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Distribution of Meiobenthic Arthropod Communities in the Hyporheic Zone of Nakdonggang

Chi-Woo Lee and Jong-Geun Park*

Department of Science Education Graduate School, Daegu University, Gyeongbuk 38453, Korea

**Correspondent: gogun@daegu.ac.kr*

The hyporheic zone is an ecologically important area for investigating habitat biodiversity. However, only few studies have been conducted on this aspect in Korea. This study aimed to investigate the distribution of arthropod communities in the hyporheic zone of Nakdonggang River between 2012 and 2013. The meiobenthic arthropod communities found in the hyporheic zone were identified using a stereomicroscope and classified into 9 taxanomic groups. The abundance of arthropod communities was higher in the hyporheic zones of streams having well-formed sandbanks and gravelly areas. The arthropod communities found along the Nakdonggang River differed depending on the conditions of levees and the regions of the river from where they were collected. The frequency of species of the order Harpacticoida was high in the Nakdonggang main stream and western downstream region. The abundance of species belonging to Cyclopidae was high in the upstream region, midstream region, and eastern downstream region of the river. The frequency of species of the order Bathynellacea was high in the riverside parks or cement levees, but that of species belonging to Cyclopidae was high in the natural levees and gabion levees. Our findings suggested that arthropod communities preferred natural levees.

Keywords: arthropod, hyporheic zone, meiobenthos, Nakdonggang

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Introduction

The hyporheic zone refers to a region along the streambed where there is an interaction between the surface stream water and ground water (Kim and Kang 2009). The hyporheic zone was initially defined as a discrete region by Orghidan (1959), and its ecological significance was recognized by Schwoerbel (1961a). Since there is continuous interaction between surface water and ground water in a hyporheic zone, contamination or development of any one water body can affect the other, which, in turn, influences the ecosystem. Studies of the hyporheic zone are critical for the management of water resources, and it cannot be considered as an independent water source (Kim *et al*. 2008). Various biogeochemical processes occur in the hyporheic zone because of its unique spatial characteristics (Brunke and Gonser 1997; Storey *et al*. 1999; Chapelle 2001; Hancock 2002; Appelo and Postma 2005; Hyun *et al*. 2011). The hyporheic zone is a habitat of various living organisms and is considered to be an ecologically important zone (Kim *et al*. 2012). It causes substantial changes to biodiversity and population dynamics and becomes a shelter for organisms during floods (NWMC 2004). Furthermore, since fluctuations in temperature occur less frequently in the hyporheic zone than in the surface water, it provides an optimal environment for organisms that are sensitive to temperature changes (Schwoerbel 1961b; Evans and Petts 1997). Further, the hyporheic zone has unique ecological and environmental characteristics (Hyun and Kim 2013).

The concept of sustainable development that can satisfy the needs of both present and future generations has been widely used in various fields since "our common future" was published by the World Commission for Environment and Development (WCED) of the UN in 1987. Since then, interest in improving the sustainability of water resources and environment has increased worldwide (Ewen and Parkin 1996; Bronstert *et al*. 2002; Asselman *et al*. 2003; Chang 2003; Legesse *et al*. 2003; Lee and Chung 2007) and efforts are being made to maintain better quality of life (Kim 2013). Sustainable use of water requires the regulation of the interface of surface and ground water in an aquifer (Hyun and Kim 2013). However, such studies have mainly focused on quantitatively securing water resources and overlooked the ecological aspects, which are important for sustainable development (Hyun and Kim 2013).

Although many international studies have investigated the diverse organisms inhabiting the hyporheic zone (Barlocher and Murdoch 1989; Robertson *et al*. 2000; Dumas *et al*. 2001), local studies in this regard are insufficient except for those conducted by the National Institute of Biological Resources, Korea, and by Hyun and Kim (2013).

Meiobenthic arthropod communities are mostly found in sediments. Because they require a stable environment for inhabitation and have a short generation time, they are sensitive to environmental changes, unlike macrozoobenthos (Sandulli and De Nicola-Giudici 1990). In Europe, zoobenthos are used to derive the index of stream by determining their level of response to environmental disturbances (Borja *et al*. 2000). Furthermore, biocenosis inhabiting streams are known to affect the ecosystem (Yoon *et al*. 1992).

