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Zooplankton Grazing on Bacteria and Factors Affecting Bacterial C-flux in Lake Paldang Ecosystem

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This study investigates bacteria-zooplankton grazing link and factors affecting their grazing relationship at trophically different two sites (Paldang Dam and Kyungan Stream) of Lake Paldang Ecosystem from April to December, 2005. Zooplankton were divided into two size groups; microzooplankton (MICZ): 60-200 μm and macrozooplankton (MACZ): >200 μm), and their grazing rates on bacteria were conducted for each size group separately. Bacterial abundance and seasonal change pattern were similar between two sites. MICZ, mostly rotifers (*e.g., Brachionus, Keratella, Polyathra*) were numerically dominant at both sites, while carbon biomass was highest in cladocerans. Zooplankton biomass was higher at the Kyungan Steam site compared to Paldang Dam site, and their high biomass during spring decreased as they were passing through the storm events in summer season at both sites. Zooplankton clearance rate (CR) was high in spring and autumn while low in summer at Paldang Dam site. However, zooplankton CR was high during the summer at Kyungan Stream site. Bacterial C-flux was high in spring and autumn when MACZ (esp. cladecerans) developed at a high biomass level at both sites. Overall, MACZ community CR and carbon flux (C-flux) were higher than those of MICZ, and the degree of difference between them was higher at Kyungan Stream site. Short hydraulic residence time and physical disturbance caused by summer storm event appeared to affect the zooplankton grazing on bacteria at both sites. The results of this study indicate that bacteria are potentially important carbon source of zooplankton, and that both biotic (*e.g.*, prey and predator taxa composition and abundance) and physical parameters appear to alter energy transfer in the planktonic food web of this river-reservoir hybrid system.

Key words : bacteria, zooplankton, trophic link, clearance rate, carbon flux, Lake Paldang, river-reservoir hybrid system

INTRODUCTION

Since the concept of 'microbial loop' (Azam *et al.*, 1983) in the aquatic ecosystems, bacteria have become a major organism in the study of plankton dynamics; *e.g.*, energy transfer and material cycling (Riemann and Søndergaard, 1986; Pace *et al.*, 1990; Wylie and Currie, 1991; Hwang and Heath, 1999; Kim *et al.*, 2000, 2002). Accumulated evidence of the role of bacteria in the plankton food web of various aquatic ecosystems during last two decades formulated some predictable hypotheses. One is that protists are the major predator of bacteria (Wylie and Currie, 1991; Vaquè *et al.*, 1992). Also important is the hypothesis that zooplankton community composition determines the degree of relative importance of bacteria as a zooplankton food source (Pace *et al.*, 1990; Hwang, 1995).

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These hypotheses as being considered more specifically, however, seem not to obtain a prevailing simple result among different environments. Although the most significant bacterial consumers appear to be protists in various environments (Vaquè *et al.*, 1992), this result seems to be variable, due to other predators such as rotifers and metazoan consumers (*e.g.*, *Daphnia*) (Pace *et al.*, 1990; Hwang and Heath 1997a). The contribution of bacteria and phytoplankton as a basic carbon sources to zooplankton in the whole plankton food web seems also to be variable, depending on the trophic status (Porter *et al.*, 1988; Heath *et al.*, 2003). Thus, the hypotheses being tested for the whole plankton food web dynamics in terms of energy transfer seem not hold a generalization along a trophic continuum (*e.g.*, Fenchel, 1988; Hwang 1997).

Although being less studied than above mentioned two hypotheses, researches of trophic dynamics conducted in lotic ecosystems shed a light on a generalization of detrimental factors of energy transfer in the plankton food web. The degree of grazing in the plankton food web appears to be affected by physical disturbance of water mass in addition to biological factors (David *et al.*, 2000). Particularly, storm events can critically disturb the community structure and grazing relationship in the plankton food web (Dickman, 1969; Margalef, 1997; Quintana *et al.*, 1998). Kim *et al.* (2002) showed that residence time was a critical factor to determine the zooplankton abundance in a regulated large river system. In this regard, water hydrology has a significance to understand the trophic dynamics in river-reservoir hybrid systems, such as a large reservoir constructed in the middle of river basin.

This study tries to understand the grazing relationship between bacteria and zooplankton in a large reservoir with combined hydraulic characteristics of river and reservoir. We selected two study sites in the consideration of both trophic status and residence time (the deepest mesotrophic dam site and shallow eutrophic inflowing river site) in Lake Paldang ecosystem. Thus, we hypothesize in this study that amount of bacterial carbon transferred to zooplankton is greater at the eutrophic river site, and the degree of carbon transfer is largely affected by incoming river water hydrology due to the monsoon storm events.

