

Filter-Feeding Effect of a Freshwater Bivalve (*Corbicula leana* PRIME) on Phytoplankton

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The purpose of this study was to evaluate the filtering-feeding effect of a freshwater mussel (*Corbicula leana*) on the phytoplankton communities in two lakes with different trophic conditions between June and September, 2000. Manipulation experiments were conducted with two treatments (the control and mussel addition), and each established in duplicate 10 l chambers. Both ambient nutrient (TN, TP) and chlorophyll-*a* concentrations were significantly ($p < 0.01$) higher in Lake Ilgam than Lake Soyang. Cyanophytes (*Microcystis*, *Oscillatoria*, *Lyngbya* and *Dactylococcopsis*) consistently dominated algal community in Lake Ilgam, while flagellated algae (*Dinobryon divergence*, *Mallomonas*, *Rhodomonas*) and cyanophytes (*Microcystis*) dominated in Lake Soyang. The net exponential death rate ($R = \text{day}^{-1}$) of total phytoplankton in the mussel treatment ranged 1.70~7.39 and 0.38~1.64 in Lakes Soyang and Ilgam, respectively. Mean filtering rate standardized by mussel AFDW ($\text{ml mgAFDW}^{-1} \text{h}^{-1}$) was much higher in Lake Soyang (1.70~3.06) than in Lake Ilgam (0.24~0.88). Estimating FR per mussel, 1 mussel filtered 1.6~7.8 l per day and 1.7~3.0 l per day in Lakes Soyang and Ilgam, respectively. Based on the C-flux to biomass ratio, *Corbicula leana* consumed 0.8~4.4 fold of phytoplankton standing stock in Lake Soyang, and 0.4~1.6 fold in Lake Ilgam per day. Mussel feeding resulted in increase of SRP concentration by 30~50%, compared with the control. The results of this study suggest that filter-feeding activity of *Corbicula leana* varies depending on the phytoplankton density and community composition. The high seston consumption rate of *Corbicula leana* even in a eutrophic lake suggests that biomanipulation approach using filter-feeding mussels can be used for water quality management in small eutrophic reservoirs.

Key words : Filter feeding, Freshwater bivalve, Phytoplankton, C-flux, Nutrient recycling, Water quality management

INTRODUCTION

Mussels play an important role in coupling the pelagic and benthic food web, by importing a large portion of phytoplankton primary production and secondary production from the water column into the sediment (Loo and Rosenberg, 1989; Dame *et al.*, 1985; Heath *et al.*, 1995; Jack

and Throp, 2000). Thus, mussels redistribute energy flow in the water column and the sediment through the food web and material cycling (Noordhuis *et al.*, 1992; Yamamuro and Koike, 1993; Heath *et al.*, 1995; Gardner *et al.*, 1995; Dame, 1996).

Recent studies (Holland, 1993; Cotner *et al.*, 1995; Fahnenstiel *et al.*, 1995; Lavrentyev *et al.*, 1995; Hwang, 1996) have demonstrated that

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mussels are efficient filter feeders being able to take up suspended particles, including bacteria, protists, phytoplankton, zooplankton, and abiotic particles. One of the most well studied bivalves, the zebra mussel, has been reported to filter a wide range of plankton, from bacterioplankton to zooplankton, at a rate of about 1 l mussel⁻¹ day⁻¹, and improve water clarity in aquatic systems (Holland, 1983). Strong filter feeding effects on aquatic sestons also have been observed in other mussel species, especially some solitary-living bivalves (Foster-Smith, 1975; Wright *et al.*, 1982; Dame, 1996).

From the management perspective, high capacity of filter-feeding activities using mussels can be applied to water quality control as a biofilter (Reeders *et al.*, 1989; Reeders and Bij de Vaate, 1990; Soto and Mena, 1999), if they were used and managed appropriately. In the Netherlands, the zebra mussels were introduced to control severe algal blooms in small, eutrophicated lakes (Noordhuis *et al.*, 1992). The results showed that Secchi transparency in the mussel-introduced lake, increased from 60 cm to 100 cm, and such condition was maintained throughout the entire year of the experiment. They also demonstrated that the simultaneous application of mussels and fish stock within the framework of active biological management increased the efficiency. Similarly, Soto and Mena (1999) showed that a solitary-living freshwater mussel (*Diploden chilensis*) was able to contribute to biocontrol of eutrophication caused by salmon aquaculture in Lake Llanquihue, Chile.

Mussel effects on phytoplankton biomass in Asian freshwater systems are not much studied. Populations of *Corbicula*, Asian introduced species to North America, increased rapidly in the exotic environments, as zebra mussel did (Gunning and Suttkus, 1966). Its ecology and distribution have been more studied in North America rather than in Asia (Dresler and Cory, 1980; Hill and Knight, 1981; Cohen *et al.*, 1984). The high filtering rate of *Corbicula* was applied to wastewater treatment (Haines, 1979). However, the detailed feeding ecology and effects of *Corbicula* on energy flow and material cycling remain largely to be solved (Yamamuro and Koike, 1993).

