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Fauna of Macroinvertebrates and Composition of Functional Feeding Groups about the Aquatic Insects to Microhabitats from the Geum River, Korea

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ABSTRACT: The main objective of this study is to find out the fauna of macroinvertebrate and composition of functional feeding groups about the aquatic insects to microhabitat from the Geum River, Korea. This study is based on investigations of the main channel of Geum River, Korea which is upstream of Daecheong Dam, and carried out in the spring and autumn of 2004. Collections from all the sites were 39,532 individuals, 130 species, 54 families, 16 orders, 7 classes, and 4 phyla of macroinvertebrates. Aquatic insects were composed of 90.76% (118 species) and 98.88% (39,088 individuals) of all the identified species. Among the microhabitats, the riffles were collected 26,293 individuals and 92 species, and the runs were collected 12,329 individuals and 89 species. Finally, the pools were collected 494 individuals and 41 species.

In this survey, the proportions of functional feeding groups of aquatic insects were as follows (percent of identified): predators 37.65%, gathering-collectors 23.53%, scrapers 16.47%, filtering-collectors 11.76%, shredders 9.41% and plant-piercers 1.18%. Also, the functional feeding groups were sorted according to microhabitat, in the riffles 30.65% were predators and 29.03% were gathering-collectors; in the run 30.3% were predators, and 28.79% were gathering-collectors; while in the pools 36.67% were predators, and 30.0% were gathering-collectors. In all microhabitats, gathering collectors and predators were predominant, because most of the survey sites are in the midstream. Also, the scrapers were shown more frequently in the riffle (17.74%) and run (18.18 %) than pool (13.13%), the filtering-collectors were shown more frequently in the riffle (14.52%) and the run (12.12%) than the pool (6.67%), and the plant-piercers (3.33%) were found only in pools. But the shredders weren't a difference in the run (10.61%), the pool (10.0%) and the riffle (8.06%), because of the characteristic.

Microhabitats (riffle and run) are much alike in composition ratio of functional feeding groups and pool was very lower out of composition ratio in microhabitats. But riffle is very important than run, because most of individual occur in streams. Besides, pool was diverse to composition ratios, considering the number of individuals.

Key words: Aquatic insects, Functional feeding group, Guem River, Macroinvertebrates, Microhabitat

INTRODUCTION

Stream ecosystems occur within long channels of flowing water. And there exists the many biota such as Plants, Planktons, Macroinvertebrates (Invertebrates and aquatic Insects) and Fishes. Above all, macroinvertebrates are the important component in the aquatic ecosystem and have long been used to evaluate the water quality of streams and aquatic insects are the most diversified and abundant group among the macroinvertebrates in streams (Hilsenhoff 1977). As they are mostly primary and secondary consumers, they are very important members at food chain of the stream ecosystem (Hynes 1970, Ward 1992, Wiliam and Feltmate 1992). Since the various food resources of stream ecosystems are used by groups of animals with different feeding strategies, a classification of the functional feeding groups was proposed and is now often used to describe the ecological function of these animals (Cummins and Klug 1979, Merritt and Cummins 1984, 1996). Changes occurring in aquatic fauna or the proportions of their functional feeding groups due to artificial reasons such as water pollution often indicate damage to the ecosystem which needs attention (Allan 1995, Quinn and Hickey 1990, Vannote et al. 1980).

The Geum River is very big river in South Korea after the Han and Nakdong Rivers. In the past, the Geum River has been known for its clean water; however, the water quality is now getting worse because of expansion of cities due to population increase, rapid industrial development, and the increase of stock feeding facilities in agricultural areas within the river basin. There have not been many biological investigations for organisms inhabiting in Geum River comparing to those on the Han and Nakdong Rivers (Hwang et al.

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1992a, b).

According to the river continuum concept, the composition of the functional feeding groups was changed from upper to downstream with changes in the aquatic environment. Also, community patterns of species different with microhabitats. There is little research on functional feeding groups in Korea except the study of Bae et al. (2003), which analyzed the composition of the functional feeding groups of aquatic insects living in Gapyeong Stream, Gyeonggi-do. Therefore, the objective of this study is to find out the fauna of macroinvertebrates and composition of functional feeding groups about the aquatic insects in the microhabitats for the main stream of the Geum River.

MATERIALS AND METHODS

Study Period and Area

This study was performed in 2004. Sampling was carried out from May 24 to May 28, when aquatic insects most frequently occur in larval forms, and from September 25 to September 30, when the river stabilizes after the disturbances caused by heavy rainfall during summer.

Nine sample sites were selected on the mainstream of the Geum River, upstream of Daecheong Dam. The study areas were sorted into three categories. Upstream sites were at more than 500 m elevation. Midstream sites were at 500 to 150 m, and downstream sites were at less than 150 m elevation (Fig. 1).

Methods

1. Sampling Details

Collections of larva were made using both qualitative and quantitative methods. Qualitative collections were made using a scoop net (15×15 cm^2, mesh 0.5 mm). Quantitative samples were made using a 0.5 mm diameter Surber net (30×30 cm^2, 50×50 cm^2, mesh 0.75 mm); mainly in the main stream. Nine sites where a riffle-run-pool sequence repeated more than twice were selected and quantitative collections were made twice at each site.

