the aquatic ecosystem of upper and lower streams of weirs in Ham-an Stream was carried out from June to October, 2006. Results of the investigation showed that some meaningful effects on the ecosystems had occurred by the weirs.

The fish fauna in upper stream of the weir with a fish-way appeared to include 3 families, 8 species, and 184 individuals, while that in the lower stream of the weir appeared to include 5 families, 14 species, and 664 individuals. The fish fauna in the upper stream of the weir without a fish-way appeared to include 3 families, 9 species, 107 individuals, while that in the lower stream of the weir appeared to include 9 families, 19 species, 520 individuals, disclosing that, no matter with or without a fish-way, fish fauna species diversity and size of population were more abundant and bigger in the lower stream than in the upper stream, but that difference of fish fauna species diversities between upper and lower streams of the weirs appeared to be bigger for the weir with a fish-way than for the weir without a fish-way.

Benthos species diversity and size of population were found to be more abundant and bigger in lower stream than in upper stream, and in wet season than in dry season.

Keywords: Weir, Upper stream, Lower stream, Flora, Fauna

1. Introduction

The 1999 amendment to the River Act of 1962 had mainly focused on the beneficial use of public waters and flood control. However, as the quality of life is upgraded and awareness of environmental importance is widely spreaded among people due to the activities of non-governmental organizations, such as Coastal Area Conservation Network, there arises an urgent need for ecosystem conservation and restoration for rivers and streams.[1)] Since the 1990s, as an effort to meet such a need, nation-wide campaign for the improvement of ecological function of rivers and streams, majority of which were small to medium size ones that flowed through or around cities and towns, had been initiated by local governments. Most of the efforts were focused on changing the flooded areas of rivers and streams to elevated riparian parks and rest areas for urban dwellers. In other words, the focus of such a project for improving the environments of rivers and streams, which was planned in the lack of idealogical philosophy, methodological and technological knowledge, and sufficient experiences, was put rather on construction of artificial water friendly riparian spaces for people than restoration of stream ecosystem.[2)]

In this context, it is evident that any project to improve the impaired ecosystems of rivers and streams hereafter should be the ones to bring the disrupted ecosystems to its natural states. In addition to the increased influx of water pollutants by industrialization and population growth, one of most problematic water pollutions is representatively the artificial weirs put across rivers and streams, which, obstructing the free flow of streams and rivers, unfavorably change the physiochemical and biological environments of the water bodies.[3)] As of now, numerous weirs have been put in rivers and streams, but few comprehensive impact assessments of such weirs on ecosystems of rivers and streams, including biological habitats, organism structure, and biogeochemical cycles, have been done. So, with no precedent studies, it is rather difficult to put relative importance among factors affecting riparian ecosystems and to develop alternatives

† Corresponding author
E-mail: ryu1773@naver.com
Tel:+82-02-383-0694, Fax: +82-02-383-0693

to secure the stability of the ecosystem.

As the present water quality assessment system based on the physiochemical and biological methodologies can only represent the instantaneous concentrations or biomass, it has limited ability to represent the ever-changing environmental factors. In particular, it is not possible to identify tens of thousands of water pollutants in a water body in terms of manpower and economic costs, and it is very difficult to assess the risk because of the synergistic effects of complex water pollutants interaction. This study assess the biological environment of upper streams and lower streams of the weirs with and without a fish-way in Ham-an Stream (Class 1 local stream), a branch of Namchun in Nakdong river watershed. The assessment is wholly based on chemical and biological parameters of the water bodies identified through field surveys.

2. Material and Experimental Methods

2.1. Description of Study Area

The study areas are consisted of two-100 m reaches of Ham-an Stream. Each reach has a weir in the middle of it, one with a fish-way and another without a fish-way. Ham-an Stream is a Class 1 local stream, originated in Yeuhang-myun, Haman-kun, Kyungsangnam-do and joined by Ham-an national river at its endpoint. The watershed area of Ham-an Stream is 31.2 km^2, and flow-length and stream-length are 10.4 km, 8.4 km respectively. From the sampling sites, we collected water quality and biota (fish and benthic macro-invertebrates) samples twice in June for wet season and early October for dry season, respectively (Fig. 1).