This study aimed to investigate the distribution and population of meiobenthic arthropod communities inhabiting the Nakdonggang hyporheic zone. Kim *et al*. (2009) stressed on the importance of waterside soil; hence, we determined the biomass and population distribution of these communities according to the form of levees present at the investigation sites. Our findings might increase the awareness regarding hyporheic zones that harbor various species and the importance of their management and provide useful data for conducting local studies on this aspect. Moreover, our data might be used for establishing environmental policies that advocate ecosystem preservation, such as stream maintenance project that focuses on ecologically sustainable development.

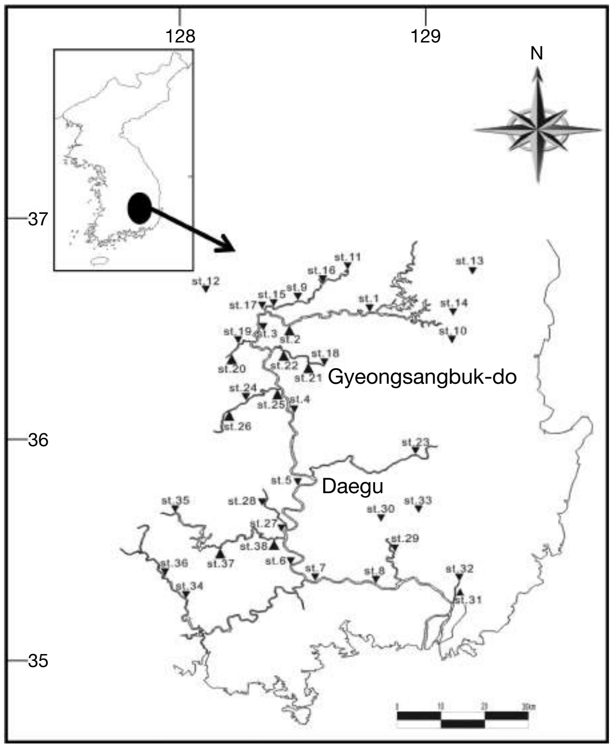

Fig. 1. Map showing the sampling sites at Nakdonggang.

Materials and Methods

1. Investigation period and study site

The investigation was conducted between March 2012 and October 2013 at 38 sites around Nakdonggang (Fig. 1); the geographic information of each site is shown in Table 1. For the survey, Nakdonggang River was divided into main stream and upstream, midstream, western downstream, and eastern downstream regions. This stratification was necessary to investigate the communities of meiobenthic arthropod inhabiting the hyporheic zone because Kim *et al*. (2011) showed that the water quality and characteristics at Nakdonggang vary across different regions due to the effluent water from the upstream dam, which contaminates the midstream regions such as Gumi and Daegu, and the influence and stagnation caused by Namgang dam and estuary banks in the downstream region. The river basins in Nakdonggang and names of each region are shown in Table 2. Specimens were collected from 7 rivers and streams - Banbyeoncheon, Yongjeoncheon, Naeseongcheon, Weechon, Byeongseongcheon, Ssanggyecheon, and Yeonggang - from the upstream region of Nakdonggang; 3 rivers and streams - Gamcheon, Hoecheon, and Geumhogang - in the midstream region; 2 rivers - Hwanggang and Namgang - in the western downstream region; and 3 rivers and streams - Cheongdocheon, Yangsancheon, and Miryanggang - from the eastern downstream region.

2. Study methods

Among the hyporheic zones, sites with well-formed sandbanks and gravelly areas were selected, and water was sampled using two methods. First, a 1×1 m pit was dug at the selected collection sites 5-10 m away from the stream by using a shovel, and the water flowing out from the ground was collected. Second, a 1-m sampling core was mounted in the same location by using a hammer, and water was collected using a manual pump. The sampling core was a device for sampling water from the hyporheic zone; the dimensions of this device are shown

Table 1. Administrative region, latitude, longitude, and altitude of study sites.