The purpose of this study was to evaluate the filter-feeding effect of *Corbicula leana* on phytoplankton communities, in order further to seek its possible use as a biofilter in the water quality

management of small eutrophic lakes in Korea. In this study, we focused on the mussel effect on different phytoplankton communities and densities by conducting feeding experiments with lake waters of different trophic status.

MATERIALS AND METHODS

General description of the mussel

Corbicula is found to be very common in many lakes and rivers in Korea, and widely distributed throughout southern regions of the Korean peninsula. The genus is reported to include 6 species in Korea (Kwon, 1990). *Corbicula leana* Prime, used in this study, is known to be more tolerant to water pollution than any other species of this genus (Lee and Kim, 1997). Recent molecular systematic study on the genus *Corbicula* showed that molecular similarity was highest between *C. leana* and *C. colorata* (0.737) along with the second highest similarity between *C. leana* and *C. fluminea* (0.689) (Lee and Kim, 1997).

C. leana was collected using a mussel collector in the upstream of the Han River (the largest river in Korea), where the river water was mesotrophic and the depth was about 2 m. Collected mussels were transported to the laboratory, and acclimated in several aquaria with sand and mud collected from the sampling site. The lake water in the aquaria was replaced every 5~7 day to provide new food sources. Mussels were transferred into a new aquarium, filled with GF/C filtered lake water, one day before the experiment. We used healthy-looking mussels in the experiment and their age was approximately 2~3 years old.

Study sites

This study was conducted in two lakes with different trophic states. Lake Soyang, located in the upstream of the Han River, is a large artificial lake made by a dam constructed for the multi-purpose of hydroelectricity and drinking water. The maximum and mean depth of the lake are 100 m and 42 m, respectively. It has a very large drainage area (2,703 km²), which consisted mostly of forest and agricultural area (Kim *et al.*, 2000). The primary productivity of Lake Soyang has slowly increased, and the current trophic status of the lake is mesotrophic

with dominant algae are of diatoms. In contrast, Lake Ilgam, located in the downtown of metropolitan area (Seoul), is small (mean depth: 1.6 m, surface area: 55,661 m²) and is a hypertrophic condition. The dominant algae in Lake Ilgam are colonial and filamentous cyanobacteria.

Sample collections and measurements of water quality parameters

Sampling was conducted at monthly intervals, from June to September 2000, at the deepest site of Lake Ilgam and a site near the dam in Lake Soyang. Water samples were collected from the epilimnion (0.5 m) in both lakes between 10:00 and 12:00 hours, using a 3.2 l Van Dorn water sampler. Water samples were placed in acid-washed 20 l polyethylene carboys, and kept in the shade at nearly ambient temperature during the transportation.

Water samples were filtered through pre-combusted GF/F filters to determine chlorophyll-*a* and suspended solids concentrations (APHA, 1995). Chlorophyll-*a* (chl. *a*) concentration was determined by the method of Lorenzen (1967). Water samples for soluble reactive phosphorus (SRP) and nitrate were filtered using 0.2 µm polycarbonated membrane filters. SRP and nitrate-N were determined with ascorbic acid method and cadmium reduction method (APHA, 1995), respectively. Total phosphorus (TP) and total nitrogen (TN) concentrations were determined by the ascorbic acid method and cadmium reduction method, respectively, after decomposing with alkalate persulfate (APHA, 1995). Water temperature, pH, and specific conductivity were measured with Hydro-Lab (RS-232/SDI-12) and water transparency was determined with a black-white (20 cm diameter) Secchi Disk in the field. For phytoplankton analysis, duplicated 100 ml aliquots were taken, placed in Whirl-Pak bags, and immediately preserved with Lugol's solution (2%, final conc.).

Mussel feeding experiment

The feeding experiment was conducted on site in 10 l chambers with wide-open mouth in duplicate, without and with mussels (1 mussel/l). To minimize the effect of large zooplankton, lake water was pre-filtered through 200 µm mesh before added to all chambers, including the control. As soon as mussels were added, duplicated

100 ml aliquots were sampled from each chamber, placed in Whirl-Pak bags, and preserved with Lugol's solution (2%, final conc.). Chambers were transported to the laboratory, and incubated for 24 hours at nearly ambient temperature. After 24 hours, duplicated 100 ml aliquots were carefully removed from the middle of the water column, and preserved as described above. Then, subsamples were taken in order to determine nitrogen and phosphorus changes caused by mussels feeding on phytoplankton in the mussel treatment.

The net death rate ($R = \text{day}^{-1}$) of phytoplankton was calculated using the following equation :

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

where N_0 and N_t are initial and final cell densities, and t is a duration of the experiment.

Ash-free dry weights (AFDW) of mussels were determined by measuring the weight of soft tissues of mussels. After feeding experiments done, shells were opened, and tissues were carefully placed into combusted, pre-weighed aluminum planchets, dried 100°C for 72 hours, and combusted at 500°C for 2 hours. Mussel filtering rate ($FR = \text{ml mgAFDW}^{-1} \text{h}^{-1}$) on phytoplankton was determined for each experiment by the following equation :

$$FR = V \times \ln(C/M) / (W \times t)$$

where V is lake water volume (l) in the container; M and C were the final densities of phytoplankton in containers with and without mussels, respectively; W is the AFDW of mussels; and t is the duration of experiments.