2.2. Sampling Method and Sampling Gears

The fish samples were collected by two types of sampling gears as casting net and kick net, each size of the mesh were 7×7 mm and 4×4 mm, respectively, which are appropriate for collection of juvenile fish as well as large-size adult fish. The number of species and individuals were identified using keys of Kim and Park (2002)[4] and classified into the order of tolerant guild as sensitivity, intermediate, and tolerant species. Among collected specimens, some species necessary for detailed further identification and observation were fixed with 10% formalin solution and transported to the laboratory.

Benthic macro-invertebrates were collected for each sampling point by Modified D-frame deep net(mesh size: 250 μm). Quantitative specimen was taken by 100 μm Standard Sieve and the samples collected by hand-net, hard bottom scraper, and Core Sampler, etc., were used as qualitative specimen. Samples collected at the site were fixed in Kale's solution, and identified in laboratory under stereo microscope ×40, ×80 or optical microscope and classified referring to Kim,[5] Kwon,[6] Choi,[7] Min et al.,[8] NFRDI,[9] and Jung.[10]

Physical and chemical parameters such as water temperature, dissolved oxygen (DO), pH, electric conductivity (EC) and turbidity were measured using YSI 600 Modle in the field. SS and

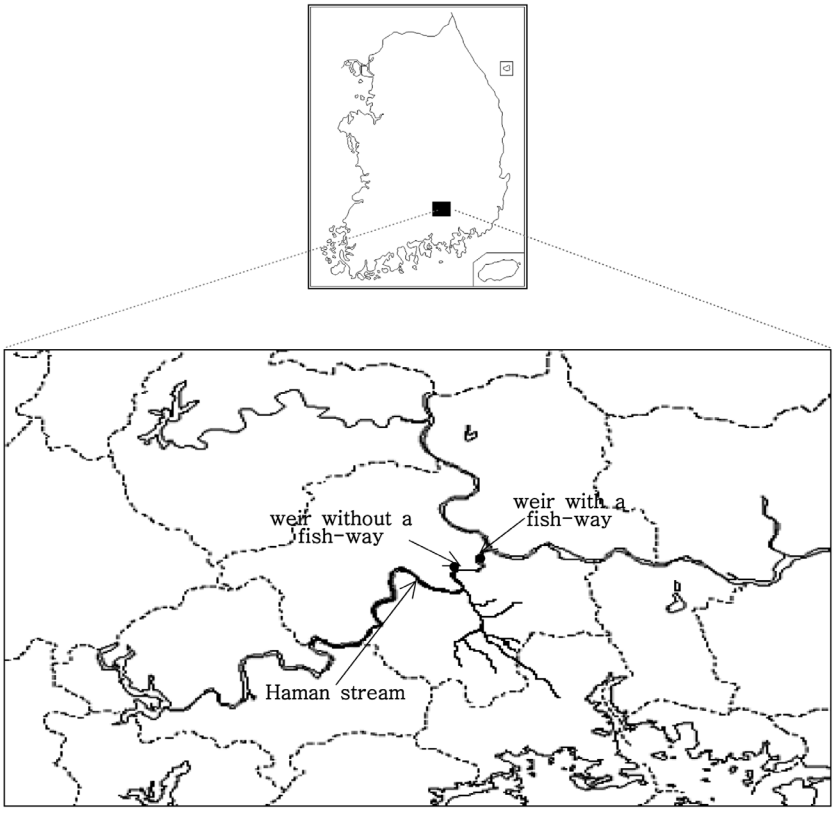


Fig. 1. Study sites of Ham-an Stream.

BOD were analysed by Korea Standard Method of Examination for Pollution Control. Flow rate was measured using a Valeport model 002 and Flo-tote II model.