The sample collections were delivered to the laboratory and the specimens identified and classified using a stereoscopic microscope (Nikon SMZ-1) referring to the materials of Kim (1973, 1977), Kwon et al. (1993), Song (1995), Lee (1971) and Yoon (1988, 1995). The identified specimens were preserved in 80% ethanol and stored in the Laboratory of Animal Taxonomy and Ecology at Daejeon University, Daejeon, Korea.

2. Microhabitat

Physical factors of microhabitats such as velocity, water depth and substrate etc. were various. Above all, microhabitats of stream were sorted by velocity. Riffle was more than 0.5 m/s, run was from 0.5 to 0.1 m/s and pool was less than 0.1 m/s.

3. FFG (Functional Feeding Group)

Members of an FFG can be assigned according to the shape of their mouthparts, and this morphological character was the criterion for our classification. From this, the functional feeding groups of aquatic insects in Korea were classified into 6 groups at the level of genus. The six functional feeding groups were: 1) Shredders that eat coarse particulate organic materials, 2) Scrapers that eat algae and biofilms attached to stones, 3) Filtering collectors that harvest their food from flowing water, 4) Gathering collectors that scratched their food from substrate, 5) piercers that suck nutrients from aquatic plants and 6) predators that capture and consume living prey. The FFG methods were carried out according to Ro (2002).

RESULTS AND DISCUSSION

Fauna of Benthic Macroinvertebrates

In this investigation of all sites, the benthic macroinvertebrates were collected 39,532 individuals, 130 species, 54 families, 16 orders, 7 classes, and 4 phyla. Above all, aquatic insects were composed of 90.76% (118 species) and 98.88% (39,088 individuals) of all the identified species. Among the microhabitats, the riffles were collected 26,293 individuals and 92 species, and the runs were collected 12,329 individuals and 89 species. Finally, the pools were collected 494 individuals and 41 species (Appendix 1). Also, among the aquatic insects, members of three orders made up 69.49% of all species. Members of Trichoptera made up 26.92%, Ephemeroptera 24.62%, and Diptera 11.54% of all the macroinvertebrate species. Also, those three orders also made up 92.24% of total individuals. Members of Ephemeroptera made up 42.88%, Trichoptera 36.24%, and Diptera 13.12% of all the individuals (Table 1). The number of aquatic insect species obtained more than Hwang and Chang (1992b), considering the number of survey sites.

When the diversity of macroinvertebrates by survey site was tabulated, survey site 7 was greatest with 66 species. The other sites showed a wide range: site 6 (61), site 5 (60), site 2 as (51), sites 1 and 8 (48), site 9 (39) and site 3 with 30 species (Fig. 2). Among the upstream sites, sites 1 and 2 had more species than site 3. Site 4 had fewer species than sites 5 and 6, which were midstream sites. Among the downstream sites, the number of species decreased with distance to the Daecheong Dam. The presence of more macroinvertebrates in midstream areas, rather than in upstream or downstream areas is typical of monsoon regions, including Korea (Ward 1992, Williams and Feltmate 1992).