	Site	Latitude (N)	Longitude (E)	Altitude (m)
st.1	Gb Andong-si Ogya-dong	36°33′27″	128°43′32″	91
st.2	Gb Uiseong-gun Dain-myeon Yonggok-ri	36°31′50″	128°21′54″	59
st.3	Gb Uiseong-gun Danmil-myeon Nakjeong-ri	36°21′22″	128°18′3″	40
st.4	Gb Gumi-si Haepyeong-myeon Haepyeong-ri	36°11′43″	128°22′1″	30
st.5	Gb Goryeong-gun Dasan-myeon Hochon-ri	35°48′49″	128°28′30″	13
st.6	Gn Hapcheon-gun Cheongdeok-myeon Angjin-ri	35°32′24″	128°21′10″	4
st.7	Gn Changnyeong-gun Namji-eup Namji-ri	35°23′7″	128°27′5″	6
st.8	Gn Miryang-si Hanam-eup Susan-ri	35°22′4″	128°43′12″	6
st.9	Gb Yecheon-gun Yecheon-eup Saengcheon-ri	36°40′37″	128°27′35″	96
st.10	Gb Cheongsong-gun Pacheon-myeon Jungpyeong-ri	36°28′13″	129°2′2″	177
st.11	Gb Yeongju-si Munjeong-dong	36°47′56″	128°37′1″	135
st.12	Gb Mungyeong-si Gaeun-eup Hagoe-ri	36°39′36″	128°3′23″	153
st.13	Gb Yeongyang-gun Irwol-myeon Gokgang-ri	36°40′54″	129°7′15″	259
st.14	Gb Cheongsong-gun Pacheon-myeon Hwangmok-ri	36°28′16″	129°1′56″	177
st.15	Gb Yecheon-gun Yonggung-myeon Daeeun-ri	36°34′55″	128°19′51″	62
st.16	Gb Yeongju-si Munsu-myeon Sudo-ri	36°44′0″	128°37′14″	114
st.17	Gb Yecheon-gun Yonggung-myeon Hyangseok-ri	36°34′59″	128°17′27″	60
st.18	Gb Gunwi-gun Uiheung-myeon Eumnae-ri	36°10′32″	128°42′59″	120
st.19	Gb Sangju-si Inpyeong-dong	36°23′54″	128°10′12″	55
st.20	Gb Sangju-si Cheongni-myeon Susang-ri	36°20′36″	128°7′29″	69
st.21	Gb Uiseong-gun Geumseong-myeon Sanun-ri	36°15′4″	128°41′1″	92
st.22	Gb Uiseong-gun Bongyang-myeon Gusan-ri	36°18′37″	128°36′9″	63
st.23	Gb Yeongcheon-si Geumho-eup Namseong-ri	35°54′33″	128°51′24″	59
st.24	Gb Gimcheon-si Apo-eup Ui-ri	36°11′6″	128°13′26″	63
st.25	Gb Gumi-si Goa-eup Hwangsan-ri	36°14′13″	128°17′26″	50
st.26	Gb Gimcheon-si Apo-eup Daesin-ri	36°9′45″	128°11′34″	53
st.27	Gn Hapcheon-gun Deokgok-myeon Hak-ri	35°40′49″	128°20′13″	16
st.28	Gb Goryeong-gun Ugok-myeon Yajeong-ri	35°41′20″	128°19′38″	26
st.29	Gn Miryang-si Sangdong-myeon Oksan-ri	35°33′56″	128°45′43″	43
st.30	Gb Cheongdo-gun Cheongdo-eup Won-ri	35°36′39″	128°46′1″	55
st.31	Gn Yangsan-si Sangbuk-myeon Soseok-ri	35°24′11″	129°3′24″	29
st.32	Gn Yangsan-si Habuk-myeon Sunji-ri	35°29′28″	129°5′3″	123
st.33	Gb Cheongdo-gun Maejeon-myeon Geumgok-ri	35°40′28″	128°52′3″	80
st.34	Gn Sancheong-gun Danseong-myeon Changchon-ri	35°15′54″	127°53′43″	77
st.35	Gn Geochang-gun Gabuk-myeon Yongsan-ri	35°45′6″	127°59′5″	337
st.36	Gn Sancheong-gun Saengcho-myeon Eoseo-ri	35°28′59″	127°48′29″	126
st.37	Gn Hapcheon-gun Yongju-myeon Yongji-ri	35°32′45″	128°6′33″	39
st.38	Gn Hapcheon-gun Cheongdeok-myeon Gahyeon-ri	35°34′20″	128°20′30″	8

Gb = Gyeongsangbuk-do, Gn = Gyeongsangnam-do

in Figure 2. Next, 30 L of sampled water was concentrated per tube by installing a 50-mL capped tube (SPL Lifesciences, Korea) having a 50-μm net.