3. Result and Discussion

3.1. Flow Conditions and Water Quality

The results of the first survey showed that the effluent flow rate of the weir with a fish-way was equivalent to only one-half of influent flow rate because the influent water was slowed down by the weir and allowed to be released only through the fish-way on the left side of the weir. For the weir without a fish-way the flow rates of upper stream and lower stream of the weir appeared to be identical because of no significant stagnation of water flow by the weir. The result of the second survey showed that there was almost no variation of flow rate in upper streams and lower stream of the weirs with and without a fish-way.

The water quality of upper streams and lower stream of the weirs was found to be almost same for all water quality parameters except suspended solids(SS) in the first and the second survey. The result of the first survey showed that suspended solid concentration was a little higher for the upper streams of the weirs than the lower stream. And for the weir without a fish-way the concentration of suspended solid in the lower stream was higher than that in the upper stream. The result of the second survey showed that for the weir with a fish-way suspended solid concentration in the lower stream appeared to be higher than that in the upper stream, and for the weir without a fish-way no variation were observed in suspended solid concentration (Table 1).

3.2. Fishes

Species diversity indices of ichthyofauna of upper stream and lower stream of the weir with a fish-way in Ham-an Stream appeared to be 0.41 and 0.22 respectively,[11] a big difference between the two water bodies, showing that movement of fishes over the weir was not free.[4] However, in upper stream and lower stream of the weir without a fish-way with no substantial head of water, species diversity indices and evenness appeared to be almost identical, showing that movement of fishes over the weir was free (Table 2).

The result of the first and the second survey showed that in the upper stream of the weir with a fish-way a total of 3 families, 8 species, and 184 individuals were identified, of which dominance index of Zacco platypus was 69, followed by 20 of Herzensteir and 11 of Pseudorasbora parva.[12] In the lower stream of the weir with a fish- way in the collected samples were included a total of 5 families, 14 species, and 664 individuals. In the upper stream of the weir without a fish-way the collected samples disclosed a total of 3 families, 9 species, and 107 individuals, but in the lower stream a total of 9 families, 19 species, and 520 individuals were identified, of them five individuals were identified Pseudobagrus brevicorpus, the Endangered Species Class 1 as well as Natural Monument No.455 (Table 3).[13]

3.3. Benthos

3.3.1. Distribution

The first and the second survey identified a total of 3 phyla, 4 classes, 9 orders, 25 families, 44 species and 633 individuals of benthic macro-invertebrates in the weirs with and without a fish-way. In comparison with the number of species and individuals occurred in the mid-streams of typical Korean streams, bio-diversity around the weirs were found to be almost same as theirs or a little smaller than theirs (Table 4). It is considered that the decrease in the biodiversity of the waters around the weirs, together with stagnation of water flow in the weirs, is due to the

Table 1. Flow rates and water quality of Ham-an Stream

Parameter \ Survey area	The weir with a fish-way				The weir without a fish-way			
	1st		2nd		1st		2nd	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Flow (m^3/s)	1.2	0.6	0.4	0.4	1.3	1.2	0.4	0.4
Temperature (°C)	25.7	25.1	19.9	19.8	26.1	25.5	21.1	20.8
DO (mg/L)	8.4	8.8	8.3	8.3	7.6	8.6	8.5	8.4
pH	8.2	8.4	8.2	7.7	8.5	8.4	8.6	8.3
Conductivity (μs/cm)	162	164	160	162	169	170	160	161
Turbidity (NTU)	3.1	2.8	6.7	11.5	3.0	3.2	7.6	7.2
SS (mg/L)	6.7	4.9	8.4	10.4	5.2	6.9	7.6	7.6
BOD (mg/L)	0.9	1.8	0.9	1.0	0.9	0.9	1.2	0.6

