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The influence of salinity, diurnal rhythm and daylength on feeding behavior in *Meretrix meretrix* Linnaeus

Shuhong Zhuang *

Biological Science and Chemical Engineering School, Yantai University, Yantai 264005, China

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Abstract

A nature-simulating culture system was used to explore the influence of salinity, the diurnal cycle and daylength on ingestion rate (IR) and assimilation efficiency (AE) of *Meretrix meretrix*. The clams used in the experiments were grouped into three sizes: small, with a shell length of 2.70 ± 0.10 cm and a dry fresh weight of 0.35 ± 0.04 g; medium, with a shell length of 4.00 ± 0.05 cm and a dry fresh weight of 1.25 ± 0.05 g; and large, with a shell length of 5.00 ± 0.10 cm and a dry fresh weight of 2.45 ± 0.10 g. The clams in all size groups demonstrated a common response pattern in IR and AE under salinities ranging from 18 to 34 ppt. The clams achieved the greatest IR within the salinity range 27 to 30 ppt. There was a marked reduction in IR outside this range. Of the salinities tested 18 ppt was the harshest stress to the feeding of *M. meretrix*. Between the salinities 24 to 34 ppt, changes in AE of the clam were the inverse of those observed in IR, suggesting that *M. meretrix* is able to compensate for the loss of IR by an increase in AE. Although the effect of both salinity and body size of the clam was significant on both IR and AE, salinity had evidently stronger influence than body size. All sizes of clam showed a three-phase diurnal feeding pattern: a high ingestion phase from 00:00 to 08:00, a low ingestion phase from 12:00 to 20:00, and a changing phase between low and high ingestion phases. The IR response to daylength comprised a high and constant feeding phase at daylengths from 0 to 16 h (longer darkness) and a declining and unstable feeding phase as daylength increased from 16 to 24 h (shorter darkness). All sizes of clams demonstrated an inverse adaptation to AE compared with IR, indicating that the clam is able to achieve a stable feeding physiology by compensating for daylength-induced variations in IR by changing AE. The ANOVA analysis also showed that both diurnal cycle and daylength affected IR and AE of the clam very significantly, body size did not, however.

Keywords: *Meretrix meretrix*; Ingestion rate; Assimilation efficiency; Salinity; Diurnal cycle; Daylength

1. Introduction

Meretrix meretrix L. is a nearly equilateral, triangular shaped clam with highly coloured shells. It inhabits sandy substrates in the lower intertidal and shallow subtidal areas of the Bohai and western Yel-

* Fax: +86 535 6902063.
E-mail addresses: zhuangsh@china.com.cn, zhuangshh@netscape.net.

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low Seas. For several years this clam has been cultured by the native farmers of the Shandong Peninsula, China because of its relatively high meat yield, delicious and tender taste and ease of culture in the natural habitat as well as for its attractive appearance (He et al., 1997; Zhuang and Wang, 2004).

The feeding physiology and ecology of bivalves, particularly cultured species, have been widely studied for decades. In these studies, physiological and ecological parameters, such as clearance rate, ingestion rate, assimilation efficiency and scope for growth, have been widely used in considering the energetic budget and nutrient cycles (Aldridge et al., 1995; Fang et al., 1996; Kuang et al., 1996; MacDonald et al., 1998; Hawkins et al., 2002). In a previous study, the feeding physiology of *M. meretrix* on a laboratory scale was preliminary to a further determination of economical farming densities and environmental carrying capacity in the local intertidal zones and shallow sub-littoral areas (Zhuang et al., 2004). In order to highlight feeding behavior under different culture circumstance, this subsequent study was focused particularly on the variation of ingestion rate and assimilation efficiency as influenced by salinity, diurnal cycle and daylength. There is currently no information on these aspects of the physiology of this species in the scientific literature.

2. Materials and methods

2.1. Clams used in the experiments

A range of sizes of *M. meretrix* to support the experiments was collected from the intertidal zone of the local island of Changshan archipelago in July 2003. The collected clams were grouped into 3 sizes: small, with a shell length of 2.70 ± 0.10 cm and a dry fresh weight of 0.35 ± 0.04 g; medium, with a shell length of 4.00 ± 0.05 cm and a dry fresh weight of 1.25 ± 0.05 g; and large, with a shell length of 5.00 ± 0.10 cm and a dry fresh weight of 2.45 ± 0.10 g. The healthy clams were acclimated for at least one week in a acclimation tank of the laboratory culture system to an ambient temperature of 16–18 °C and a natural diurnal cycle of 13 h light/11 h dark. After acclimation healthy individuals were selected for each experiment. During the acclimation the diet type and concentration in the culture tanks were identical to those used in the experiments.

2.2. Experimental methods

The experiments were carried out in the marine propagation center of the Changdao Institute of Marine Aquaculture between August and October 2003. A tank culture system was set up to simulate the natural environment of the clam with regard to both water and substrate. Seawater was first pumped into a large (100 m^3) sedimentation container and then into a smaller reservoir. The latter functioned as a water pressure regulator and an inflow diet concentration regulator to maintain a constant flow of water with constant diet concentration into the $40 \times 40 \times 45$ cm deep culture tanks in which the clams were held. The clams were stocked at a density of 10 per tank. Each experiment comprised four replicate culture tanks and two controls that were used to eliminate the influence of both diet propagation (such as microalgae) and sedimentation as experimental variables. During the experiments the diet concentration in the inflow and outflow water was microscopically monitored. The diet concentration of inflow water was regulated by adding the microalga, *Isochrysis zhanjangensis*, to the reservoir tank. For each experiment the shell length and dry weight of both the shell and the flesh of the clam were precisely measured.

To determine the effect of salinity, the feeding pattern of the clam was observed for three days at each of the following five salinities: 18, 23, 27, 30 and 34 ppt (NaCl) which were diluted with fresh water or strengthened with sea salt. The treatment of salinities was separate with the test sequence from 18 to 34 ppt. After a salinity treatment had been finished, the salinity in the reservoir was regulated for next salinity treatment and the clam in the culture tank was renewed from the acclimation tank. The salinity of the culture water was measured with a salinometer (Jenco-3107).

For observation of the feeding rhythm of the clam during the diurnal cycle, a normal cycle of 12 h light (06:00 to 18:00 h)/12 h dark (18:00 to 06:00 h) was chosen to obtain a generalized and unstressed feeding pattern. The light intensity used in the light period was 9.8 W m^{-2} (on the water surface of the culture tank) which was about the average light intensity at the