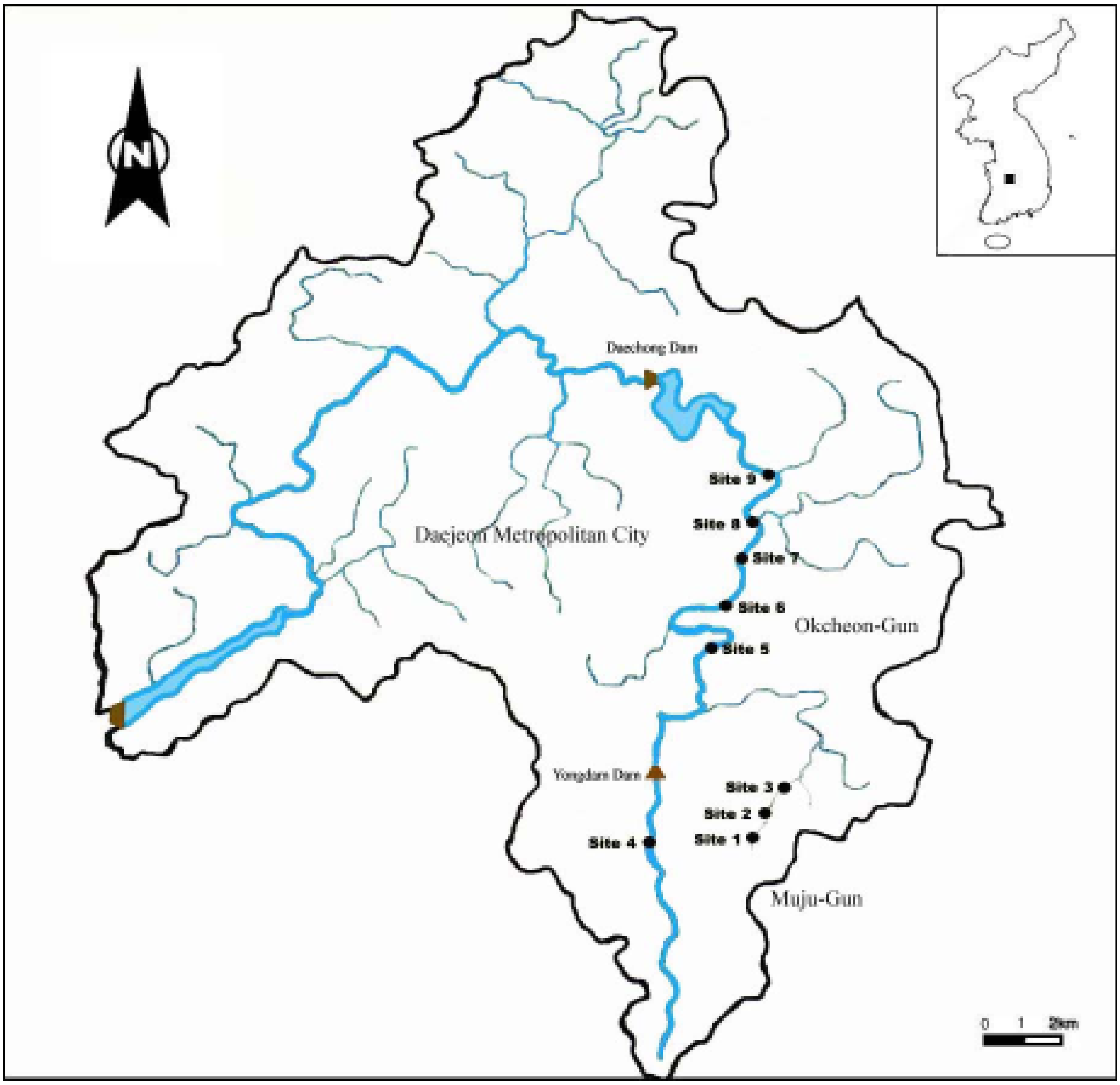

Fig. 1. Location of sampling sites in the Geum River.
Site 1: Upstream near a Buddihist temple of Baengnyeon, waterfall of Guchoen in Mt. Deogyu.
Site 2: Gucheon waterfall in Mt. Deogyu, Sangsam-myeon, Muju-gun.
Site 3: Pahoi, Mujugucheondong, Sangsam-Myeon, Muju-gun.
Site 4: Gamak-ri, Jinan-eup, Jinan-gun.
Site 5: Naedo-ri, Muju-eup, Muju-gun.
Site 6: Daesan-ri, Jewon-myeon, Geumsan-gun.
Site 7: Gugang-gyo, Gugang-ri, Yangsan-myeon, Yeongdong-gun.
Site 8: Simcheon 1 Water Gate, Simsheon-ri, Simcheon-myeon, Yeongdong-gun.
Site 9: Hapgeum-ri, Dongi-myeon, Okchoen-gun.

Composition of Functional Feeding Groups

The composition of the FFGs found at the sites on the Geum River was based upon 65 genera (85 species) which were classified into functional groups by aquatic insects (Appendix 1). When the composition of the functional feeding group was illustrated, predators were the biggest group of 37.65%; gathering collectors were 23.53%, scrapers 16.47%, filtering-collectors 11.76%, shredders 9.41 %, and plant-piercers 1.18%. Gathering collectors and predators occur

Table 1. Composition of species and individuals in the Geum River

Orders	Number of species	%	Number of individuals	%
Tricladida	1	0.77	27	0.07
Mesogastropoda	4	3.08	313	0.79
Basommatophora	2	1.54	9	0.02
Veneroida	1	0.77	36	0.09
Archioligochaeta	1	0.77	43	0.11
Arhynchobdellidae	2	1.54	15	0.04
Amphipoda	1	0.77	1	0.00
Total No. of Non-insecta	12	9.24	444	1.12
Ephemeroptera	32	24.62	16,944	42.88
Odonata	11	8.45	27	0.07
Plecoptera	10	7.69	1,907	4.82
Hemiptera	3	2.31	5	0.01
Megaloptera	1	0.77	21	0.05
Coleoptera	10	7.69	670	1.69
Diptera	15	11.54	5,187	13.12
Trichoptera	35	26.92	14,326	36.24
Lepidoptera	1	0.77	1	0.00
Total No. of Insecta	118	90.76	39,088	98.88
Total No. of Macroinvertebrates	130	100	39,532	100

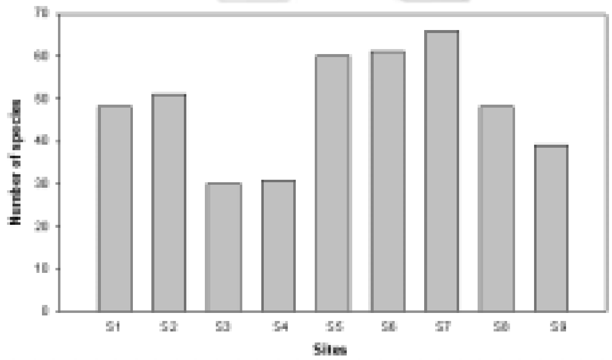

Fig. 2. Composition of macroinvertebrates at sites in the Geum River.

more frequently and show a tendency characteristic in proportion to each other at sites. The reason why predators occupied the highest shares is because the feeding groups belonging to a certain orders show carnivore characteristics (Ro 2002). And more than half of all the groups considered (51.76%) were either collectors or scrapers in the Geum River, because most of the survey sites are in the midstream (Fig. 3).