Table 2. Status of fishes diversity in the Ham-an Stream

Brological index	The weir with a fish-way						The weir without a fish-way					
	Upper			Lower			Upper			Lower		
	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total
Species diversity	0	0.41	0.41	0.47	0.60	0.22	0.59	0.44	0.61	6.52	0.87	0.87
Species richness	0	3.10	3.09	2.44	4.62	4.61	3.26	3.22	3.94	5.02	5.64	6.63
Species evenness	-	0.22	0.60	0.2	0.06	0.06	0.16	0.09	0.11	0.08	0.09	0.08

Table 3. Status of fishes in upper and lower streams of the weirs in Ham-an Stream

Family	Species	Weir with a fish-way						Weir without a fish-way					
		Upper			Lower			Upper			Lower		
		1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total
Cyprinidae	*Zacco platypus*	2	125	127	10	403	413	7	54	61	43	162	205
	Opsarliichthys bidens		2	2		3	3	2	2	4	6	23	29
	Hemiculter eigenmanni		1	1			1						
	Rhodeus notatus							4		4			
	**Rhodeus uyekii*					12	12						
	**Acheilognathus koreensis*							2		2	4		4
	Acanthorodeus assumussi					25	25						
	Cyprinus carpio					1	1		2	2		2	2
	Carassius auratus		1	1		4	4	18	3	21	3	24	27
	Pseudorasbora parva		12	12	2	31	33		2	2		3	3
	Pungtungia herzi		38	38	4	104	108					98	98
	**Squalidus gracilis majimae*					4	4					4	4
	Microphysogobio yaluensis					16	16						
Cobitidae	*Misgurnus anguillicaudatus*										1	19	20
	Niwaella multifaciata											1	1
Iksookimia	*Misgurnus anguillicaudatus*					21	21						
Odontobutidae	**Odontobutis platycephala*		1	1		18	18		4	4	1	50	51
Bagridae	*Pseudobagrus brevicorpus*											5	5
Odontobutidae	**Odontobutis platycephala*		1	1		18	18		4	4	1	50	51
Bagridae	*Pseudobagrus brevicorpus*											5	5
Gobitidae	*Rhinogobius brunneus*				1	4	5					21	21
	Tridentiger obscurus											5	5
	Chaenogobius urotaenia											11	11
Siluridae	*Silulus asotus*					1	1				1		1
Centropomidae	**Coreoperca herzi*							1	6	7	1	28	29
Osmeridae	*Plecoglossus altivelis*										1		1
Centrarchidae	*Micropterus salmoides*		2	2							1	2	3
Total		2	182	184	17	647	664	34	73	107	62	458	520

Table 4. Benthic macro-invertebrates species in Ham-an Stream

Species	Weir with a fish-way				Weir without fish-way			
	Upper		Lower		Upper		Lower	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
MOLLUSCA								
Gastropoda								
Basommatophora								
Lymnaeidae								
Lymnaea auricularia	1		6	8			9	
Physidae								
Physa acuta	14	2	2	3	11		3	
Planorbidae								
Gyraulus chinensis			3	2			2	
Hippeutis cantori			1				1	
Polypylis hemisphaerula	1		1	4			1	
ANNELIDA								
Oligochaeta								
Archioligochaeta								
Tubificidae								
Limnodrilus gotoi	5	2	4	1				

Table 4. Benthic macro-invertebrates species in Ham-an Stream (continued)