The pH, electrical conductivity, and temperature of the collected samples were measured using a multi-purpose water quality analyzer (Thermo 5 ORION Star, Thermo Electron Coporation, USA). Then it was transferred to the laboratory, substituted with 70% ethanol, and kept at 4°C before microscopic examination. For microscopic examination and classification of meiobenthic arthropod fauna in the concentrated specimen, stereomicroscope (Nikon SMZ 800, Japan) was used with 10-63× magnification. Classified organisms were stored in 70% ethanol for each group.

The classification criteria by Thorp and Covich (2009) were followed.

Results and Discussion

1. Distribution of meiobenthic arthropod communities in the hyporheic zone of Nakdonggang

Meiobenthic arthropod communities were found at all the 38 sites of the hyporheic zone in Nakdonggang. The identified organisms belonged to Arthropoda and were classified into 9 taxonomic groups (Table 3). Among them, Ostracoda was classified up to the class level; Harpacticoida, Amphipoda, Isopoda, and Acari, up to the order level; Parabathynellidae, Bathynellidae, and Cyclopidae, up to the family level; and *Parastenocaris*, up to the genus level. The composition rates of these organisms are shown in Figure 3.

Table 2. Composition of Nakdonggang mainstream and the 4 regions.

Region	Riverbasin	Location
Nakdonggang mainstream	1. mainstream I	Andong
	2. mainstream II	Gumi
	3. mainstream III	Goa, Seongju, Waegwan
	4. mainstream IV	Dalseong
	5. mainstream V	Changnyeong, Namji
	6. mainstream VI	Bugok, Namji
Nakdonggang upstream	1. Imhadam	Yeongyang, Cheongsong
	2. Naeseongcheon	Yeongju, Bonghwa, Yecheon
	3. Yeonggang	Mungyeong, Gaeun
	4. Byeongseongcheon	Sangju
	5. Ssanggyecheon	Uiseong
	6. Wicheon	Gunwi
Nakdonggang midstream	1. Gamcheon	Gimcheon
	2. Geumhogang	Yeongcheon, Daegu
	3. Hoecheon	Goryeong
Nakdonggang downstream western	1. Hwanggang	Geochang, Hapcheon
	2. Namgang	Sancheong
Nakdonggang downstream eastern	1. Cheongdocheon	Cheongdo
	2. Miryanggang	Miryang
	3. Yangsancheon	Yangsan

2. Biotic communities of the Nakdonggang mainstream

In all, 75 organisms were found in Nakdonggang mainstream (sites 1, 2, 3, 4, 5, 6, 7, and 8). Their composition rates are shown in Figure 4. In the Nakdonggang mainstream, Cyclopidae were low in number, and its total biomass was also lower than that at the other collection sites. You (2013) showed that the construction of stank had greater influence on living organisms than by the physical quality of water; the stank at Nakdonggang has likely affected the organisms inhabiting the hyporheic zone.

3. Biocenosis in each region of Nakdonggang

1) Organisms in the Nakdonggang upstream region

In all, 4,286 organisms were collected from the Nakdonggang upstream region. Their composition rates are shown in Figure 5. Cyclopidae showed the highest composition rate at 42.3%. The second and third highest were two families belonging to Bathynellacea (combined rate, 49.0%). The composition rate of Harpacticoida was 6.6%, and that of Isopoda, Amphipoda, Acari, and Ostracoda was less than 2.0%.

The organisms found in the 7 streams of the upstream region of Nakdonggang are shown in Table 4. The abun-

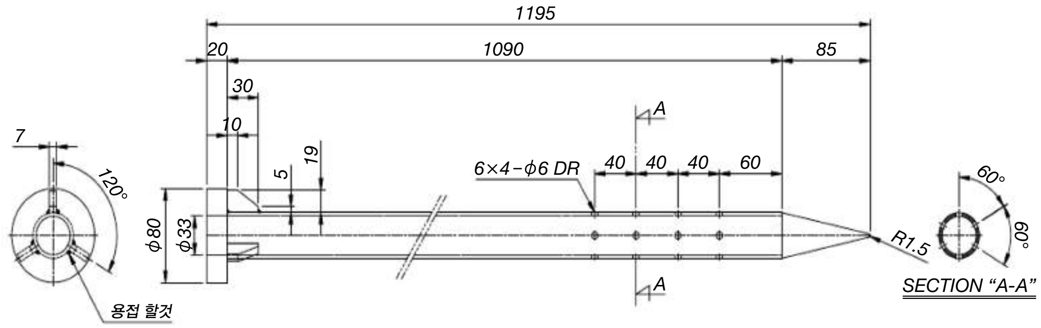

Fig. 2. The detailed dimensions of the sampling core used in this study.

