The ingestion rate of *Mytilopsis sallaei* at different salinity and mussel size

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Abstract

The large amount of nutrients released into natural waters is causing algal blooms all over the world. Many attempts is being done to try to control the blooms and recent research is investigating a method were mussels is used to clean the water from algal biomass with regard to their removal function of particle matter from water. Mytilopsis sallei is a small, finger-nail sized mussel, growing to an average size of 25 mm. It is a suspension feeder; zooplankton, phytoplankton and other suspended particulate organic matter are consumed. This mussel has been responsible for massive fouling on wharves and marinas but it can alter aquatic environments through its substantial filtration capability which is related to their ingestion rate. This study used lentic method to (1) determine the ingestion rate of Mytilopsis sallei fed Isochrysis galbana at different salinity and (2) determine the ingestion rate of the same mussel fed Chlorella vulgaris for different mussel size. The ingestion rates of Mytilopsis sallei on Isochrysis galbana were highest at salinity 25‰, second at 30‰, third at 20‰, fourth at 35‰ and lowest at 15‰. The ingestion rate decreased with time for all observed salinities. The ingestion rate of Mytilopsis sallei on Chlorella vulgaris was increasing with mussel size. The result from this research can be used to predict the large-scale grazing effects of the mussel and for developing an industrial biofilter based on mussel filtration.

Key words: Mytilopsis sallei, ingestion rate, salinity, mussel size
1. Introduction

Algal blooms occur worldwide at an increasing rate and many scientists explain this by the large release of nutrients into our natural waters. The releases are mostly due to anthropogenic activities such as the use of fertilizers in agriculture and waste product produced by the industry sector. These algal blooms is harmful for the marine ecosystems and also to humans when eating seafood or when getting in contact with affected water. When algal biomass is increasing the organisms in the water is aggregating near the surface causing a decrease of available light and when the algae dies a great amount of oxygen is needed for degrading of the algal biomass and this in turn leads to oxygen lack further down in the sea (Anderson et al, 2002).

Many attempts has been and is being done to control algal blooms and now research is being made whether specific mussels can be used in the process of cleaning water to reduce the effects of the blooming. In particular, *Dreissena polymorpha*, a freshwater bivalve, is being studied in regard of their removal function of particle matter from water (Inoue et al, 2000). *Mytilopsis Sallei* is a mussel in the same family as *Dreissena polymorpha*, *Dreissenidae*, originating from Central America. In 1990 the mussel was found in Maluan Bay in Xiamen, south east China (Mingyang et al, 2008). Mytilopsis Sallei has an extensive range of environmental tolerance, including a wide range of temperature and salinity (Verween et al, 2007). The removal function of particle matter is related to the ingestion rate of the mussel which in turn differ with changes in salinity. In this research the relation between salinity and ingestion rate has been studied in an attempt to find at which salinity and at what time the ingestion rate is the highest so that an optimal rate can be achieved when using the mussels in water treatment. The ingestion rate was also studied as a function of different mussel sizes. The micro algae used when determined the ingestion rate at different salinities was *Isochrysis galbana* and the green micro algae *Chlorella vulgaris* was used when determined the relationship between ingestion rate and mussel size.

1.1 Aim

The aim of this study was

- To determine when during 9 hours and at which salinity the ingestion rate for *Mytilopsis sallei* is the highest using the micro algae *Isochrysis galbana*.
- To determine the relation between the ingestion rate and mussel size. of *Mytilopsis sallei* using the micro algae *Chlorella vulgaris*.

1.2 Acknowledgements

This project was based on State Natural Sciences Fund and has been conducted under the supervision of Professor Cai Lizhe, Xiamen University. This project has been done by students participating in Summer Research School 2009 at Xiamen University.

2. Materials and method
2.1 Mytilopsis Sallei and Chlorella preparations

*Mytilopsis sallei* was collected in Yuandan Lagoon, Xiamen. The shells of the mussels were cleaned from deposits and then the mussels were kept in an aquarium 15 days before the experiment started to make sure the mussels got used to the environment in the laboratory. During the experiment the mussels were fed by the micro algae *Isochrysis galbana*.