Enumeration and biomass determination of phytoplankton

Phytoplankton were sedimented for 24 hours, and known volume of concentrated sample was placed in 1 ml Sedgewick-Rafter counting chamber. At least 300 cells were counted under 200~400 fold magnification of a microscope. Algal biovolume was determined on the basis of geometric solid which closely approximated each cell or colony shape (Kellar *et al.*, 1980; Wetzel and Likens, 1991). Cell size of each species was measured separately on at least 10 cells in each sample. Carbon biomass of phytoplankton was calculated using several conversion factors: $10^{(-0.427 + 0.784 (\log V_{\mu\text{m}^3}))}$ µgC for bacillariophytes (Mullin *et al.*, 1966),

$10^{(-0.460 + 0.866(\log \mu\text{m}^3))}$ μgC for cyanophytes and chlorophytes (Mullin *et al.*, 1966), and $200 \text{ fgC}/\mu\text{m}^3$ for phototrophic flagellates (Strathmann, 1967).

Statistical analysis

One-way analysis of variance (ANOVA) was used to compare environmental parameters between two sites. Student t-test was done to compare phytoplankton growth rates and mussel filtering rates between two lakes.

RESULTS AND DISCUSSION

Limnological conditions

Two lakes showed a distinct contrast in the limnological characteristics. The most parameters including secchi depth, pH, specific conductivity, TP and chl-*a* showed significant ($p < 0.01$) differences between the two Lakes (Table 1). The

trophic condition of Lake Ilgam was much higher. The differences in TN and SRP, however, were minor between two lakes. Considering higher chl-*a* in Lake Ilgam, inorganic nitrogen may contribute to the nitrogen pool in Lake Soyang. Interestingly, nitrate concentration in Lake Ilgam was significantly ($p < 0.01$) lower than Lake Soyang, indicating its active uptake by algae. Similarly, low concentration of SRP might be due to a rapid uptake by phytoplankton photosynthesis in both lakes.

Ambient phytoplankton composition and biomass

Two lakes showed a distinct difference in the phytoplankton compositions during the study period (Table 2). In Lake Soyang, dominant taxa changed from flagellate algae, *Dinobryon*, *Rhodomonas* and *Mallomonas* in June, through *Aulacoseira* in July to *Microcystis*, in September. In

Table 1. Limnological characteristics of Lakes Soyang and Ilgam between June and September 2000. Terms of S.D. and SRP denote Secchi depth transparency and soluble reactive phosphorus, respectively. N.D. denotes the detection limit of $\text{NO}_3\text{-N}$ and SRP ($< 0.02 \text{ Nmg/l}$, $< 2.2 \mu\text{gP/l}$).

Lake	Date	S.D (m)	Temp. (°C)	pH	Cond. $\mu\text{S/cm}$	TN mg l^{-1}	$\text{NO}_3\text{-N}$ mg l^{-1}	TP $\mu\text{g l}^{-1}$	SRP $\mu\text{g l}^{-1}$	Chl- <i>a</i> $\mu\text{g l}^{-1}$
L. Soyang	June	5.8	23.0	7.5	58.7	1.3	1.3	6.3	N.D	1.4
	July	3.5	26.4	7.6	58.5	1.3	1.2	6.9	N.D	4.0
	August	3.7	28.4	8.1	72.4	1.4	1.3	6.9	N.D	3.8
	September	4.0	21.0	7.2	57.8	1.4	1.3	10.8	N.D	5.9
L. Ilgam	June	0.6	27.1	9.3	246.9	1.4	0.07	57.3	7.2	62.3
	July	0.4	28.2	9.0	209.4	1.7	0.02	65.9	3.5	84.1
	August	0.6	28.8	9.4	203.8	1.0	N.D	51.5	N.D	52.4
	September	0.3	24.5	9.8	164.1	1.5	N.D	61.9	N.D	75.9

Table 2. List of dominant phytoplankton taxa in Lakes Soyang and Ilgam between June and September 2000. Dominant taxa represent greater than 5% of total cell density (d) or biomass (b) in each lake.

Month \ Lake	L. Soyang	L. Ilgam
June	<i>Dinobryon divergens</i> (d)	<i>Oscillatoria</i> spp. (d, b) <i>Microcystis aeruginosa</i> (b)
	<i>Rhodomonas</i> sp. (d)	
	<i>Mallomonas</i> sp. (b)	
July	<i>Aulacoseira varians</i> (d)	<i>Microcystis aeruginosa</i> (d) <i>Lyngbya contartata</i> (d) <i>Apanocapsa delicatissima</i> (d) <i>Peridinium</i> sp. (b)
	<i>Ceratium hirundinella</i> (b)	
August	<i>M. aeruginosa</i> (d)	<i>Oscillatoria</i> spp. (d) <i>Peridinium</i> sp. (b)
	<i>Peridinium</i> sp. (b)	
September	<i>Aulacoseira varians</i> (d)	<i>Dactylococcopsis acicularis</i> (d, b) <i>Peridinium</i> sp. (b)
	<i>Microcystis aeruginosa</i> (d)	
	<i>Ochromonas mutabilis</i> (b)	