In the upstream sites, shredders and collectors occur more frequently (Site 1 and 2), and midstream sites, scrapers and collectors are shown more frequently (Site 5~7). Finally in the downstream area scrapers and collectors are getting reduced (Site 8 and 9), as shown in Fig. 4. These conditions are consistent with the general characteristics of streams in Korea (Bae et al. 2003).

The decrease of the scrapers when it gets nearer to Daecheong Dam is because of the characteristics of streams, which are open to the sunlight all year round except the upstream including the source and show high primary productive capacity. Therefore the share of the scrapers is relatively constant. Even so, it is estimated that the relative emergence rates and occupancy rates could be different; the capacity of the river for primary production is influenced by seasonal factors (Allan 1995).

Composition of Functional Feeding Groups by Microhabitats

When the functional feeding groups were sorted according to microhabitat, predators were 30.65% and gathering collectors were 29.03 % of all taxa in the riffles, predators were 30.3% and gathering collectors were 28.79% in the runs, and predators were 36.67% and gathering collectors were 30.0% in the pools. In all microhabitats, gathering collectors and predators were predominant, because most of the survey sites are in the midstream. Also, the scrapers were shown more frequently in the riffle (17.74%) and run (18.18%) than pool (13.13%), the filtering-collectors were shown more frequently in the riffle (14.52%) and the run (12.12%) than the pool (6.67%), and the plant-piercers (3.33%) were found only in pools. But the shredders weren't a difference in the run (10.61%), the pool (10.0%) and the

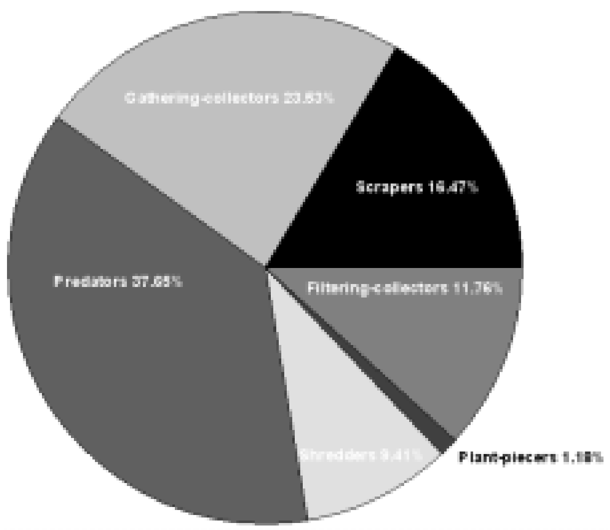

Fig. 3. Composition of functional feeding groups in the Geum River.