2.2 Experimental procedure

4 tanks, 3 experimental and 1 control tanks, each containing 8 liters of seawater with the algae *Isochrysis galbana* were prepared in the laboratory. The salinity was determined using a Hand Refractometer produced by Atago and adjusted to fit the different predestined salinities by adding either pure water if the salinity was too high or NaCl if the salinity was too low. 30 mussels were collected from the aquarium and separated from other species and then put 10 by 10 in each of the experimental tanks. The fourth tank was used as a control tank due to possible change in algal concentration during the experiment. To prevent the algae from sinking an air charging system were put in each tank and kept there during the whole experiment. Due to changes in ingestion rate over the day, depending on amount of available light and temperature in the laboratory, the different experiments were performed during the same time of the day for all 5 salinities. The experiments started at 10:30 am every time and the measurements were then done at 1:30 pm, 4:30 pm and 7:30 pm respectively. The concentration of algae in the water was measured by Z2 Coulter Particle Count and Size Analyzer produced by Beckman Coulter. The initial concentration was measured when the mussels where first placed in the tanks and then the concentration of algae in the tank water was continuously measured every third hour during a 9 hour period. 3 tests from each tank were taken at every measurement and then the average value of the concentration was calculated. Because of the Z2 Coulter Particle Count and Size Analyzer counting every particle in the tests including both algae and other particles in the water the background concentration was controlled at every measurement and drawn of the result to get only the algae concentration in the water. This procedure was performed at 5 different salinities; 15, 20, 25, 30 and 35‰. The experiment where the relation between ingestion rate and mussel size was to be determined the mussels was divided into 3 groups, A, B and C, depending on their length, height and width. The mean value of the sizes in the different groups can be seen in Table 1. The same procedure as described above was then applied at this experiment as well but during 6 hours instead, the concentration of micro algae in the water was determined every third hour during this period at salinity 30‰.
Table 1. Mean value of length, height and width for 3 different groups of mussels.

<table>
<thead>
<tr>
<th></th>
<th>Length (cm)</th>
<th>Height (cm)</th>
<th>Width (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.91</td>
<td>1.32</td>
<td>1.11</td>
</tr>
<tr>
<td>B</td>
<td>2.52</td>
<td>1.23</td>
<td>1.09</td>
</tr>
<tr>
<td>C</td>
<td>2.18</td>
<td>1.02</td>
<td>0.91</td>
</tr>
</tbody>
</table>

**2.3 Ingestion rate calculations**

The ingestion rate was calculated after every 3 hour period for each of the 5 salinities using the following formulae (Farhadian et al, 2007):

\[
I_R = ( (C_0 - C_t) - (A \cdot C_0) ) \cdot B
\]

where

\[
A = \frac{(C_1 - C_2)}{C_1}
\]

\[
B = \frac{V}{(n \cdot t)}
\]

Parameters used in the formula is described below.

- \( I_R \) number of algae ingested mussel\(^{-1}\) hour\(^{-1}\)
- \( C_0 \) initial algal concentration in each experimental tank
- \( C_1 \) final algal concentration in each experimental tank
- \( C_1 \) initial algal concentration in each control tank
- \( C_2 \) final algal concentration in each control tank
- \( V \) volume of the tank
- \( n \) number of mussels in each tank
- \( t \) experimental time

**3. Results**
The ingestion rate of Mytilopsis sallei is the highest at salinity $25\%$ and between 0 and 3 hours. The result of the ingestion rates from all 5 salinities is presented in Figure 1 and to make the result more lucid the exact value of the ingestion rates can be seen in Table 2.

