Filtration Rates of Tropical Freshwater Bivalve Mollusks: *Pilsbryoconcha excilis compressa, Ensidens ingallsianus ingallsianus, Corbicula boudoni* and *Corbicula moreletiana*

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ABSTRACT

Filtration rates of four species of freshwater bivalve mollusks collected from Thai waters were measured in laboratory. Average filtration rates of *Ensidens ingallsianus ingallsianus, Pilsbryoconcha excilis compressa, Corbicula boudoni* and *Corbicula moreletiana* were 0.320, 0.322, 0.957 and 0.862 L/h/individual, 0.015, 0.025, 0.124 and 0.114 L/h/g total wet weight, and 0.326, 0.652, 5.107 and 3.817 L/h/d dry meat weight, respectively. Average filtration rates per individual and average filtration rates per gram biomass of both *Corbicula* species were significantly higher ($P<0.05$) than those of *Ensidens ingallsianus ingallsianus* and *Pilsbryoconcha excilis compressa*. Average filtration rates per individual of *C. boudoni* and *C. moreletiana* were 3.0 and 2.7 times that of *E. ingallsianus ingallsianus* and *P. excilis compressa*. Average filtration rate per gram total wet weight of *C. boudoni* and *C. moreletiana* were 8.3 and 5.0, and 7.6 and 4.6 times that of *E. ingallsianus ingallsianus* and *P. excilis compressa*. Considering their filtration capability, *C. boudoni* and *C. moreletiana* seem to have a higher potential to be used for the remediation of eutrophic water bodies and eutrophic aquaculture ponds. However, more detail studies of these bivalve species regarding population dynamics and their ability to live in polluted waters are needed in order to verify their suitability as bioremediators.

Keywords: Freshwater bivalve mollusk, Filtration rate, *Ensidens ingallsianus ingallsianus, Pilsbryoconcha excilis compressa, Corbicula boudoni, Corbicula moreletiana*

INTRODUCTION

Bivalve mollusks are suspension feeders, filtering algae, detritus and other organic and inorganic materials from the water through their gills. Unwanted material is ejected as pseudo-feces. The rejected particles are wrapped together in mucus and are expelled without passing through the digestive tract. This feeding behavior makes bivalve mollusks a potential candidate as a bioremediator in polluted eutrophic water bodies and for the treatment of aquaculture pond water and aquaculture pond effluents containing a heavy load of organic- rich suspended solids. Marine bivalve mollusks

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such as oysters and mussels have been used to reduce nutrient pollution from waste salmon feed by co-culturing them with salmon (Neori *et al*., 2004; Sterling and Okumus, 1995). Jones *et al*. (2001) reported that oysters reduced levels of nitrogen and phosphorus in shrimp effluent by 72 and 86%, respectively. Similarly, turbidity and chlorophyll *a* concentrations in fish farm effluent were reduced by 68 and 79%, respectively (Shpigel *et al*., 1997). In estuaries, the cultivation and harvest of pearl oysters (*Pinctada imbricata*) can balance the nitrogen input of a sewage treatment plant (Gifford *et al*., 2005 cited by Gifford *et al*., 2006). The deployment and harvest of bivalve mollusks have been proposed in Sweden and USA, to mitigate anthropogenic nutrient input to coastal waters (Haamer, 1996 and Rice, 2001 cited by Gifford *et al*., 2006). Re-establishment of oyster bars is being done in many areas of the USA including Chesapeake Bay to mitigate eutrophication problems (Coen and Luckenbach, 2000; Kirby and Miller, 2005).