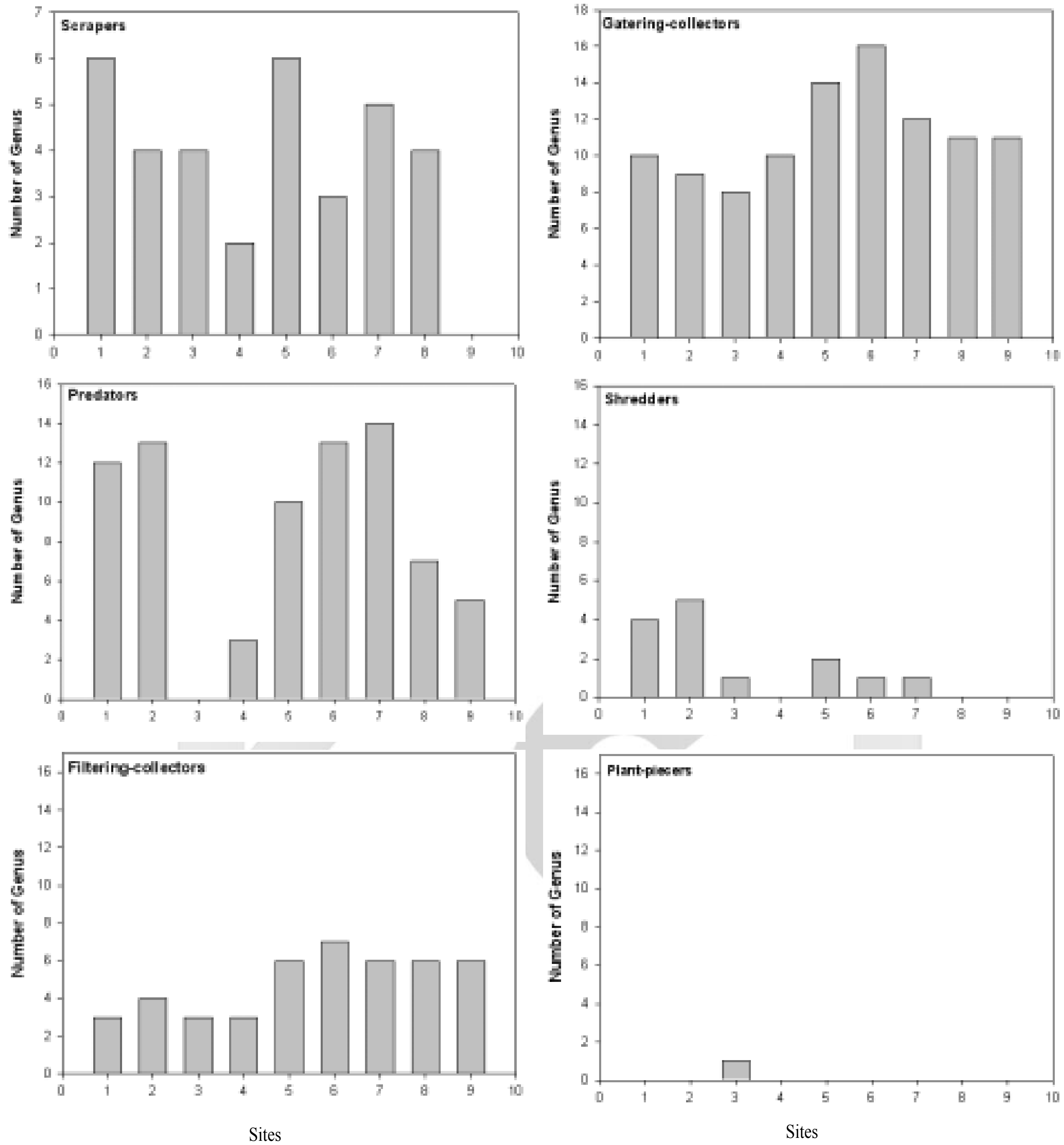

Fig. 4. Characteristics of functional feeding group at sites in the Geum River.

riffle (8.06%), because of the characteristic (Fig. 5). Microhabitats (riffle and run) are much alike in composition ratio of functional feeding groups and pool was very lower out of composition ratio in microhabitats. But riffle is very important than run because most of individual occur in streams. Besides, pool was diverse to composition ratios, considering the number of individuals (Appendix 1).

Ro and Chun (2004) reported that the concept of river continuum provides for a monitoring system based upon the identification of changes, such as contamination and disturbances in stream ecosystems. It is also considered the most important theoretical base from which to diagnose and restore aquatic habitat and by which to identify the characteristics of lotic ecosystems. This information will provide baseline data that can be used in describing the functional standards on the Geum River ecosystems.

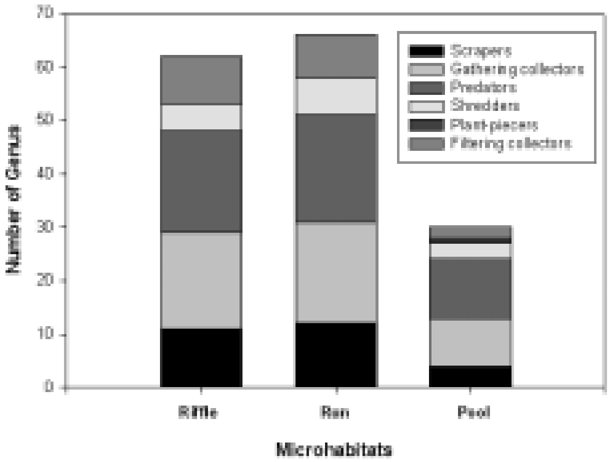

Fig. 5. Composition of functional feeding group about microhabitats in the Geum River.

LITERATURE CITED

Allan JD. 1995. Stream Ecology (Structure and Function of Running Waters). Chapman & Hall, London.

Bae YJ, Won DH, Hoang DH, Jin YH, Hwang JM. 2003. Community composition and functional feeding groups of aquatic inscts according to stream order from the gapyeong creek in Gyeonggi-do, Korea. Korean J Limnol 36: 21-28.

Cummins KW, Klug MJ. 1979. Feeding ecology of stream invertebrates. Ann Rev Ecol Syst 10: 147-172.

Hilsenhoff WL. 1977. Use of arthropods to evaluate water quality of streams. Tech. Bull. No. 100, Dept. of Natural Resources, Madison, Wisconsin, U.S.A.

Hwang SO, Chang YD. 1992a. Studies on the Effects of Environmental factors to Aquatic Insects in the upper stream of Kum River. Korean J Limnol 25: 235-242.

Hwang SO, Chang YD. 1992b. Studies on the Aquatic Insect Community in the upper stream of Kum River. Korean J Limnol 25: 243-252.

Hynes HBN. 1970. The ecology of running waters. University of Toronto Press, Toronto.