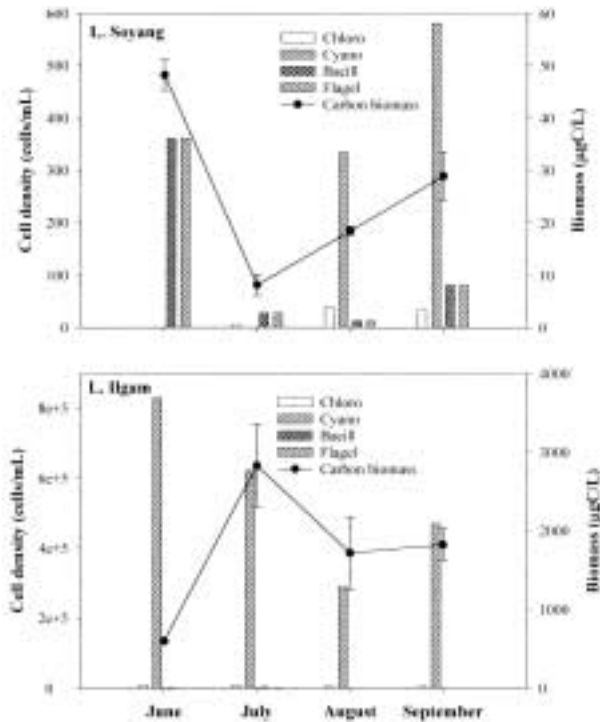


Fig. 1. Ambient phytoplankton density and carbon biomass in Lakes Soyang and Ilgam between June and September 2000. Chloro, Cyano, Bacil, and Flagel denote chlorophytes, cyanophytes, bacillarphytes, and flagellates, respectively.

contrast, cyanobacteria were most dominant in Lake Ilgam during June–September, especially *Microcystis* followed by *Oscillatoria*, *Lyngbya*, and *Dactylococcopsis*.

Cell density and biomass of phytoplankton in Lake Ilgam were significantly ($p < 0.01$) higher than those in Lake Soyang (Fig. 1). Temporal changes in phytoplankton cell density and biomass did not always coincide with those in biomass. Flagellated algae, including *Dinobryon*, *Chlamydomonas*, and *Mallomonas*, largely appeared (55–99% of total biomass) in Lake Soyang. In Lake Ilgam, cyanobacteria were always dominant, in the cell density range of >98%. However, their biomass was highest (54–59%) in July and August when flagellated algae (especially, *Peridinium*) occurred.

Feeding effects of *Corbicula leana* on phytoplankton communities

Effects on phytoplankton abundance and carbon biomass: Feeding effects of the mussel on phyto-

plankton were considerably different in two lakes (Figs. 2, 3). In Lake Soyang, the declining pattern in both cell and carbon biomass was almost the same, and the proportion of both phytoplankton cell and carbon in the mussel treatment was within 0–36% of the control (Fig. 2). Except for the period of August, when *M. aeruginosa* dominated, almost all phytoplankton was removed in the mussel treatment. These results indicate that phytoplankton in Lake Soyang were nearly grazed, and most phytoplankton was in a favorable size range for mussel filtering (Winkel and Davids, 1982; Hwang, 1996). In Lake Ilgam, the mussels also significantly reduced phytoplankton density, but the magnitude of grazing effects was small in comparison with that observed in Lake Soyang (Fig. 3). The proportion of remaining phytoplankton in the mussel treatment, in comparison with the control, was 27–107% in density and 34–76% in biomass during the study period.

The significant difference of feeding effects of the mussel on phytoplankton in two lakes suggests that the cell density and species composition of phytoplankton are of important factors in mussel feeding on them. Several previous studies indicated that mussel filtering rate was positively related to the food density (Winter, 1973; Sprung and Rose, 1988; Reeders and Bil de Vatte, 1990; Hwang, 1996). However, the ranges of phytoplankton cell density, in which the filtering rate of mussel increase, vary depending on the food sources and mussel species (Sprung and Rose, 1988; Dorgelo and Smeenk, 1988; Winter, 1973). Hwang (1996) noted that zebra mussel filtering rate was 5-fold lower in the eutrophic, cyanobacteria-dominated region of Saginaw Bay than in the oligo-mesotrophic diatom and flagellate-dominated region. The results agrees with our findings, where the feeding effects of the mussel on phytoplankton was clearly higher in mesotrophic Lake Soyang than in hypertrophic Lake Ilgam (Figs. 2, 3).

Phytoplankton mortality and mussel filtering rate: Mussel effect on phytoplankton mortality always was greater in Lake Soyang ($1.70 \sim 7.39 \text{ day}^{-1}$) than in Lake Ilgam ($0.38 \sim 1.64 \text{ day}^{-1}$), and its mean difference was 4-fold (Fig. 4), and the difference of mean mortality was significant ($p < 0.05$).