For freshwater bivalve species, recent attention has been given to the possible use of zebra mussel (*Dreissena polymorpha*), in the restoration of eutrophic lakes by means of biomanipulation (Richter, 1985 as cited by Reeders *et al*., 1989). As a filter feeder, all suspended particles are filtered from the water column indiscriminately. Food particles are selected and the remaining fraction is deposited as pseudo-feces resulting in net removal of particles from water column (Morton, 1969 cited by Reeders *et al*., 1989; Ten Winkel and Davids, 1982). The introduction of zebra mussel into Lake Erie resulted in a markedly decrease in water turbidity. Secchi disc visibility increased by 1.24 m and chlorophyll *a* concentrations reduced by 43% (Leach, 1993 cited by Gifford *et al*., 2006). Meanwhile, Phelps (1994) reported that following the establishment of the Asiatic clam (*Corbicula fluminea*) in the Potomac River estuary in the early 1980s, water quality improved substantially, with submerged aquatic vegetation that had been absent for 50 years reappearing; subsequent fish and bird surveys revealed large increases in their respective population. In this study we measured and compared filtration rates of four tropical freshwater bivalve mollusks collected from Thai waters to evaluate their potential as bioremediators for eutrophic water bodies.

MATERIALS AND METHODS

Four species of freshwater bivalve mollusks, namely *Ensidens ingallsianus ingallsianus, Pilsbryoconcha excilis compressa, Corbicula boudoni* and *Corbicula moreletiana* were collected from natural beds in Huay Sai and Pasak rivers in Saraburi province and were acclimated in fiber-glass tanks in the laboratory for one week prior to the experiment. Shell length of the bivalves were between 6.0-6.8 cm for *Ensidens ingallsianus ingallsianus*, 5.8-6.4 cm for *Pilsbryoconcha excilis compressa*, 2.4-2.7 cm for *Corbicula boudoni* and 2.3-2.6 cm for *Corbicula moreletiana*, with respective total wet weights between 17.64-23.53, 9.45 -17.58, 6.41-9.40 and 6.48-9.00 g (Table 1). The experiments were initiated by placing individuals in separate glass aquaria containing 500 ml dechlorinated tap water

Table 1. Shell size, total wet weight and dry meat weight of freshwater bivalve mollusks used in the experiment (Mean±S.D. and size range)

Species	Size (cm)			Total wet weight (g)	Dry meat weight (g)
	length	height	depth		
Ensidens ingallsianus ingallsianus	6.3±0.3	2.6±0.1	1.9±0.1	20.36±2.43	0.97±0.14
	6.0-6.8	2.5-2.8	1.7-2.0	17.64-23.53	0.91-1.13
Pilsbryoconcha excilis compressa	6.1±0.2	2.8±0.1	1.4±1.8	12.78±3.30	0.53±0.21
	5.8-6.4	2.7-2.9	1.1-1.8	8.62-17.58	0.28-0.91
Corbicula boudoni	2.5±0.2	2.7±0.2	1.7±0.1	7.81±1.12	0.19±0.02
	2.4-2.7	2.4-2.9	1.6-1.8	6.41-9.40	0.16-0.22
Corbicula moreletiana	2.5±0.1	2.5±0.2	1.8±0.1	7.56±0.88	0.24±0.08
	2.3-2.6	2.2-2.7	1.7-2.0	6.48-0.88	0.16-0.37

and allowing each bivalve to acclimate for 1 h. Each aquarium was slightly aerated. *Chlorella* sp. was mass cultured in the algal laboratory and used as feed for all treatments. Algal cell concentration was estimated by counting under microscope using haemacytometer. Algal cell size was measured using a microscope equipped with DP2BSW software and algal cell volume was calculated using geometric models for calculating cell biovolume (Sun and Liu, 2003). Dry meat weight of the experimental mollusks was obtained through oven drying overnight at 103-105^{o}C. Temperature during the experiment was between 27-28.5^{o}C. Treatments consisted of four bivalve species plus a control without any bivalve, with six replications per treatment. After 1 h the bivalves were fed with *Chlorella* sp. at 1.5 mm^3/l. Filtration rates were calculated from the decline in the number of *Chlorella* sp. after 1 h using an equation derived from Coughlan (1969) (Reeders *et al.*,1989) as follows:

$$FR = (V/nt)\ [(\ln Co-\ln Ct) - [(\ln Co^{/}-\ln Ct^{/})]$$

Where, FR = filtration rate (l/h), V = volume water (l), n = the number of bivalves, t = timespan (h), Co and Ct = the concentration (cells/l) at time t = 0 and t respectively, $Co^{/}$ and $Ct^{/}$ ditto for the blank.