Species	Weir with a fish-way				Weir without fish-way			
	Upper		Lower		Upper		Lower	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Limnodrilus sp.	7	1		1				
Hirudinea								
Arhynchobdellidae								
Hirudinidae								
Hirudo nipponica				2				1
Whitmania edentula			1	1			2	1
Whitmania sp.			2		1			
ATHROPODA								
Insecta								
Ephemeroptera								
Baetidae								
Baetis silvaticus			9	2			11	5
Baetis sp.				1	2		4	2
Cleon dipterum							4	3
Potamanthidae								
Rhoenanthus coreanus			1					
Heptageniidae								
Epeorus latifolium			8	4			5	3
Epeorus curvatulus			3	2			2	1
Odonata								
Coenagrionoidae								
Cercion hieroglyphicum			4	2			2	1
Ischnura asiatica			2	1			2	1
Calopterygidae								
Calopteryx japonica			1				4	3
Aeshnidae								
Anax parthenope julius			1				1	
Anax nigrofasciatus							1	
Corduliidae								
Somatochlora graeseri							1	
Libellulidae								
Orthetrum albistylum speciosum			3	2			2	3
Pantala flavescens				4				2
Hemiptera								
Belostomatidae								
Muljarus japonicus	1		3	2			4	3
Nepidae								
Laccotrephes japonensis			2	1			1	3
Ranatra chinensis			1	1			2	3
Gerridae								
Aquaris paludum	4		1	2	3		1	1
Coleoptera								
Dytiscidae								
Laccophilus difficilis					2		1	3
Hydrophilidae								
Sternolophus sp			2					
Elmidae								
sp.							1	
Trichoptera								

Table 4. Benthic macro-invertebrates species in Ham-an Stream (continued)

Species		Weir with a fish-way				Weir without fish-way			
		Upper		Lower		Upper		Lower	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Hydropsychidae									
Hydropsyche KUb								8	5
Hydropsyche sp.1								4	2
Hydropsyche sp.2				9				5	
Limnephilidae									
Nothopsyche KUa				2					
Diptera									
Tipulidae									
Tipula KUa								2	1
Tipula sp.2				1					
Chironomidae									
sp. 1 - red type		6		3		17	3	2	
sp. 2		2		21	16			23	11
sp. 3				49	37		7	72	43
Tabanidae									
sp.1				2				1	
sp.2								1	1
Culicidae									
sp.1		3				1			
Total	Species	10	3	30	23	8	2	33	23
	Population	44	5	149	100	38	10	185	102

eutrophication of the waters by the influx of nutrients from non-point sources. In the benthos identified at all of the sampling points were included 5 species and 75 individuals of mollusca, and 5 species and 75 individuals of annelida, and 34 species and 526 individuals of athropoda, which took up 77% in number of species and more than 83% in number of individuals.[14)]

3.3.2. Variation of Number of Species and Individuals

The first and the second surveys showed that at all sampling points benthos were more diverse and abundant in the lower stream zone than in the upper stream zone. In the first survey for the upper stream of the weir with a fish-way were collected 10 species and 44 individuals, and 30 species and 149 individuals for the lower stream of the weir, three times as many species and individuals collected in the lower stream than in the upper stream.[15)]

In the upper stream of the weir without a fish-way 8 species and 38 individuals were collected while 33 species and 185 individuals were collected in the lower stream, almost four times as many species and individuals in the lower stream than in the upper stream. In the second survey for the upper stream of the weir with a fish-way 3 species and 5 individuals, and in the lower stream 23 species and 100 individuals were collected respectively. In the upper stream and the lower stream of the weir without a fish-way 2 species and 10 individuals, and 23 species and 102 individuals were collected respectively (Fig. 2, Fig. 3).

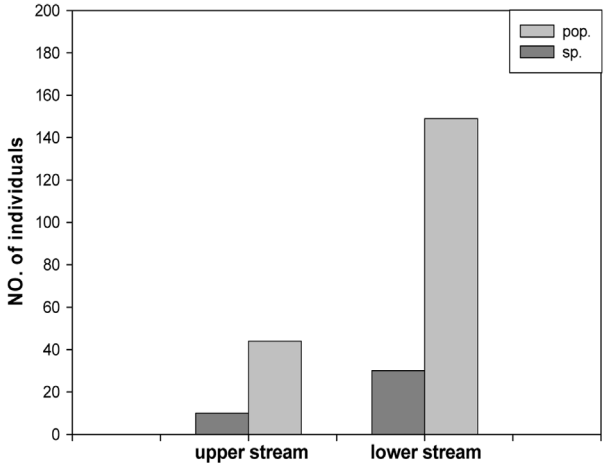
3.3.3. Dominant Species and Subdominant Species

The results of the first and the second survey showed that, regardless of sampling points and sampling date and time, Annelida diptera Chironomidae species were dominant, and subdominant species were some Chironomidae, Limnodrilus, Hydropsychidae, and Lymnaeidae. This means that all of the waters of the study area were polluted (Table 5).