Table 3. Taxonomic groups at the 38 hyporheic zone sites.

Kingdom	Phylum	Class	Order	Family	Genus
Animalia	Arthropoda	Malacostraca	Bathynellacea	Bathynellidae	
			Bathynellacea	Parabathynellidae	
			Isopoda		
			Amphipoda		
		Maxillopoda	Cyclopoida	Cyclopidae	
			Harpacticoida		
			Harpacticoida	Parastenocaridae	Parastenocaris
		Archnida	Acari		
		Ostracoda			

dance of Cyclopidae was the highest or the second highest at all the 7 streams. Although NIBR (2010) showed Weechon and Byeongseongcheon were the most frequent species in Nakdonggang, Weechon (site 18), Byeongseongcheon (sites 19 and 20), and Ssanggyecheon (sites 21 and 22) were found in the least frequency in the upstream region in this study. This could be attributed to the fact that these 3 streams have undergone or are currently undergoing construction from 2011. Naeseongcheon (sites 9, 11, 15, 16, and 17) showed the presence of all 9 taxonomic groups and had the highest number of organisms among all regions. Most parts of the stream in Naeseongcheon consist of sand, and there are no artificial structures (Park *et al*. 2005). Furthermore, no constructions were ongoing around the stream during the investigation. Thus, the Naeseongcheon hyporheic zone might have become a suitable habitat for living organisms.

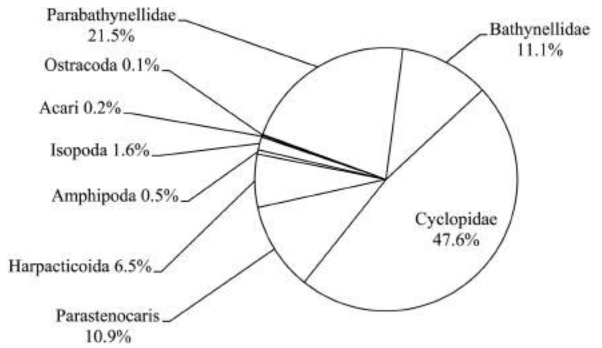

Fig. 3. Composition rate of meiobenthic faunal groups found at the 38 sites in the hyporheic zone of Nakdonggang.

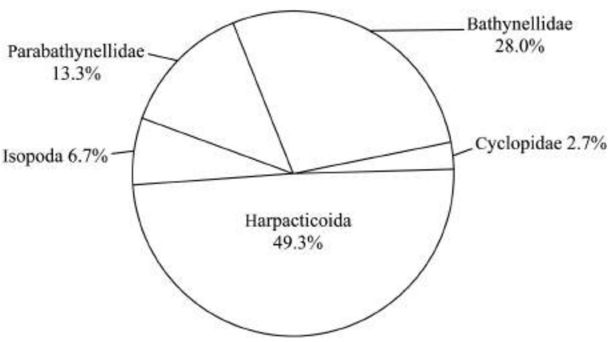

Fig. 4. Composition of meiobenthic faunal groups in the hyporheic zone of Nakdonggang main stream.

2) Organisms found in the Nakdonggang midstream region

In all, 1,422 organisms were found in the midstream region of Nakdonggang. Their composition rates are shown in Figure 5. Cyclopidae showed the highest composition rate (80.0%), followed by Harpacticoida (11.6 %), Bathynellacea (5.1%), and Isopoda (2.7%). The following organisms were detected at a rate of less than 1.0%: Amphipoda (0.2%), Acari (0.2%), and Ostracoda (0.1%).