Average values of filtration rates of each bivalve species were compared statistically using Duncan's New multiple Range Test.

RESULTS AND DISCUSSION

The filtration rates of the four bivalve species are presented in Table 2, including filtration rates per gram of biomass (wet weight and dry meat weight), and average filtration rates per individual and per gram of biomass.

Table 2. Filtration rates of 4 species of freshwater bivalve mollusks (Mean±S.D.)

Species	Shell length (cm)	Total wet weight (g)	Dry meat weight (g)	Filtration rate		
				L/h/ individual	L/h/g total wet weight	L/h/g dry meat weight
Ensidens ingallsianus ingallsianus	6.3±0.3	20.36±2.43	0.97±0.14	0.320±0.138	0.015±0.005	0.326±0.114
Pilsbryoconcha excilis compressa	6.1±0.2	12.78±3.30	0.53±0.21	0.322±0.117	0.025±0.007	0.652±0.268
Corbicula boudoni	2.5±0.2	7.81±1.12	0.19±0.02	0.957±0.223	0.124±0.029	5.107±1.172
Corbicula moreletiana	2.5±0.1	7.56±0.88	0.24±0.08	0.862±0.119	0.114±0.011	3.817±1.109

When average values of filtration rates of these bivalve species were compared statistically there was no significant difference (P>0.05) between average filtration rates of *E. ingallsianus ingallsianus* and *P. excilis compressa,* neither average filtration rates per individual nor per gram biomass. Average filtration rates per individual and per gram total wet weight of the two *Corbicula* species were also not significantly different (P>0.05) but average filtration rates per gram dry meat weight of *C. boudoni* was significantly higher than that of *C. moreletiana* (P<0.05). Average filtration rate per gram dry meat weight of *C. boudoni* was 1.3 times that of *C. moreletiana* (Table 3).

Average filtration rates per individual and per gram biomass of both *Corbicula* species were significantly higher (P<0.05) than those of *E. ingallsianus ingallsianus* and *P. excilis compressa* (Table 3). Average filtration rates per individual of *C. boudoni* and *C. moreletiana* were 3.0 and 2.7 times, respectively, that of *E. ingallsianus ingallsianus* and *P. excilis compressa*.

Average filtration rate per gram total wet weight of *C. boudoni* was 8.3 and 5.0 times that of *E. ingallsianus ingallsianus* and *P. excilis compressa*. Average filtration rate per gram dry meat weight of *C. boudoni* was 15.7 and 7.8 times that of *E. ingallsianus ingallsianus* and *P. excilis compressa*.

Average filtration rate per gram total wet weight of *C. moreletiana* was 7.6 and 4.6 times that of *E. ingallsianus ingallsianus* and *P. excilis compressa*. Average filtration rate per gram dry meat weight of *C. moreletiana* was 11.7 and 5.9 times that of *E. ingallsianus ingallsianus* and *P. excilis compressa.*

There have been previous studies reported on filtration rates of a few species of freshwater bivalve mollusks. Another *Corbicula* species, the Asian freshwater clam (*C. fluminea*) which is native to Southeast Asia, was reported to have high filtration rates of up to 2.50 L/h (McMahon, 1991). Filtration rates of *Limnoperna fortenei*, another freshwater bivalve mollusk native to the rivers of Southeast Asia, were 9.9,

Table 3. Comparison of the mean filtration rates of the 4 species of freshwater bivalve mollusks