MATERIALS AND METHODS

1. Study site and sampling

The Han River is the largest river system in South Korea, and composed of three major tributaries; the North Han River, the South Han River and Kyungan Stream. Lake Paldang is located at the junction of three rivers above mentioned. The river is hydrologically regulated by building a multipurpose dam. Lake Paldang had been impounded by building a dam in 1973. It is located about 45 km northeast from Seoul, has a storage capacity of 244 million tons of water covering the watershed area of 23,713 km^2 (Cha *et al.*, 1977), and is the main water resource for drinking and agricultural uses (Kong, 1997). However, the construction of the dam accelerated the eutrophication of the lake (Kim *et al.*, 1998) with the increased loading of external nutrients (Kong, 1997). The investigated stations are Paldang dam and Kyungan Stream sites (Kwangdong Bridge). Grazing experiments and sampling were carried out at monthly basis with 7 occasions from April through December of 2005, except July and September. Rainfall data were obtained from water management information system (WAMIS).

2. Plankton community abundance and biomass analyses

Duplicated water samples for bacterial enumeration were obtained from the surface water (0.5 m depth) and fixed with 5% glutaraldehyde solution (final concentration 1%). One milliliter of each sample was diluted with 0.2 μm-pre-filtered distilled water to 1 : 100, and an 1 mL aliquot of each diluted sample was filtered through a 0.2 μm black GTBP Millipore membrane filter. Bacteria on the filters were stained with DAPI (4′, 6-diamidino-2-phenylindole) according to Porter and Feig (1980). At least 300 bacterial cells were enumerated under ×1,000 magnification using a Zeiss epifluorescent microscope and the matched number of field area was used to calculate bacterial abundance (cell mL^{-1}). Bacterial carbon was estimated using a conversion factor of 13.2 fgC cell^{-1} (mean value of Laws *et al.*, 1984; Lee and Fuhrman, 1987; Nagata, 1988; Simon and Azam, 1989; Wylie and Currie, 1991).

Zooplankton were sampled in duplicate by towing a 64 μm plankton net vertically from the depth of 8 m below the surface. Collected animals were preserved with sucrose-formalin (1%, final concentration) until analysis. The zooplankton were divided into two size groups (microzooplankton (MICZ): rotifer, nauplii, macrozooplankton (MACZ): copepods, cladocerans) and were counted with an inverted microscope (Zeiss) at ×100 magnification. Zooplankton size and biomass were measured separately with 10 individuals of each taxon. Biovolume of each rotifer taxon was determined by applying the formula for the most closely matching solid geometric shape (Downing and Rigler, 1984). Fresh weight (μg) was calculated from biovolume (μm^3) by the factor of 1.025 (Hall *et al.*, 1976), and dry weight (μg) was treated as a tenth of fresh weight (Pace and Orcutt, 1981). Dry weight of cladocerans and copepods was determined using published length-weight relationships (Culver *et al.*, 1985). Carbon content was converted from dry weight by multiplying a factor of 0.48 (Anderson and Hessen, 1991).

3. Measurements of zooplankton clearance rates (CR) and bacterial carbon flux (C-flux)

Zooplankton grazing experiments were conducted according to Lehman and Sandgren (1985) method. Clearance rates ($mL \cdot \mu gdw^{-1} \cdot d^{-1}$) and carbon flux ($\mu gC \cdot L^{-1} \cdot hr^{-1}$) were determined experimentally by manipulating grazer zooplankton densities. The grazing experiments were conducted with two size groups (MICZ: 60-200 μm; MACZ: >200 μm) separately.

Zooplankton treatments were established by filling 2 L bottle with ambient water through 60 μm mesh filter and subsequently inoculating zooplankton (MICZ, MACZ) at densities of ×2, ×4, ×8 of ambient levels. The treatment with no zooplankton (control) also was accompanied in each replication. All MICZ and MACZ treatments were duplicated. All bottle were incubated in ambient temperature with 12L : 12D light condition for 24 h. Duplicated initial and final aliquots (50 mL) for bacteria were removed from the bottles, preserved and enumerated as mentioned above. Bacterial growth rate in each treatment was estimated using the following equation.

$$r = (\ln N_t - \ln N_0)/t$$

r = the rate of population growth (day^{-1})
N_t = final cell density ($cells \cdot mL^{-1}$)
N_0 = initial cell density ($cells \cdot mL^{-1}$)
t = duration of incubation (day)

The relationship between bacterial growth rate and zooplankton biomass was assessed by a least squared linear regression. The slope of this relationship provides an estimate of the biomass-specific clearance rates ($mL \cdot \mu gdw^{-1} \cdot d^{-1}$). Carbon flux ($\mu gC \cdot L^{-1} \cdot hr^{-1}$) of bacteria to MICZ and MACZ was calculated by the following equation.

$$BCF = CR \times B \times Z \times (24\ hr\ day^{-1})$$

BCF = bacterial C-flux to zooplankton ($\mu gC \cdot L^{-1} \cdot hr^{-1}$)
CR = clearance rate ($mL \cdot \mu gdw^{-1} \cdot hr^{-1}$)
B = bacterial carbon biomass ($\mu gC \cdot L^{-1}$)
Z = ambient zooplankton biomass ($\mu gdw \cdot L^{-1}$)

4. Statistical analysis

Analysis of variance (ANOVA) was used to compare bacterial abundance and biomass, zooplankton abundance and biomass, clearance rates and bacterial carbon fluxes between two sites and sampling times (SPSS 10.0). Statistical significance was identified at $P < 0.05$.