Similarly, filtering rate ($\text{ml mgAFDW}^{-1} \text{ h}^{-1}$) was always higher in Lake Soyang ($1.70 \sim 3.06$)

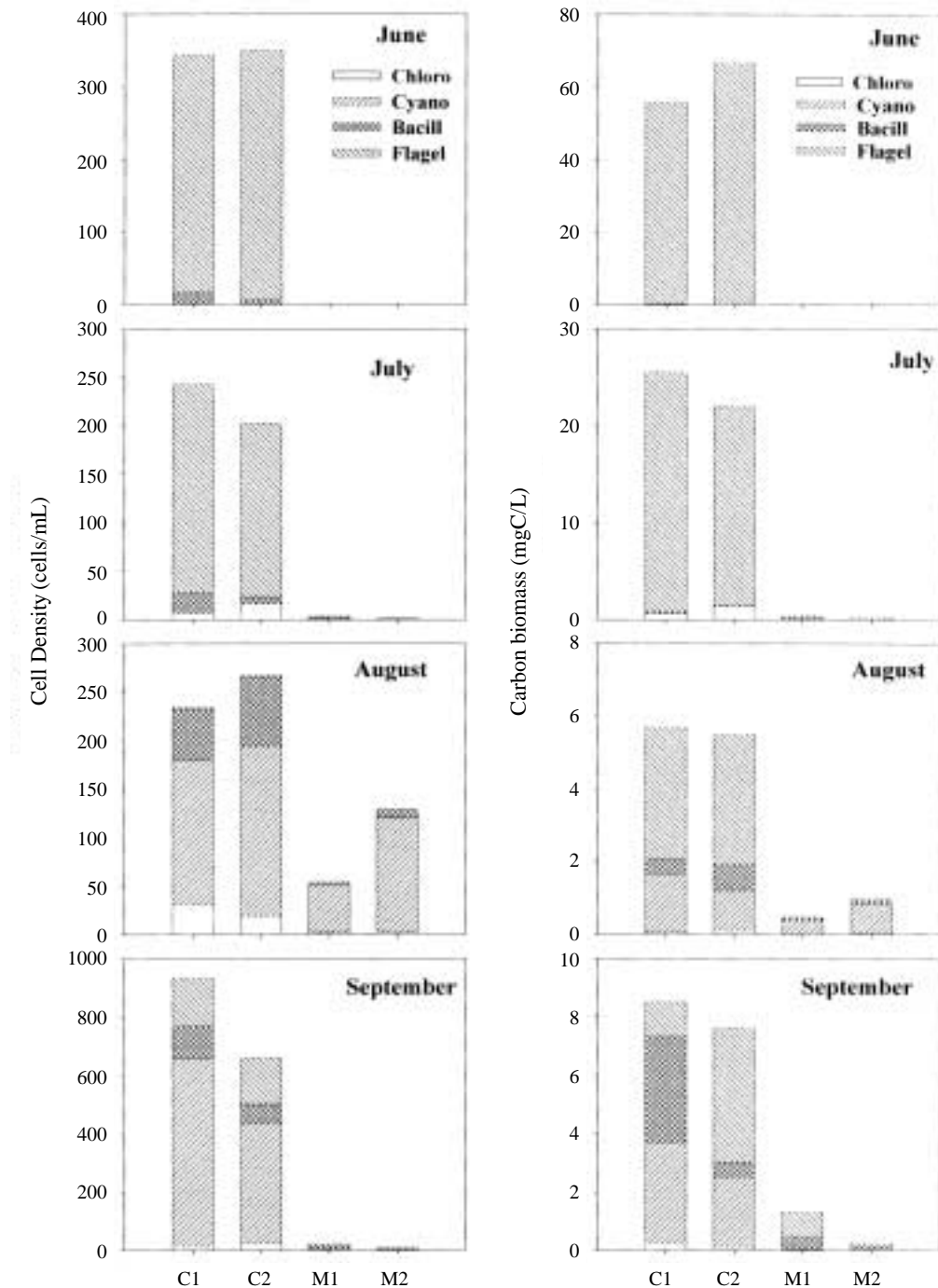


Fig. 2. Phytoplankton density and carbon biomass in different treatments (C1: control 1, C2: control 2, M1: mussel addition 1, M2: mussel addition 2) of feeding experiment in Lake Soyang between June and September 2000.

than in Lake Ilgam (0.24~0.88) (Fig. 5), and resulting difference of both filtering rates were significant ($p < 0.05$). Filtering rate per mussel ($l \text{ mussel}^{-1} \text{ day}^{-1}$) also was greater in Lake Soyang (1.6~7.8) than in Lake Ilgam (1.7~3.0) (Fig. 5).