Kim HS. 1973. Illustrated Encyclopedia Fauna & Flora of Korea. Vol. 14 Anomura·Brachyura. Ministry of Education, Seoul. (in Korean)

Kim HS. 1977. Illustrated Encyclopedia Fauna & Flora of Korea. Vol. 19 Macrura. Ministry of Education, Seoul. (in Korean)

Kwon OK, Park GM, Lee JS. 1993. Coloured Shells of Korea. Academybook, Seoul. (in Korean)

Lee CE. 1971. Illustrated Encyclopedia of Heteroptera of Korea. Samhwasa, Seoul pp 103-1059. (in Korean)

Merritt RW, Cummins KW. 1984. An introduction to the aquatic insects of North America. 2nd. Ed. Kendall/Hunt Publ. Co., Dubuque, Iowa.

Merritt RW, Cummins KW. 1996. An Introduction to the Aquatic Insects or North America. 3rd. ed. Kendall/Hunt Publ. Co., Dubuque, Iowa.

Quinn JM, Hickey CW. 1990. Characterisation and classification of bentic invertebrate communities in 88 New Zealand rivers in relation to environmental factors. New Zealand Journal of Marine and Freshwater Research 24: 387-409.

Ro TH, Chun DJ. 2004. Functional Feeding Group Categorization of Korean Immature Aquatic Insects and Community Stability Analysis. Korean J Limnol 37: 137-148.

Ro TH. 2002. Categorization and Ecological Importance of Functional Feeding Groups as Essential Units in Lotic Ecosystems. Bulletin of the KACN ser 21: 68-93.

Song KR. 1995. Systematics of the Hirudinea (Annelida) in Korea. Korea Univ. Seoul. (in Korean)

The Entomological Society of Korea and Koeran Society of Applied Entomology, 1994. Check list of Insects from Korea. Konkuk Univ. Press. Seoul. (in Korean)

Vannote RL, Minshall GW, Cummins KW, Sedell JR, Cushing CE. 1980. "The river continuum concept." Can J Fish Aquat Sci 37: 130-137.

Ward JV. 1992. Aquatic insect ecology. John Wiley & Sons, New York.

Willams DD, Feltmate BW. 1992. Aquatic Insects. C·A·B International. Wallingford, UK.

Yoon IB. 1988. Illustrated Encyclopedia Fauna & Flora of Korea Vol. 30 Aquatic Insects. Ministry of Education, Seoul. (in Korean)

Yoon IB. 1995. Aquatic insects of Korea. Jeonghangsa, Seoul. (in Korean)

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Appendix 1. List of species occurred according to microhabitats in the Geum River

Scientific name	S1			S2			S3			S4			S5			S6			S7			S8			S9			FFG
	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	
Planariidae sp.	–	–	–	–	–	–	2	7	–	–	–	–	2	1	–	2	1	–	3	5	–	–	1	–	1	2	–	–
Semisulcospira libertina	–	–	–	–	–	–	–	–	–	–	–	–	1	9	2	–	–	–	37	143	1	17	93	–	–	–	–	–
Semisulcospira gottschei	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2	–	2	–	–	–	–	–
Koreanomelania nodifilla	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Koreoleptoxis globus ovalis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Lymnaea auricularia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Physa acuta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	–	–	–	–	–	–	–
Corbiculla sp.	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	8	1	2	14	5	–	3	1	–	–
Chaetogaster limnaei	–	–	–	–	–	–	3	1	–	–	2	–	5	–	–	15	10	–	1	–	–	–	–	–	1	5	–	–
Whitmania acranulata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	8	–	–	–	–	–	1	–	–	–
Erpobdella lineate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	4	–	–	–	–	–	–
Gammarus sp.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ameletus montanus	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Acentrella gnom	–	–	–	–	–	–	–	–	–	–	5	–	126	12	–	88	100	–	171	81	–	132	60	–	212	17	–	GC
Acentrella sibirica	–	–	–	–	–	–	191	69	–	120	42	–	65	1	–	12	4	–	6	2	–	12	1	–	16	5	–	GC
Baetiella tuberculata	–	–	–	–	–	–	36	44	–	357	33	–	70	–	–	16	–	–	17	2	–	58	3	–	32	2	–	UN
Baetis fuscatus	57	42	18	21	7	19	107	134	95	113	64	–	494	141	5	366	327	38	631	253	–	554	266	22	227	52	12	GC
Baetis ursinus	–	–	–	–	–	–	–	–	–	4	6	–	9	–	–	2	–	–	–	–	–	–	–	–	–	–	–	GC
Baetis KUa	1	5	3	13	18	–	–	–	–	4	–	–	7	4	–	39	11	–	5	1	2	10	1	–	7	2	–	GC
Caenis KUa	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	3	–	1	–	–	1	1	–	10	2	–	GC
Cincticostella levanidovae	–	–	–	2	–	–	46	10	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Drunella aculea	17	28	3	25	35	1	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Drunella lepnevae	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Serratella setigera	6	3	–	2	7	–	–	–	–	15	13	–	1	2	–	1	5	–	1	8	–	2	1	–	–	–	–	GC
Uracanthella rufa	–	–	–	–	–	–	64	71	–	342	122	5	350	287	4	75	68	–	137	60	–	214	59	–	49	10	–	UN
Ephemera orientalis	–	–	–	–	–	–	–	–	–	–	–	–	6	2	–	–	3	–	8	–	1	11	1	–	1	3	2	GC
Ephemera separigata	–	1	–	–	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	GC
Cinygmula grandifolia	6	9	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Ecdyonurus dracon	1	1	–	–	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Ecdyonurus kibunensis	12	51	47	53	272	13	2	3	2	4	4	–	48	76	–	8	82	–	13	74	–	7	65	–	13	28	–	UN
Ecdyonurus levis	–	–	–	–	–	–	–	–	–	–	–	–	1	16	–	–	17	–	–	2	–	–	4	–	2	5	–	UN
Epeorus curvatulus	5	2	–	13	1	–	26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	GC
Epeorus pellucidus	1	–	–	3	6	–	42	35	1	119	35	–	350	99	–	122	35	–	74	25	–	82	32	–	18	3	–	GC
Heptagenia kihada	–	–	2	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Iron aesculus	230	152	–	240	1	–	26	25	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	GC
Cinygmula sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	SC
Rhithrogena sp.	–	–	–	–	–	–	–	–	–	–	–	–	23	1	–	63	2	–	23	24	–	26	7	–	6	1	–	GC
Heptageniidae sp.	11	–	–	–	–	–	–	–	–	3	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Isonychia japonica	–	–	–	–	–	–	–	–	–	3	1	–	185	5	–	151	33	–	104	50	–	39	19	–	89	2	–	GC