Filtration rate ± S.D.	***Ensidens ingallsianus ingallsianus***	***Pilsbryoconcha excilis compressa***	***Corbicula boudoni***	***Corbicula moreletiana***
l/h/individual	0.320 ± 0.138[a]	0.322 ± 0.117[a]	0.957 ± 0.223[b]	0.862 ± 0.119[b]
l/h/g total wet weight	0.015 ± 0.005[a]	0.025 ± 0.007[a]	0.124 ± 0.029[b]	0.114 ± 0.011[b]
l/h/g dry meat weight	0.326 ± 0.114[a]	0.652 ± 0.268[a]	5.107 ± 1.172[b]	3.817 ± 1.109[c]

Remark: Average values with different superscripts in the same row are significantly different ($P<0.05$).

13.1 and 17.7 ml/h/mg tissue dry weight at temperatures of 15, 20 and 25°C, respectively, for 23 mm bivalve, and 17.7, 20.8 and 29.5 ml/h/mg tissue dry weight at temperatures of 15, 20 and 25°C, respectively, for 15 mm bivalve (Sylvester *et al*., 2005). Filtration rate of zebra mussel (*Dreissena polymorpha*), the most successful invasive species in Europe and North America, was reported to be between 15.3-68.6 mL/h/individual (Yu and Culver, 1999). MacIsaac *et al*. (1992) estimated that zebra mussel population on Hen Island Reef in Lake Erie, U.S.A., could theoretically filter a 7 m water column between 3.5 and 18.8 times per day.

Based on their filtration capability, *C. boudoni* and *C. moreletiana* have a higher potential to be used as bioremediators for the remediation of eutrophic water bodies including aquaculture ponds. However, more detailed studies concerning their population dynamics and their ability to live in polluted water are needed to further verify their suitability as bioremediators. Freshwater bivalve mollusks have been proven to be effective bioremediators in eutrophic water, as in the case of the Asiatic clam (*Corbicula fluminea*) in which the establishment of its population in the Potomac River estuary, in Washington, D.C., USA in the early 1980s resulted in substantial improvement in water quality, the reappearance of submerged aquatic vegetation which had been absent for 50 years, and the increase in fish and bird population (Phelps, 1994). Recently, attention has also been given to the potential of using *Dreissena polymorpha* in the restoration of eutrophic lakes through biomanipulation (Richter,1985 cited by Reeders *et al*., 1989) because zebra mussels can improve water quality by reducing phytoplankton biomass (Holland, 1993 and Fahnensteil *et al*., 1995 cited by Pires and Donk, 2002; Caraco *et al*., 1997), decreasing seston concentration (Budd *et al*., 2001), and changing phytoplankton composition (Smith *et al*., 1998; Strayer *et al*., 1999).

CONCLUSION

Average filtration rates of *Ensidens ingallsianus ingallsianus, Pilsbryoconcha excilis compressa, Corbicula boudoni* and *Corbicula moreletiana* were 0.320, 0.322, 0.957 and 0.862 L/h/individual, 0.015, 0.025, 0.124 and 0.114 L/h/g total wet weight, and 0.326, 0.652, 5.107 and 3.817 L/h/d dry meat weight, respectively. Average filtration rates per individual and average filtration rates per gram biomass of both *Corbicula* species were significantly higher ($P<0.05$) than those of *E. ingallsianus ingallsianus* and *P. excilis compressa*. Average filtration rates per individual of *C. boudoni* and *C. moreletiana* were 3.0 and 2.7 times those of *E. ingallsianus ingallsianus* and *P. excilis compressa*, and average filtration rate per gram total wet weight of *C. boudoni* and *C. moreletiana* were 8.3 and 5.0, and 7.6 and 4.6 times those of *E. ingallsianus ingallsianus* and *P. excilis compressa*, respectively. Considering their filtration capability, *C. boudoni* and *C. moreletiana* have a higher potential to be used as bioremediators for the remediation of eutrophic water bodies including aquaculture ponds. However, more detailed studies concerning their population dynamics and their ability to live in polluted waters are needed to further verify their suitability as bioremediators.

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