This range is comparable to that of the zebra mussel (0.09~2.4) but greater than that of *Corbicula fluminea* (0.38~1.64) (Cohen *et al.*, 1984; Hwang, 1996; Reeders *et al.*, 1989). The disagreement of the highest values in both filtering

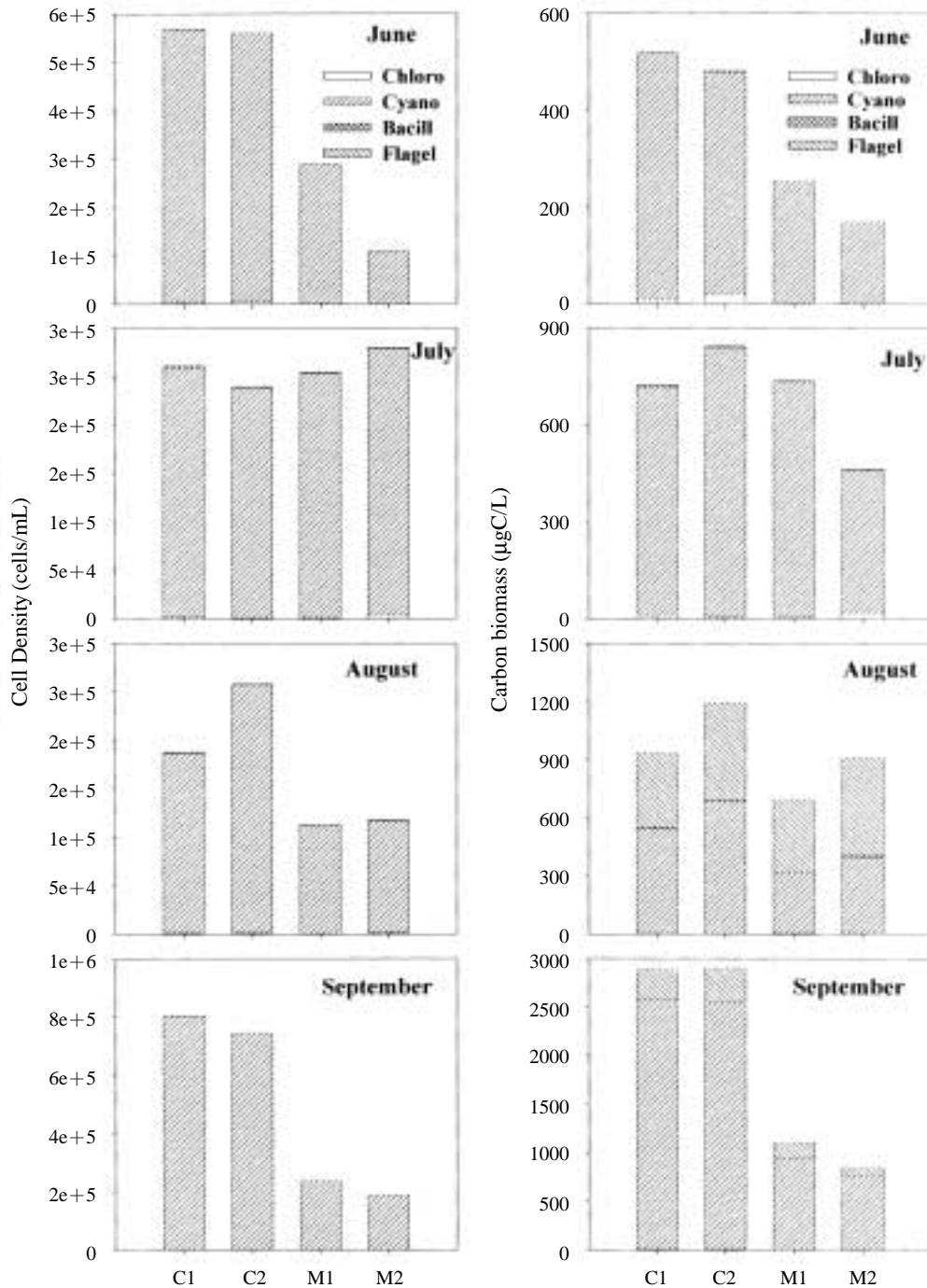


Fig. 3. Phytoplankton density and carbon biomass in different treatments (C1: control 1, C2 : control 2, M1 : mussel addition 1, M2 : mussel addition 2) of feeding experiment in Lake Ilgam between June and September 2000.

rates was due to the difference of mussel AFDWs (i.e., size). The mussel AFDW in July was smaller by 2-fold and 3-fold in Lakes Soyang and Ilgam, respectively. This result indicates that filtering activity of *Corbicula leana* did not pro-

portionately depend on the mussel size, and that smaller mussels seem to more actively filter ses-

Phytoplankton carbon flux: Total mean phytoplankton carbon flux to mussel (*C. leana*) was 3~