RESULTS

1. Bacterial abundance and carbon biomass

Bacterial abundance changed at a great degree during the study period at both sites, ranging from 2.8×10^6 to 64.7×10^6 $cell \cdot mL^{-1}$ at Paldang Dam site and from 6.1×10^6 to 43.3×10^6 $cell \cdot$

Table 1. Bacterial abundance and biomass at Paldang Dam and Kyungan Stream site.

Month	Paldang Dam		Kyungan Stream	
	Abundance ($\times 10^6$ cells $\cdot mL^{-1}$)	Biomass ($\mu gC \cdot L^{-1}$)	Abundance ($\times 10^6$ cells $\cdot mL^{-1}$)	Biomass ($\mu gC \cdot L^{-1}$)
Apr.	2.8±0.2	37.3± 0.1	6.1±0.4	81.0± 0.8
May	6.5±0.3	86.1±13.8	7.9±0.2	104.7±19.4
Jun.	17.2±0.4	227.1±11.6	43.3±7.7	570.9±56.1
Aug.	24.8±1.0	326.7±12.7	16.0±2.9	211.4±38.7
Oct.	26.2±3.0	345.9±39.8	38.3±1.6	506.0±20.9
Nov.	64.7±7.5	853.3±99.0	32.4±0.5	427.9± 6.0
Dec.	22.3±0.3	302.2± 4.0	28.2±0.5	372.2± 6.0

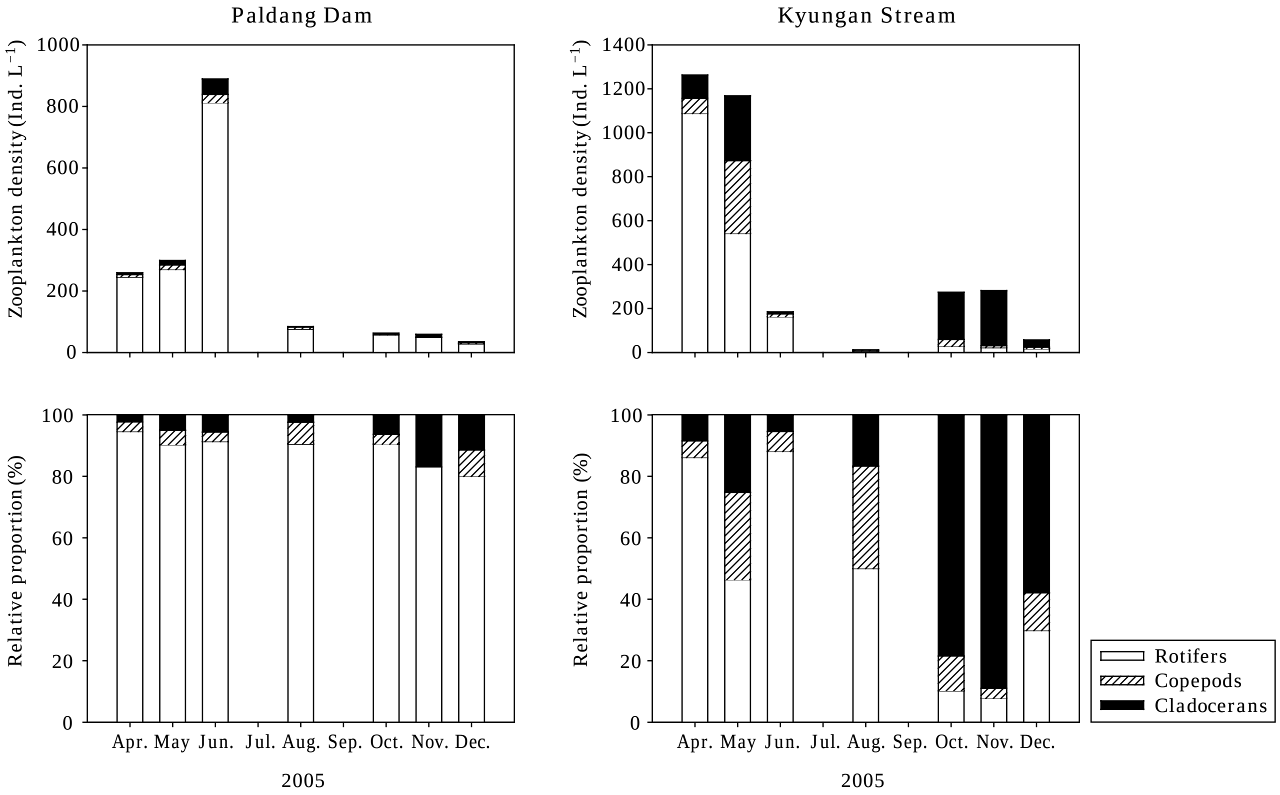

Fig. 1. Zooplankton abundance and relative proportion of major zooplankton groups at Paldang Dam and Kyungan Stream site.