Appendix 1. Continued

Scientific name	S1			S2			S3			S4			S5			S6			S7			S8			S9			FFG
	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	
Choroterpes (Euthraulus) altioculus	–	–	–	–	–	–	3	1	–	130	158	5	716	316	–	324	308	–	196	444	–	271	474	–	158	191	–	GC
Paraleptophlebia chocolate	35	52	34	62	173	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	GC
Ephoron sshigae	–	–	–	–	–	–	–	–	–	–	–	–	31	17	–	–	1	–	–	–	–	–	–	–	1	4	–	GC
Rhoenanthus (Potamanthindus) coreanus	–	–	–	–	–	–	–	–	–	80	75	–	11	17	–	17	35	–	74	71	1	44	44	–	7	13	–	UN
Siphlonurus chankae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	GC
Cercion calamorum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	4	P
Davidius lunatus	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Onychogomphus ringens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	7	1	–	1	–	–	P
Ophiogomphus obscura	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	P
Stylurus annulata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	P
Gomphus postacularis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	P
Trigomphus citimus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	P
Trigomphus melampus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	P
Gomphidae sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	1	–	–	2	UN
Orthetrum albistylum speciosum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	P
Orthetrum triangulare melania	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	P
Scopura laminate	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Nemoura KUax	125	135	–	213	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Amphinemura KUa	114	48	–	159	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Nemoura sp.	49	2	3	557	164	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Yoraperla KUa	64	9	–	25	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Megarcys ochracea	1	–	–	5	2	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	P
Kamimuria KUa	8	–	1	13	–	–	–	–	–	–	–	–	5	3	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Neoperla coreensis	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	5	7	–	–	–	–	–	1	–	–	–	–	P
Paragnetina flavotincta	27	10	–	11	–	–	–	–	–	–	–	–	2	–	–	4	5	–	5	3	–	1	4	–	2	–	–	P
Sweltsa nikkoensis	6	6	14	10	26	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Hesperocorixa kolthoffi	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	PP
Aquaris paludum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	5	P
Metrocoris histrio	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	P
Protohermes grandis	–	–	–	–	–	–	–	–	–	–	–	–	5	1	–	1	–	–	3	2	–	6	3	–	–	–	–	P
Neonectes natrix	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	P
Agabus browni	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	3	P
Ilybius sp.	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P