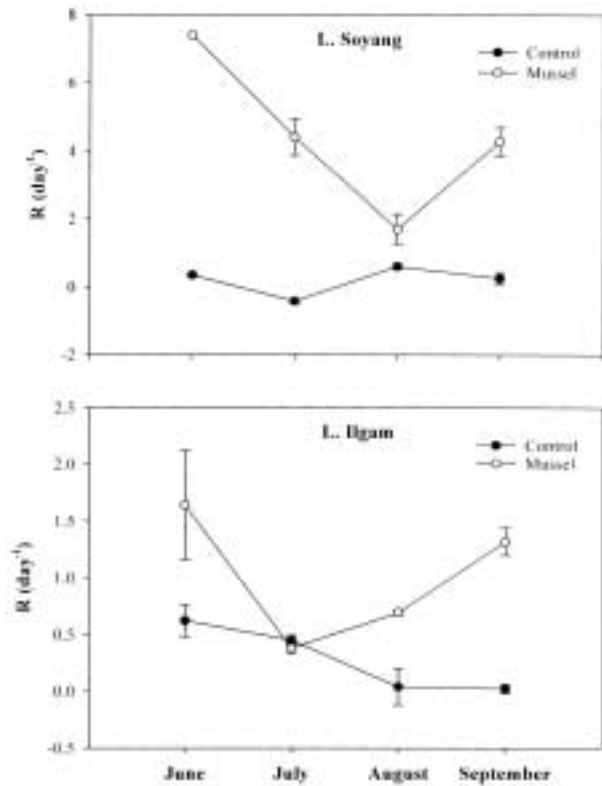


Fig. 4. Exponential death rate (R : day^{-1}) of phytoplankton in each treatment (C: control, M: mussel addition) in Lakes Soyang and Ilgam between June and September 2000.

40 fold greater in Lake Ilgam than Lake Soyang (Table 3). This is evident that although filtering rate was higher in Lake Soyang, total phytoplankton biomass was greater in Lake Ilgam. Based on the C-flux to biomass ratios, *C. leana* consumed 0.8~4.4 fold of phytoplankton standing stock in Lake Soyang, and 0.4~1.6 fold in Lake Ilgam per day (Table 3).

Much higher CF/CB ratios in Lake Soyang suggest that grazing effects of the mussel is likely stronger in less trophic condition, where algal density is relatively low. An inverse relationship between seston density and filtering activity of mussels (e.g., zebra mussel, *Mytilus edulis*) was observed in several studies (Winter, 1973; Dorigo and Smeenk, 1988; Sprung and Rose, 1988). The high density of phytoplankton, along with their large cell size or colonial forms in Lake Ilgam, might have caused more variable or presumably adverse influence on mussel filtering on seston (Hwang, 1996). While, mussels might had

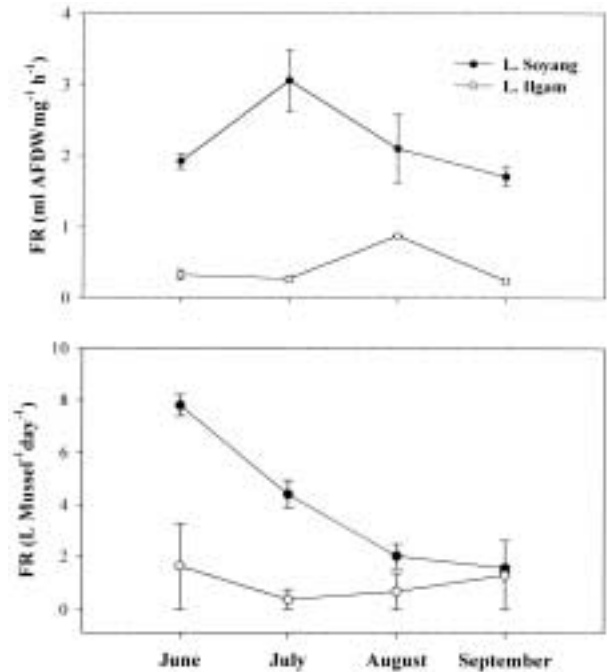


Fig. 5. Filtering rate (FR: $\text{ml mgAFDW}^{-1} \text{h}^{-1}$) of phytoplankton in each treatment (C: control, M: mussel addition) in Lakes Soyang and Ilgam between June and September 2000.

to more actively filtered sestons to compensate relatively small amount of food concentration in Lake Soyang.

Phosphorus and nitrogen change in the mussel treatment

Mussel feeding on phytoplankton affected phosphorus and nitrogen concentration in the feeding chambers. TP concentration in the mussel treatment decreased by about 5~34%, while SRP concentration increased by 30~50% in comparison with the control (Table 4). A decrease in TN also occurred, but there was no corresponding reduction of nitrate concentration. The decreases of TP and TN were mainly due to seston grazing by mussels. The degree of change in TP, TN, and SRP was similar between two lakes, and no distinct temporal patterns were observed.

This result suggests that bioavailable phosphorus and nitrogen is recycled by mussel feeding on phytoplankton. Recycled nutrients also would affect the growth of cells remaining alive in the pseudofeces or phytoplankton cells, which avoided the mussel filtering (Yamamuro and Koikes,

Table 3. Phytoplankton C-flux ($\mu\text{g C l}^{-1} \text{ day}^{-1}$) and percent C-flux to biomass ($\mu\text{g C/l}$) ratio in Lakes Soyang and Ilgam. C-flux was calculated by the product of carbon biomass and filtering rate for the mussel, using the following equation of $\text{CF} = \text{CB} \times \text{FR} \times \text{AFDW} \times (24 \text{ hrs/1 day}) \times (1 // 1,000 \text{ ml})$. C-flux to the mussel was estimated from 1 mussel as 1 l according to the feeding experiment.