mL^{-1} at Kyungan Stream site (Table 1). Seasonal change pattern of bacterial abundance between two sites was similar with the increase of abundance towards summer and autumn, except an abrupt decrease at Kyungan Stream site in August due to a large storm event. Bacterial carbon biomass ranged from 37.3 to 853.3 μgC · L^{-1} and 81.0 to 570.9 μgC · L^{-1} at Paldang Dam and Kyungan Stream site, respectively.

2. Zooplankton abundance, biomass and community composition

Overall, zooplankton abundance was high during spring season, while very low for the rest of the time (Fig. 1). Particularly, total zooplankton abundance abruptly decreased during summer monsoon season. Total zooplankton biomass was significantly higher at Kyungan Stream than at Paldang Dam site ($P < 0.05$, n=7, ANOVA)

Dominant zooplankton taxa at Paldang Dam site were *Brachionus* spp., *Keratella* spp., *Polyathra* spp., *Pompholyx* spp., *Daphnia* spp., *Diaphanosoma* spp. and nauplii, and they contributed greater than 90% of total abundance. Rotifer was the most dominant group (>90%) with the average abundance of 192±280 ind. L^{-1} followed by cladocerans (11±17 ind. L^{-1}), and copepods (8 ±10 ind. L^{-1}). Unlike abundance, carbon biomass was highest in the cladoceran group (Fig. 2).

Dominant zooplankton taxa at Kyungan Stream site were *Brachionus* spp., *Keratella* spp., *Polyathra* spp., *Bosmina* spp., *Daphnia* spp., copepodid, and nauplii. Average abundance of rotifers, cladocerans, and copepods was 233±410 ind. L^{-1}, 58±119 ind. L^{-1}, and 114±122 ind. L^{-1}, respectively (Fig. 1). Proportion of rotifers in the total abundance at Kyungan Stream site was lower (58%) compared to Paldang Dam site, while macrozooplankton proportion (cladocedran: 28%, copepods 14%) was higher at Kyungan Stream site.

Particularly, cladocerans including *Bosmina longirostris* and *Daphnia* sp. markedly increased after August at Kyungan Stream site, and thus occupied 60-80% of total zooplankton abundance (Fig. 2). Cladoceran biomass was highest in May,