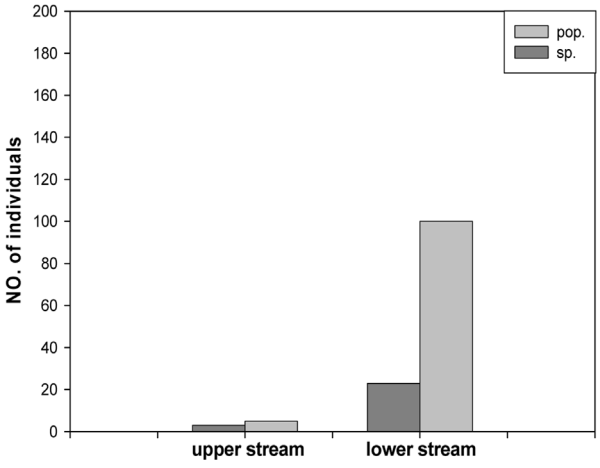
4. Conclusions

The effluent flow rates and water quality of the upper streams and lower streams of the weirs were investigated to be similar to each other, except in the first survey, where the effluent flow rate over the weir with a fish-way was one-half of the influent flow rate from the upstream. Throughout the investigation time, ichthyofauna occurrence recorded 3 families, 8 species, 184 individuals, and 5 families, 14 species, and 664 individuals respectively for the upper stream and the lower stream of the weir with a fish-way, and 3 families, 9 species, and 109 individuals, and 9 families, 19 species, 520 individuals for the upper stream and the lower stream of the weir without a fish way respectively.

Included in the benthos of the upper streams and the lower streams of the weirs in Ham-an Stream in the first and the second survey were 3 phyla, 4 classes, 9 orders, 25 families, 44 species, and 633 individuals, of which mollusca were 5 species and 75 individuals, and annelida were 5 species and 75 individuals, and athropoda were 34 species and 526 individuals, which took up 77% in terms of number of species and more than 83% in terms

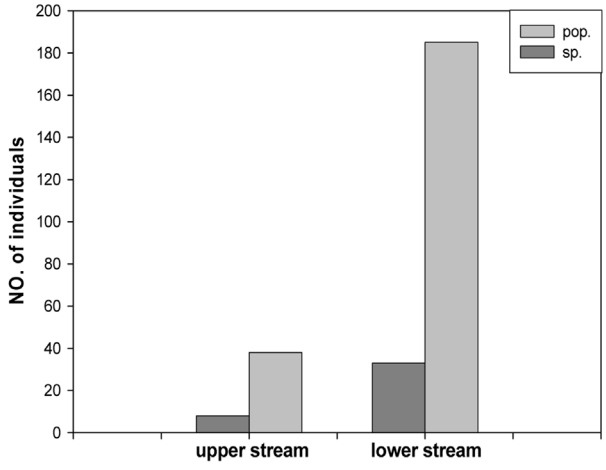


(a) Wet season

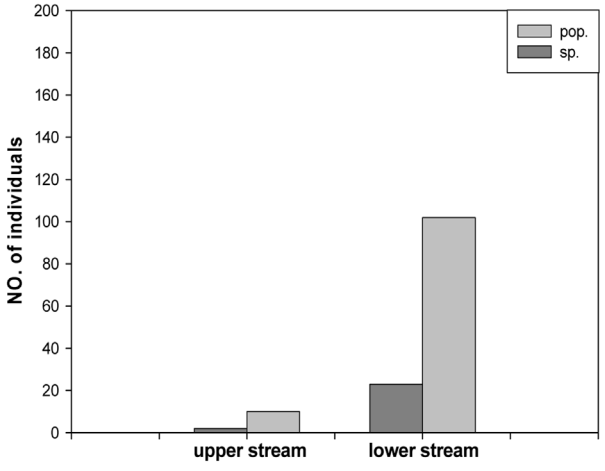


(b) Dry season

Fig. 2. Variation of species and population in the upper stream and lower stream of the weir with a fish-way.