The organisms found in the 3 streams in the midstream region are shown in Table 4. Cyclopidae showed the highest appearance in Gamcheon (sites 24, 25, and 26) and Hoecheon (sites 27 and 28). Gamcheon (sites 24, 25, and 26) showed the presence of all 9 taxonomic groups and was considered to be a desirable habitat for organisms. However, Geumhogang (site 23) did not show any appearance of arthropod communities. This could be because the average index of biological integrity (IBI) of Geumhogang obtained for fish was either “poor” or “very poor” (Yeom *et al*. 2000), although the habitat environment and food sources are different between fish and meiobenthic arthropod communities. This suggests the importance of controlling the interface of surface water and ground water as revealed by Kim *et al*. (2008).

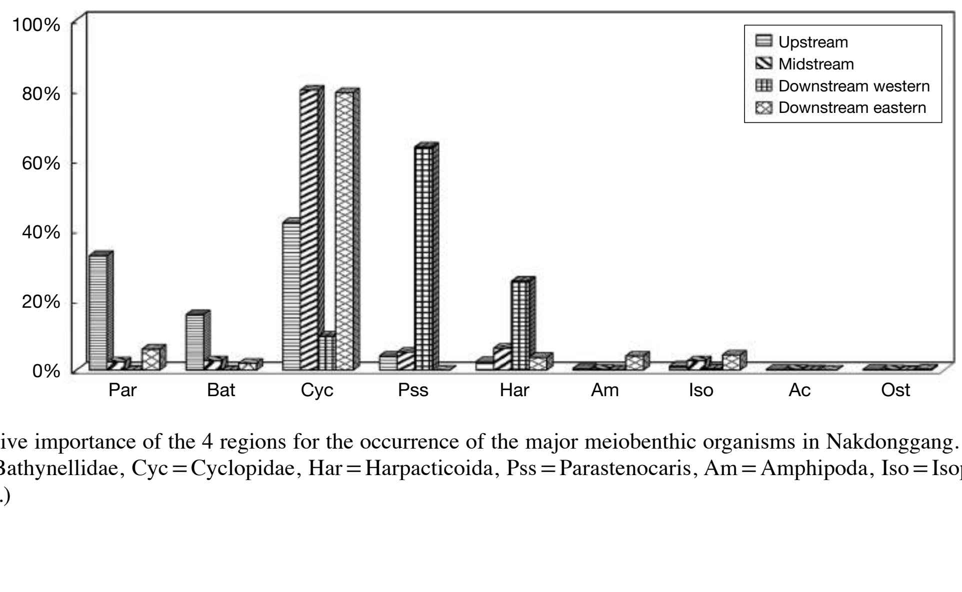

Fig. 5. The relative importance of the 4 regions for the occurrence of the major meiobenthic organisms in Nakdonggang. (Par = Parabathynellidae, Bat = Bathynellidae, Cyc = Cyclopidae, Har = Harpacticoida, Pss = Parastenocaris, Am = Amphipoda, Iso = Isopoda, Ac = Acari, Ost = Ostracoda.)

Table 4. Biomass and composition rate (%) at the hyporheic zone of Nakdonggang.

Four regions at Nakdonggang	Riverbasin	Number	Par	Bat	Cyc	Har	Pss	Am	Iso	Ac	Ost
Nakdonggang upstream region	Naeseongcheon	3715	38.0	17.9	37.3	2.5	3.3	0.1	0.7	0.1	0.2
	Yeonggang	18	5.6	27.8	27.8	16.7	5.6	5.6	5.6	–	5.6
	Banbyeoncheon	269	–	6.3	67.7	4.1	19.0	1.1	1.1	0.7	–
	Yongjeoncheon	70	–	7.1	61.4	–	–	12.9	15.7	2.9	–
	Ssanggyecheon	203	–	0.5	93.6	–	–	2.5	3.4	–	–
	Byeongseongcheon	5	–	–	40.0	20.0	–	–	40.0	–	–
	Wicheon	6	–	–	66.7	–	–	16.7	16.7	–	–
Nakdonggang midstream region	Gamcheon	691	4.6	1.4	69.3	12.2	10.7	0.1	1.0	0.4	0.1
	Hoecheon	731	0.3	4.0	90.2	1.0		0.3	4.4	–	–
	Geumhogang	–	–	–	–	–	–	–	–	–	–
Nakdonggang downstream western region	Hwanggang	761	–	–	10.0	24.4	65.2	0.1	0.3	–	–
	Namgang	16	–	–	6.3	81.3	–	–	6.3	6.3	–
Nakdonggang downstream eastern region	Cheongdocheon	268	6.3	1.9	80.6	1.9	–	4.5	4.5	–	0.4
	Yangsancheon	27	3.7	3.7	66.7	22.2	–	–	3.7	–	–
	Miryanggang	–	–	–	–	–	–	–	–	–	–