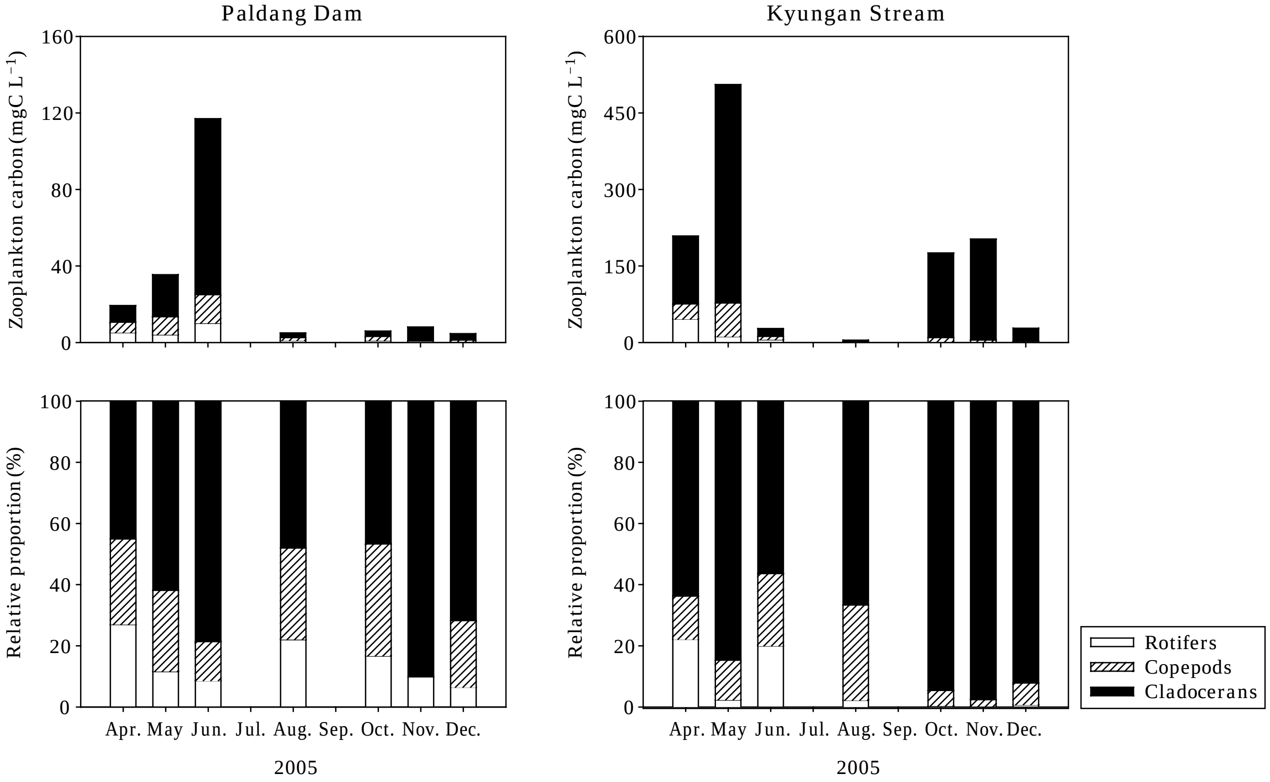

Fig. 2. Zooplankton carbon biomass and relative proportion of major zooplankton groups at Paldang Dam and Kyungan Stream site.

due to the abrupt increase of *Daphnia*.

3. Zooplankton clearance rate (CR) and carbon flux (C-flux)

Average zooplankton CR on bacteria was higher at Kyungan Stream site than at Paldang Dam site (Table 2) ($P<0.05$, n=7, ANOVA). At Paldang Dam site, zooplankton CR showed a significant seasonal variation ($P<0.05$, n=7, ANOVA), with high value in spring and autumn but low value in summer, ranging from 0.34 to 3.60 mL · μgdw^{-1} · d^{-1} (average: 1.87±1.2 mL · μgdw^{-1} · d^{-1}) for MICZ, and from 0.03 to 2.83 mL · μgdw^{-1} · d^{-1} (average: 1.55±1.1 mL · μgdw^{-1} · d^{-1}) for MACZ. Unlike Paldang Dam site, zooplankton CR was high in summer at the Kuyngan Stream site, and CR ranged from 0.31 to 1.25 mL · μgdw^{-1} · d^{-1} (average: 0.70±0.4 mL · μgdw^{-1} · d^{-1}) for MICZ, and from 0.06 to 1.92 mL · μgdw^{-1} · d^{-1} (avergae: 0.53±0.7 mL · μgdw^{-1} · d^{-1}) for MACZ.

Overall bacterial C-flux to zooplankton was relatively high at Kyungan Stream site in ac-

Table 2. Clearance rates (CR: mL · μgdw^{-1} · d^{-1}) of zooplankton on bacteria and significance level of the regression at Paldang Dam and Kyungan Stream site.

		Paldang Dam			Kyungan stream		
		CR	n	r^2	CR	n	r^2
MICZ	Apr.	0.34	8	0.77**	0.43	8	0.59*
	May	2.81	8	0.86***	0.34	8	0.59*
	Jun.	0.77	8	0.88***	1.25	8	0.55*
	Aug.	0.94	8	0.28	1.10	8	0.04
	Oct.	2.11	8	0.11	0.79	8	0.71**
	Nov.	3.60	8	0.44	0.31	8	0.37
	Dec.	2.50	8	0.30	0.67	8	0.44
	Avg.	1.87±1.2			0.70±0.4		
MACZ	Apr.	0.84	8	0.73**	0.29	8	0.99***
	May	2.66	8	0.80***	0.07	8	0.84***
	Jun.	0.03	8	0.85***	0.89	8	0.17
	Aug.	0.84	8	0.16	1.92	8	0.26
	Oct.	2.83	8	0.31	0.06	8	0.55*
	Nov.	1.15	8	0.83***	0.12	8	0.92***
	Dec.	2.52	8	0.16	0.34	8	0.72**
	Avg.	1.55±1.1			0.53±0.7		