(a) Wet season



(b) Dry season

Fig. 3. Variation of species and population in the upper stream and lower stream of the weir without a fish-way.

Table 5. Dominant index of benthic invertebrates in the upper streams and lower streams of weirs with and without a fisy-way

Site			1st dominant species	2nd dominant species	Dominant index
The weir with a fish-way	upper	1st	*Physa acuta*	*Limnodrilus sp.*	0.48
		2nd	*Limnodrilus gotoi*	*Limnodrilus sp.*	0.60
	lower	1st	Chironomidae sp.3	Chironomidae sp.2	0.47
		2nd	Chironomidae sp.3	Chironomidae sp.2	0.53
The weir without a fish-way	upper	1st	Chironomidae sp.1-red type	*Physa acuta*	0.74
		2nd	Chironomidae sp.2	Chironomidae	1.00
	lower	1st	Chironomidae sp.3	Chironomidae sp.2	0.51
		2nd	Chironomidae sp.3	Chironomidae sp.2	0.53

of number of individuals.

References

1. MOCT, Report on the Development of Nature Friendly Stream Improvement Methods, Ministry of Construction and Transportation, 390-391 (2001).
2. MOE, Development of Domesticated Natural Type Stream Construction Method, Korea Institute of Construction Technology, Ministry of Environment, 49-805 (1999).
3. MOMF, Development of a Standard Model for Standard Design and Construction Work of Fish-Way for the Protection of Aquatic Resources in Streams and a Study on its Management Practice, Ministry of Maritime Affairs and Fisheries, 143-211 (2004).
4. Kim, I. S., and Park, J. M., Korean Freshwater Fishes, Gyohaksa, Korea (2002).

5. Kim, H. S., Illustrated Encyclopedia of Fauna & Flora of Korea, **19**, Animalia (Prawn), Ministry of Education, Korea (1977).
6. Kwon, O. G., Illustrated Encyclopedia of Fauna & Flora of Korea, **32**, Animalia (Mollusca I), Ministry of Education, Korea (1990).
7. Choi, B. R., Illustrated Encyclopedia of Fauna & Flora of Korea, **33**, Animalia (Mollusca II), Ministry of Education, Korea (1992).
8. Min, D. G., Lee, J. S., Kho, D. B., and Jae, J. G., "Illustrated Encyclopedia of Korean Shellfish," Ministry of Education, Korea (2004).
9. NFRDI, Illustrated Encyclopedia of Korean Prawn, National Fisheries Research and Development Institute, Korea (2001).
10. Jung, P. R., Korean Freshwater Shellfish, Yeon Hak Sa, Korea (2003).
11. Angermeier, P. L., and Karr, J. R., "Applying an index of biotic integrity based on stream fish communities: Consideration in sampling and interpretation," *N. Am. J. Fish. Manage.*, **6**, 418-429 (1986).
12. Choi, G. C., and Lee, W. K., Our 100 Freshwater Fishes, Hyun Am Sa (1994).
13. Choi, Y. G., Fishes of Chosun, Science Academy Printing House, Korea (1964).
14. Park, B. K., Kong, D. S., and Ryu, J. K., "Benthic Macroinvertebrates as Biological Water Quality Indicators (I)," *J. Kor. Soc. Environ. Biol.*, **10**, 24-29 (1992).
15. Park, B. K., Kong, D. S., and Ryu, J. K., "Benthic Macroinvertebrates as Biological Water Quality Indicators (II)," *J. Kor. Soc. Environ. Biol.*, **10**, 40-55 (1992).