KCI

Appendix 1. Continued

Scientific name	S1			S2			S3			S4			S5			S6			S7			S8			S9			FFG
	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	
Dytiscidae sp.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Noterus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	P
Helochares (*Hydrobaticus*) *striatus*	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	–	–	4	1	1	–	–	–	–	–	–	GC
Stenelmis vulgaris	–	–	–	–	–	–	–	–	–	1	1	–	22	1	–	28	1	–	7	2	–	27	–	–	–	–	–	SC
Elmidae sp.	8	11	–	2	3	–	1	1	–	1	2	–	67	8	–	56	8	–	120	28	–	84	19	–	4	2	–	UN
Psephenoides KUa	–	–	–	–	–	–	–	–	–	–	–	–	1	2	–	2	–	–	5	5	–	4	6	–	–	–	–	SC
Mataeopsephus KUa	–	–	–	–	–	–	–	–	–	–	–	–	7	3	–	3	8	–	33	31	1	15	10	–	–	–	–	SC
Tipula KUp	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Hexatoma KUa	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Antocha KUa	4	5	–	–	3	–	123	121	–	204	207	–	16	13	–	27	40	–	21	30	–	14	24	–	16	11	–	GC
Tipula sp.	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Simulium (*Gomphostilbia*) KUa	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	FC
Simulium sp.	2	4	–	6	3	–	31	–	–	24	–	–	11	–	–	6	–	–	–	–	–	2	–	–	2	–	–	FC
Ceratopogonidae sp.	–	–	–	–	–	–	–	–	–	2	3	–	7	–	–	1	–	–	–	–	–	–	–	–	1	1	–	UN
Chironomus sp. 1	23	32	–	33	140	1	31	31	16	27	49	2	165	34	–	314	256	2	169	82	–	225	154	–	106	32	–	GC
Chironomus sp. 2	13	8	–	4	50	–	65	48	–	123	52	–	156	14	–	178	76	–	91	62	–	134	59	–	329	136	–	GC
Chironomus sp. 3	–	4	–	5	8	–	42	15	–	83	75	–	22	3	–	46	14	–	7	38	–	33	12	–	22	5	–	GC
Chironomus sp. 4	–	–	–	1	–	–	11	10	6	20	26	–	38	12	–	6	5	–	7	10	–	4	1	1	14	14	1	GC
Chironomus sp. 5	–	–	–	–	2	–	–	–	–	–	–	–	8	–	–	4	–	–	–	5	–	1	1	–	–	–	–	GC
Chironomus sp. 6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	GC
Empididae sp.	14	7	–	6	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Tabanidae sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	UN
Dolophilodes KUa	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	FC
Arctopsyche ladogensis	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	–	FC
Macronema radiatum	–	–	–	–	–	–	–	–	–	–	–	–	54	13	–	45	16	–	426	125	–	428	93	–	16	–	–	FC
Hydropsyche kozhantschikovi	–	–	–	–	1	–	149	92	–	1590	694	2	684	116	–	981	182	–	289	170	–	1044	208	–	255	61	–	FC
Hydropsyche valvata	–	–	–	–	–	–	1	2	–	779	134	–	197	20	–	567	10	–	46	22	–	1303	42	–	28	6	–	FC
Hydropsyche orientalis	1	–	–	4	2	–	62	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	FC
Hydropsyche KD	–	–	–	–	–	–	–	–	–	–	–	–	64	12	–	53	23	–	53	37	–	50	27	–	340	53	–	FC
Cheumatopsyche brevilineata	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	FC
Cheumatopsyche KUb	–	–	–	1	–	–	–	–	–	17	7	2	54	51	–	90	80	–	188	97	–	270	172	–	323	110	–	FC
Hydropsyche sp.	–	–	–	1	–	–	6	66	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	FC
Apsilochorema KUa	–	2	–	3	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P

KCI

Appendix 1. Continued

Scientific name	S1			S2			S3			S4			S5			S6			S7			S8			S9			FFG
	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	Ri	Ru	Po	
Rhyacophila articulate	16	3	–	7	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Rhyacophila KUa	–	1	–		1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Rhyacophila retracta	6	3	–	14	10	–	–	–	–	–	–	–	14	1	–	14	–	–	1	1	–	–	–	–	–	–	–	P
Rhyacophila clemens	3	10	–	10	8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Rhyacophila shikotsuensis	16	6	–	2	7	–	–	–	–	30	24	–	2	7	–	29	23	–	3	46	–	31	132	–	2	5	–	P
Rhyacophila impar	–	–	–	–	–	–	–	–	–	3	1	–	3	4	–	4	2	–	4	2	–	4	2	–	–	–	–	P
Rhyacophila nigrocephala	1	–	–	1	–	–	–	–	–	–	–	–	35	11	–	3	–	–	2	1	–	–	–	–	–	–	–	P
Rhyacophila brevicephala	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	–	–	–	–	–	–	–	–	P
Rhyacophila kuramana	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	P
Rhyacophila sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	4	–	–	–	–	–	–	–	–	P
Glossosoma KUa	–	–	–	2	–	–	181	114	–	4	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Neophylax ussuriensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	1	–	–	–	–	–	SC
Apatania KUa	24	33	–	–	–	–	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Apatania KUb	–	–	–	–	–	–	5	9	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	SC
Hydatophylax nigrovittatus	3	1	17	2	2	19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Apatania sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	1	1	–	2	13	–	–	–	–	–	4	–	SC
Limnephilidae sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	UN
Goerodes KUb	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Goerodes sp.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SH
Gumaga KUa	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	3	1	–	1	11	–	–	–	–	–	–	–	SH
Psilotreta kisoensis	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Molanna moesta	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	SC
Ceraclea KUa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	GC
Ceraclea sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	GC
Lepidoptera sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	UN
Total : 39,532 individuals, 130 species, 54 families, 16 orders, 7 classes, and 4 phyla																												

Ri, riffle of microhabitats; Ru, run of microhabitats; Po, pool of microhabitats; SC, Scarper; FC, Filtering-Collector; GC, Gathering-Collector; P, Predator; PP, Plant-piercer; SH, Shredder; UN, Unknown