*p<0.05, **p<0.01, ***p<0.001

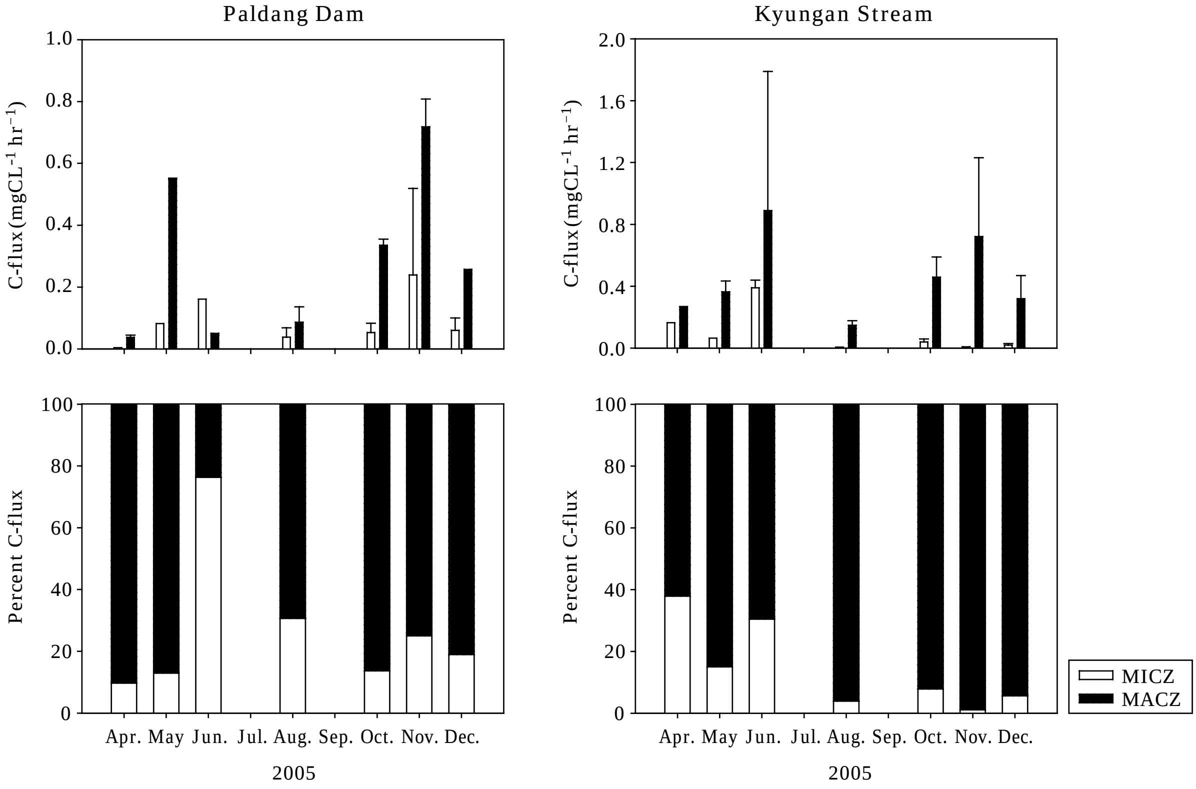

Fig. 3. Seasonal variation of bacterial C-flux and its relative proportion between MACZ and MICZ at Paldang Dam and Kyungan stream site

cordance with zooplankton CR ($P < 0.05$, n=7, ANOVA) (Fig. 3). Bacterial C-flux ranged from 0.004 to 0.239 μgC · L^{-1} · hr^{-1} (average: 0.091± 0.08 μgC · L^{-1} · hr^{-1}) for MICZ and from 0.037 to 0.718 μgC · L^{-1} · hr^{-1} (average: 0.291±0.26 μgC · L^{-1} · hr^{-1}) for MACZ at Paldangg Dam site during the study period. Most bacterial carbon was transferred to MACZ (average: 72%) compared to MICZ (28%) ($P < 0.05$, n=7, ANOVA) except for June. In consistent with CR, bacterial C-flux was high in spring and autumn.

MACZ was always more important bacterial grazers in terms of bacterial C-flux at Kyungan Stream site relative to MICZ ($P < 0.05$, n=7, ANOVA); average 84% of bacterial carbon transferred to MACZ during the study period (Fig. 3). Amount of bacterial C-flux ranged from 0.006 to 0.389 μgC · L^{-1} · hr^{-1} (average: 0.098±0.14 μgC · L^{-1} · hr^{-1}) for MICZ and from 0.147 to 0.889 μgC · L^{-1} · hr^{-1} (average: 0.452±0.26 μgC · L^{-1} · hr^{-1}) for MACZ ay Kyungan Stream site. Bacterial C-flux was high in spring and autumn.

DISCUSSION

The values of zooplankton CR and bacterial C-flux analyzed in this study lie in the comparable range to those obtained from other studies conducted in various environments (Table 3), suggesting that Lake Paldang ecosystem be supporting the bacterial-based microbial food web. Our results do not mean that algae-based food web is not important in this ecosystem. A companion study also showed that algal C-flux to zooplankton was comparable and often higher than bacterial C-flux (Hwang, 2006), in supportive of previous studies (Hwang and Heath, 1997a). However, our intention in this study is to evaluate the potential importance of bacterial-based microbial food web in Lake Paldang ecosystem. The results of trophic dynamics of whole plankton food web in Lake Paldang will soon be published.

Our results of difference of bacterial C-flux between two sites agree with a hypothesis that the degree of bacterial carbon transfer varies with

Table 3. Comparison of literature values of clearance rate (mL · L^{-1} · hr^{-1}) and bacterial carbon flux (μgC · L^{-1} · hr^{-1}).