	Lake Soyang			Lake Ilgam		
	Carbon Biomass (CB)	Carbon Flux (CF)	Percent CF/CB Ratio	Carbon Biomass (CB)	Carbon Flux (CF)	Percent CF/CB Ratio
	$\mu\text{g C/l}$	$\mu\text{g C l}^{-1} \text{ day}^{-1}$	day^{-1}	$\mu\text{g C/l}$	$\mu\text{g C l}^{-1} \text{ day}^{-1}$	day^{-1}
June	48.2	363.7 ± 0.4	75 ± 41	596	977 ± 282	164 ± 47
July	7.1	31.6 ± 3.8	444 ± 54	2,825	$1,070 \pm 136$	38 ± 5
August	18.4	31.3 ± 8.1	170 ± 44	1,714	$1,179 \pm 37$	69 ± 2
September	28.9	123.1 ± 12.6	426 ± 43	1,820	$2,379 \pm 210$	131 ± 12
Avg.	25.6	137.4 ± 6.1	279 ± 46	1,739	$1,401 \pm 166$	101 ± 16

Table 4. The variation of nitrogen and phosphorus concentration in the different treatments (C: control, M: mussel addition) of feeding experiment in Lakes Soyang and Ilgam in July and September 2000. N.D. denoted "not detected".

		$\text{NO}_3\text{-N}$ (mg N/l)		TN (mg N/l)		$\text{PO}_4\text{-P}$ ($\mu\text{g P/l}$)		TP ($\mu\text{g P/l}$)	
		T_0	T_{24}	T_0	T_{24}	T_0	T_{24}	T_0	T_{24}
		L. Soyang	C	1.27 ± 0.01	1.31 ± 0.02	1.45 ± 0.1	1.36 ± 0.05	2.7 ± 0	4.2 ± 0
September	M		1.29 ± 0.00		1.64 ± 0.1		6.5 ± 0.8		14.1 ± 0
L. Ilgam	C		N.D.		1.60 ± 0	2.2 ± 0	2.9 ± 0	66.9 ± 0	57.0 ± 0.5
July	M		N.D.		1.45 ± 0		4.5 ± 0		51.2 ± 0.5
L. Ilgam	C		N.D.		1.30 ± 0	2.7 ± 0	4.9 ± 0.8	60.0 ± 1.3	62.7 ± 2.2
September	M		N.D.		0.97 ± 0		6.4 ± 0		43.6 ± 1.0

1993). Although we exclude this possibility because phytoplankton samples were taken from the middle of water column in the chambers, its availability by various plankton needs to be examined. Yamamuro and Koike (1993) showed that the excretion rate of ammonia by filter-feeding *Corbicula japonica* was greater than the uptake of particulate organic nitrogen in a brackish lake, Japan. Taken together, filter-feeding *Corbicula* appears to be involved in bioturbation or other nonmetabolic processes of the upward flux of phosphorus and nitrogen.

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< 국문적요 >

식물플랑크톤에 대한 담수산 패류(참재첩)의 섭식효과

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영양상태가 다른 두 호수에서 식물플랑크톤 군집에 대한 담수산 패류의 섭식 효과를 2000년 6월부터 9월까지 조사하였다. 실험은 10 l 플라스틱 용기에 패류를 투입하지 않는 것과 투입한 것으로 처리되었고 2 반복으로 수행되었다. 수체 내 존재하는 총질소와 총인 그리고 엽록소 *a* 농도는 소양호에 비해 일감호에서 월등히 높았다 ($p < 0.01$). 일감호에서 우점한 식물플랑크톤 군집은 거의 대부분 남조류 였던 반면 소양호에서는 편모조류가 우점하였다. 패류가 투입된 용기 내 총 식물플랑크톤의 감소율은 소양호와 일감호에서 각각 $1.70 \sim 7.39 \text{ d}^{-1}$ 그리고 $0.38 \sim 1.64 \text{ d}^{-1}$ 의 범위였다. 시간에 따른 식물플랑크톤의 변화를 바탕으로 한 패류의 유기물함량에 따른 여과율 (FR; $\text{ml mgAFDW}^{-1} \text{ h}^{-1}$)은 일감호 ($0.24 \sim 0.88$)에서 보다 소양호 ($1.70 \sim 3.06$)에서 높았다. 조개 개체 당 여과율 ($I \text{ mussel}^{-1} \text{ day}^{-1}$)은 소양호에서 $1.6 \sim 7.8 \text{ l}$, 일감호에서 $1.7 \sim 3.0 \text{ l}$ 로 나타났다 ($p < 0.05$). 생물량에 대한 C-flux로 고려할 때, *Corbicula leana*는 소양호의 경우 식물플랑크톤 현존량의 0.8~4.4배를, 일감호에서는 0.4~1.6배를 섭식하는 것으로 조사되었다. 패류의 섭식 활동으로 인해 인의 농도가 조개가 없는 용기에 비해 30~50% 증가하였다. 본 연구에서 나타난 결과들은 참재첩 (*Corbicula leana*)의 여과 섭식 활동이 식물플랑크톤의 밀도와 군집구조에 따라 차이가 있음을 제시한다. 또한, 매우 부영양화된 호수에서도 참재첩은 높은 여과율을 나타냄으로써 국내 소규모의 부영양화된 호수에서 수질관리에 담수산패류를 이용할 수 있는 가능성을 제시한다.