Par = Parabathynellidae, Bat = Bathynellidae, Cyc = Cyclopidae, Har = Harpacticoida, Pss = Parastenocaris, Am = Amphipoda, Iso = Isopoda, Ac = Acari, Ost = Ostracoda.

3) Organisms found in the western downstream region of Nakdonggang

In all, 777 organisms were found in the western downstream region of Nakdonggang. Their composition rates are shown in Figure 5. Harpacticoida showed the highest composition rate (89.4%), followed by Cyclopidae with (9.9%), Isopoda (0.4%), and Acari and Amphipoda (0.1%). No species of Bathynellacea were found in this region.

The organisms found in the 2 streams of this region are shown in Table 4. Hwanggang (sites 35, 37, and 38) and Namgang (sites 34 and 36) showed the highest composition rates of Harpacticoida and Parastenocaris, unlike the other regions that had the highest composition rate of Cyclopidae, which mostly inhabit sandbanks. The species richness and aggregation index of benthic macroinvertebrates were largely affected by the habitat characteristics; dams are known to adversely affect species aggregation by simplifying habitats (Kil *et al.* 2010). The difference in the composition of meiobenthic arthropod communities at Hwanggang and Namgang could be attributed to the presence of dams in the upstream region of these sites.

4) Organisms found in the eastern downstream region of Nakdonggang

In all, 295 organisms were found in the eastern downstream region of Nakdonggang; their composition rates are shown in Figure 5. Cyclopidae showed the highest composition rate (79.3%), followed by Bathynellacea (8.1%), Isopoda (4.4%), Amphipoda (4.1%), Harpacticoida (3.7%), and Ostracoda (0.3%).

The organisms found in the 3 streams of this region are shown in Table 4. In Cheongdocheon (sites 30 and 33) and Yangsancheon (sites 31 and 32), the composition rate of Cyclopidae was the highest. The number of organisms or taxonomic groups was relatively lower in this region than in the other regions. Interestingly, not a single organism was observed in Miryanggang (site 29). Because meiobenthic arthropod communities are extremely sensitive to environmental pollution, they can be used for investigating the degree of pollution and developing measures to reduce pollution (Lee *et al.* 2002). The water system at Miryanggang was unstable due to various construction activities (Park and Park 2000), which likely resulted in the absence of Cyclopidae and Harpacticoida.

4. Relationship between biocenosis and environmental factors around the hyporheic zone

The biocenosis in the habitat around the hyporheic zone was investigated by classifying the levees at the hyporheic zone at the investigation site into waterside parks or cement, gabion, and natural levees. Comparison of the number of organisms that were found at each site among the 3 levees showed that 11 individuals were present in the waterside park or cement levee; 129, in the gabion levee; and 480, in the natural levee (Fig. 6). Further, 102 individuals from 5 of the 9 taxonomic groups were found in the waterside park or cement levee (Fig. 7). Harpacticoida was the highest number of species at the park or cement levee (42.2%), followed by Bathynellacea (32.4%), Cyclopidae (19.6%), and Isopoda (5.9%).

In all, 2,437 organisms were found in the gabion levee. Cyclopidae showed the highest composition rate (58.3

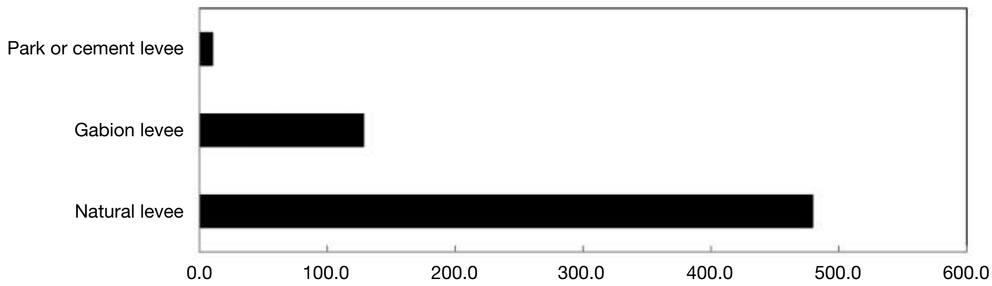

Fig. 6. Individual numbers of meiobenthic fauna at each levee.