Redator	Prey	CR	C-flux	References
Metazooplankton	0.5 μm fluorescent micropheres	0.0-0.7		Agasild and Noges (2005)
Rotifer		0.0-0.7		
Cladocerans		0.0-0.3		
Zooplankton (>140 μm)	3H-labelled bacteria	0.0-33.0	0.333-7.5	Jeppesen *et al.* (1996)
MACZ (>200 μm)	*In situ* bacteria	3.3±1.0	0.83±0.17	Hwang and Heath (1999) (Eutrophic river)
MICZ (40-200 μm)		8.0±5.1	2.20±1.29	
MACZ (>200 μm)	*In situ* bacteria	1.5±0.5	0.11±0.04	Hwang and Heath (1999) (Oligo-mesotrophic lake)
MICZ (40-200 μm)		4.6±2.4	0.23±0.15	
MACZ (>157 μm)	0.75 μm fluorescent micropheres	0.8±2.4	0.0004-0.296	Kim *et al.* (2000)
MICZ (<157 μm)		2.1±4.0	0.001-0.417	
MACZ (>200 μm)	*In situ* bacteria	0.3-7.1	0.037-0.718	This study (Paldang Dam)
MICZ (60-200 μm)		0.1-1.1	0.004-0.239	
MACZ (>200 μm)	*In situ* bacteria	0.7-4.0	0.147-0.889	This study (Kyungan Stream)
MICZ (60-200 μm)		0.02-1.8	0.006-0.389	

the trophic condition (Hwang, 1997), which determines abundance of bacteria and zooplankton, and their composition (Pace *et al*., 1990; Weisse *et al*., 1990; Wylie and Currie, 1991; Hwang and Health, 1997b). In this study, bacterial C-flux was higher at the more eutrophic Kyungan Stream site than at the mesotrophic Paldang Dam site in spite of similar bacterial abundance between both sites, indicating that zooplankton community composition and biomass were likely important factors to control bacterial C-flux in Lake Paldang ecosystem. The community composition of phytoplankton also seems to be important to affect bacterial C-flux to zooplankton in our study ecosystem (Lampert, 1987). The high bacterial C-flux during October and November at Paldang Dam site, relative to the same period at Kyungan Stream site, appeared to be related with the bloom of unpalatable filamentous diatom (*Aulacoseira* spp.) at Paldang Dam site (Uhm and Hwang, 2006).

On an individual basis of the grazer, overall bacterial C-flux may depend on the combination of three factors; *i.e.*, body size (Knoechel and Holtby, 1986), feeding mechanism (Moralities and Lacroix, 1990), and abundance (Hwang and Heath, 1999). The result that large metazoan zooplankton was much more important grazers in our study system might be related with that efficient MACZ (usually cladocerans) having a high clearance rate dominated the zooplankton community at most times (Figs. 1, 3). Thus, MACZ might be competitively superior to MICZ in grazing bacteria (Burkill *et al*., 1995; Kim *et al*., 2003). However, MICZ, mostly rotifers, were reported to be more important than MACZ in certain environments, where bacterivorous rotifers develop at high level of abundance (Havens, 1994; Arndt and Heerkloos, 1989; Lair and Ali, 1990; Christoffersen *et al*., 1990). Relatively high bacterial C-flux to MICZ was observed in June at Paldang Dam site and April at Kyungan Stream site in accordance with the development of *Keratella cochlearis* and *Brachionus angularis*, respectively.

On the other hand, copepods are reported to be inefficient in grazing on bacteria in most environments (Pedros-Alio and Brock, 1983; Forsyth and James, 1984; Hwang and Heath, 1999). This was also the case in this study. However, copepods, owing to their feeding mechanism (raptorial feeding), usually graze actively moving protistan organisms (flagellates and ciliates) (Stoecker and Capuzzo, 1990; Gifford, 1991; Wylie and Currie, 1991; Burns and Gilbert, 1993), and, thus their role in the microbial food web is likely to support an indirect bacterial C-flux pathway to higher trophic levels, from bacteria through protists to copepods (Burns and Schallenberg, 1996; Hwang and Heath, 1997a).

Although it is not well demonstrated throughout aquatic ecosystems, hydrologic and hydraulic parameters which result in physical disturbance might as well to affect plankton dynamics (David