![Figure 1. Mean value of the ingestion rate at different time intervals and for different salinities.](image)

<table>
<thead>
<tr>
<th>Salinity</th>
<th>0-3 h</th>
<th>3-6 h</th>
<th>6-9 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>15‰</td>
<td>18231</td>
<td>15307</td>
<td>12335</td>
</tr>
<tr>
<td>20‰</td>
<td>25821</td>
<td>21796</td>
<td>19329</td>
</tr>
<tr>
<td>25‰</td>
<td>33991</td>
<td>31027</td>
<td>28309</td>
</tr>
<tr>
<td>30‰</td>
<td>30727</td>
<td>27413</td>
<td>26212</td>
</tr>
<tr>
<td>35‰</td>
<td>22658</td>
<td>18732</td>
<td>16315</td>
</tr>
</tbody>
</table>

Bigger mussels in group A, with a mean length 2.91 cm, mean height of 1.32 cm and mean width of 1.11 cm, has a higher ingestion rate than the smaller mussels in group B and C for both time intervals; 0-3 hours and 0-6 hours. The ingestion rate for the different groups of mussels is presented in Figure 2 and the numbers is shown in Table 3.
Figure 2. Mean value of ingestion rate as a function of time for different sizes of mussels.

Table 3. Ingestion rates during 3 time intervals for different sizes of mussels.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3h</td>
<td>356393</td>
<td>281547</td>
<td>19609</td>
</tr>
<tr>
<td>0-6h</td>
<td>718271</td>
<td>577204</td>
<td>508842</td>
</tr>
</tbody>
</table>

4. Discussion

From the result it’s clear that the ingestion rate is the highest as salinity 25‰. Comparing the background concentration in the control tank of micro algae at the different salinity the explanation of this can be the increasing amount of algae with time at 25‰ compared to the same or decreasing amount at the other salinities. Thus, this is the most optimal salinity for *Isochrysis galbana* amongst the salinities used in this research and the more algae available for the mussel, the higher ingestion rate. The ingestion rate is decreasing with time for all salinities and is the lowest for 15‰. This can be due to the fact that no algae were added to the tanks during the experiment and hence the amount of algae decreased with time as a consequence of the mussel consuming algae. When bivalves experience lower algal concentrations this in turn leads to reduction in siphon-opening and valve-gape and sometimes to complete closure (Riisgard et al, 2003). The mussel is consuming algae at all salinities and no dead mussels were observed during the experiment which indicate that the mussel has a wide salinity range, which also has been discussed in another report (Verween et al, 2007). The ingestion rate is significantly different between different
salinities indicating that salinity is an important factor influencing the feeding, a result also shown in another research where marine bivalves have been studied (Zhuang, 2006). The ingestion rate is the lowest at salinity 15‰ and this outcome is similar to the result found by Zhuang (2006) where 18‰ was the harshest stress to the feeding on bivalve *Meretrix Meretrix* out of the salinity range 18-34‰. The highest ingestion rates in that study were found to be at salinity 27-30‰ which is in the same range as the highest ingestion rates found here at salinity 25 and 30‰ (Zhuang, 2006). In the study by Zhuang (2006) the mussels where divided into 3 groups depending on size, the same method as used in this research. All 3 groups showed similar pattern in ingestion rate as a function of salinity, just as observed in this experiment as well; the bigger the mussel, the higher the ingestion rate. The ingestion rate is related to the filtration rate which is defined as the volume of water that passes through the mussels’ gills per unit of time (Elliot et al). The filtration rate is possible higher within the bigger mussels due to their having bigger gills and therefore they also have a higher ingestion rate. Little research has been found on the filtration rate as a function of mussel size for *Mytilopsis sallei* and even though there are some information about mussels in the same family the filtration rate can differ between them (Xioa-xin et al, 2000).

5. Conclusion

This research has shown that *Mytilopsis sallei* achieved the highest ingestion rate at salinity 25‰ and also that the bigger mussels of this species the higher rate of ingestion. Results also pointed out that the ingestion rate at the most effective salinity, 25‰, was decreasing during 9 hours. The result can be used when designing how to use this mussel specie in water treatment. However, this project just point out two of many variables that may effect the ingestion rate of *Mytilopsis sallei* and further investigation need to be done about how the ingestion rate of the mussel changes with temperature, pH, velocity of flow and the structure and concentration of different algae species.
6. References


BAO Yong-bo, YOU Zhong-jie (2006), The present researching status of ingestion rate’s influence factors of marine suspension-feeding shellfish, Vol 27, No. 1