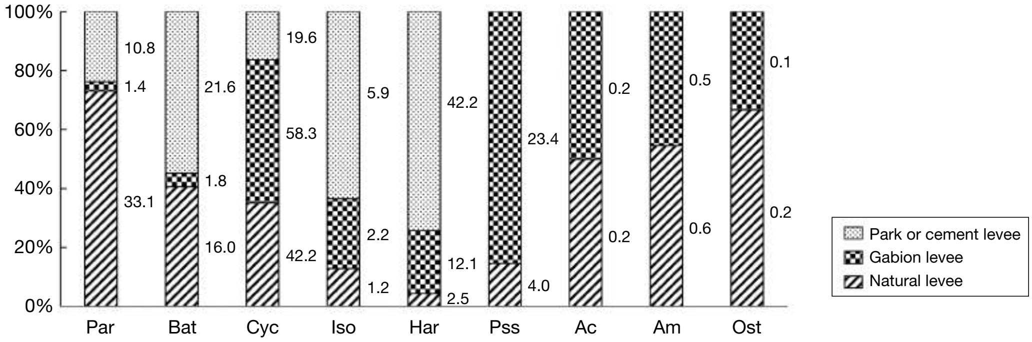

Fig. 7. Composition of meiobenthic faunal groups in the 3 levees. (Par = Parabathynellidae, Bat = Bathynellidae, Cyc = Cyclopidae, Har = Harpacticoida, Pss = Parastenocaris, Am = Amphipoda, Iso = Isopoda, Ac = Acari, Ost = Ostracoda.)

%), followed by Harpacticoida (35.5%), Bathynellacea (3.2%), and Isopoda (2.2%). The following organisms showed less than 1% of appearance: Amphipoda (0.5%), Arachnida (0.2%), and Ostracoda (0.1%).

In all, 4,316 organisms were found in the natural levee. Cyclopidae showed the highest composition rate (42.2 %), followed by Bathynellacea (49.1%), Harpacticoida (6.5%), and Isopoda (1.2%). Amphipoda, Arachnida, and Ostracoda showed less than 1% of appearance.

The levee with the lowest biomass was park or site constructed with cement. Only 5 taxonomic groups were observed at such sites. Gabion levee also had lower number of organisms than those found in natural levee.

Shin *et al.* (2014) showed that construction of levees reduces the space of stream and causes discontinuation of ecosystem connectivity, thereby decreasing the environmental function of the stream. While building parks, cement or gabion levees are introduced around the stream; this might affect the environment at the hyporheic zone in which organisms inhabit. In addition, Jeon (2011) reported that, although levees are necessary for the prevention of floods and regulating water flow, concrete levees might restrict the migration of living organisms. In other words, construction of levees on streams is likely to negatively affect biodiversity. This is because extraneous water in the hyporheic zone enters through streams and ground water from adjacent regions, and levees made of cement or gabion prevent such inflow. Therefore, the analysis of the biomass at the 3 kinds of levees suggests that natural levees are desirable for the growth of meiobenthic arthropod communities in the hyporheic zone of streams.

Summary

The hyporheic zones of streams had well-established sandbanks or gravelly areas. We found that the environments at each stream varied across the regions, and sandbanks and gravelly areas disappeared toward the downstream region of the river and streams. Furthermore, they were absent at sites that had levees around the streams. This affected the biomass composition at the 38 sites of hyporheic zones in Nakdonggang. The number of organisms per region with levees around the stream was markedly lower than that in regions without levees. In all, 480 organisms per site were found in regions with natural levees, whereas 11 organisms per site were found in regions with parks or cement levees. This suggests that construction around streams largely affects the inhabitation of meiobenthic arthropod communities in the hyporheic zone. Moreover, the total number of organisms at the 8 investigation sites in Nakdonggang mainstream was 75, which was very low. Most of these sites had ongoing constructions. Our findings suggest that organisms inhabiting hyporheic zone are affected by the construction of artificial structures around streams.

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