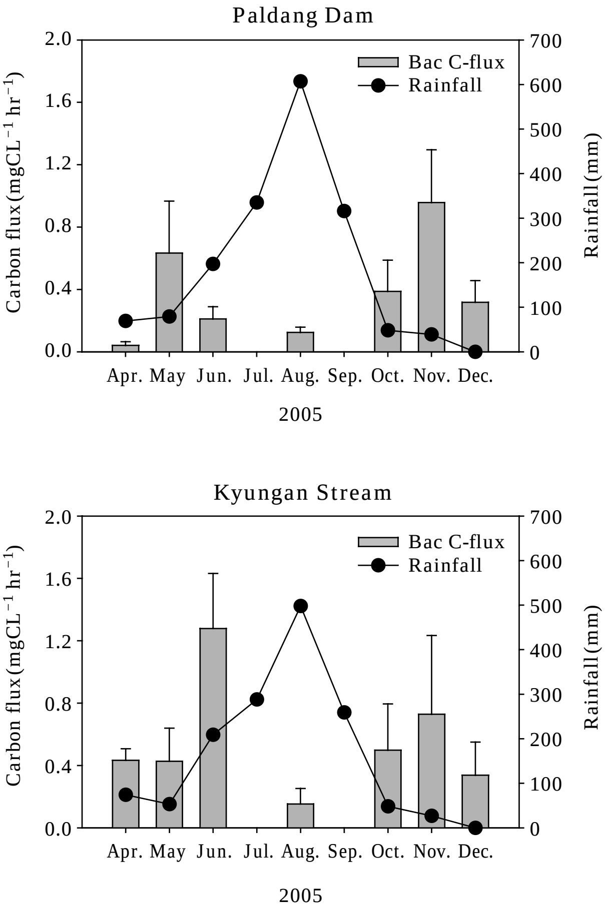

Fig. 4. Seasonal change of bacterial C-flux and rainfall pattern at Paldang Dam and Kyungan Stream site.

et al., 2000). Particularly, heavy storms in the monsoon climate region can modify communities of aquatic ecosystem (Dickman, 1969), and thus resulting physical disturbance could set the grazing relationship unstable (Margalef, 1997; Quintana *et al.*, 1998). Our results of the contrasting pattern of change between bacterial C-flux and the intensity of precipitation (Fig. 4) indicate a probable effect of hydrology on the zooplankton grazing on bacteria, possibly through flushing and large input of suspended sediments (Shin *et al.*, 2004). Additionally, an intense storm during a short period of time may keep a harmful effect for a longer period of time (Descy, 1993; Muylaert *et al.*, 2001). This fact also supports our result that although storm events markedly decreased bacterial C-flux during the monsoon storm period, it did not reached back to the level of the spring C-flux after then (Fig. 4). There also are other factors engaged in the variation of bacterial C-fluxes in aquatic ecosystems. Fish predation is well known to affect plankton dynamics (*e.g.*, Kerfoot and Sih, 1987; Polis and Winemiller, 1996), and thus, we believe that fishes were likely to affect on bacterial C-flux in our study ecosystem. This aspect is open to study in the future.

In conclusion, our results demonstrate that bacteria are a potential energy source for zooplankton through the direct grazing in Lake Paldang ecosystem. In supportive of proposed hypotheses of this study, bacterial C-flux was higher in more eutrophic environment, which supports development of large efficient metazoan filter feeders, and physical disturbance caused by the storm events appeared to be a potentially important factor to alter the degree of bacterial carbon transfer to zooplankton in our studied river-reservoir hybrid system.

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＜**국문적요**＞

팔당호 생태계에서 동물플랑크톤의 박테리아 섭식 및 영향인자

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박테리아-동물플랑크톤의 영양적 관계와 이에 미치는 요인들을 파악하기 위하여 2005년 4월부터 12월까지 팔당호 생태계의 영양상태가 다른 팔당댐앞과 경안천 두 지점을 선정하여 동물플랑크톤의 여과율과 박테리아의 C-flux를 분석하였다. 동물플랑크톤은 소형(Microzooplankton, MICZ: 60-200 μm)과 대형동물플랑크톤(Macrozooplankton, MACZ: ＞200 μm)으로 구분하여 각 그룹에 대하여 별도로 섭식률을 조사하였다. 두 지점에서 박테리아 밀도와 계절적 변화양상은 유사하게 나타났다. 동물플랑크톤은 두 지점 모두 윤충류(*Brachionus*, *Keratella*, *Polyathra*)가 수적으로 크게 우점하였으나, 탄소생물량은 지각류(*Daphnia*)가 가장 높았다. 동물플랑크톤은 봄에 높은 밀도와 탄소생물량을 보였고 여름철 집중강우 시기를 기점으로 크게 감소하였다. 지점별로는 경안천에서 상대적으로 높은 탄소생물량이 나타났다. 박테리아에 대한 동물플랑크톤 여과율은 팔당댐앞에서 봄, 가을철에 높고 여름철에 낮게 나타나는 계절에 따른 변화가 명확하게 나타난 반면, 경안천에서는 팔당댐앞과는 달리 여름철에 높게 나타났다. C-flux는 두 지점 모두 봄철과 가을철에 높게 나타났다. 군집여과율과 박테리아 C-flux는 MACZ가 MICZ보다 높았고, 그 정도는 경안천에서 더 높게 나타났다. 여름철의 집중강우로 인한 짧은 체류시간과 수체의 교란이 동물플랑크톤의 섭식에 영향을 미치는 것으로 파악되었다. 본 연구의 결과, 팔당호 생태계에서 박테리아는 동물플랑크톤의 중요한 먹이원이며, 또한 플랑크톤 먹이망 내에서 에너지 전달율은 먹이원과 섭식자의 생물량 및 종조성과 같은 생물적 요인과 함께 강우와 같은 물리적인 요인에 의해 잠재적인 영향을 받는 것으로 파악되었다.