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Influence of Water Temperature and Salinity on Oxygen Consumption and Filtration Rate of Ark Shell, *Anadara granosa bisenensis*

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ABSTRACT

The filtration rate and oxygen consumption of *Anadara granosa bisenensis* were measured at 4 different temperature (10℃, 15℃, 20℃, and 25℃) and 4 different salinity levels (20, 25, 35, and 40 psu), using an indirect method under laboratory conditions.

The samples were divided into two groups: a large-sized group (shell length: 34.58 ± 2.23 mm, body weight: 12.43 ± 0.44 g) and a small-sized group (shell length: 20.60 ± 0.85 mm, body weight: 4.41 ± 2.30 g).

Filtration rate and oxygen consumption increased with the increase of various temperatures and salinity levels. Also, the filtration rate and oxygen consumption of the small-sized group were higher than those of the large-sized group.

These results indicate that the filtration rate and oxygen consumption of *Anadara granosa bisenensis* depends on environmental conditions, especially on water temperature and salinity.

Keywords: *Anadara granosa bisenensis,* Salinity, Temperature, Filtration rate, Oxygen consumption.

INTRODUCTION

The ark shell, *Anadara granosa bisenensis*, is distributed throughout Japan, China, Korea, and the Philippines. Its habitat is usually soft mud with fine sand, with a water depth of about 3-50 m. It uses its byssus to attach to gravel or dead shells. The temperature range for growth is 5-25℃, with a salinity range of 26-32 psu. It grows more quickly from April to October, the period of highest temperatures. This species, which has a rather large shell, is of high economic value (Wang, 1993).

The oxygen consumption and filtration rate are very important parameters in determining individual growth status. With reference to relative studies, Devi and Uma (1996) performed an experiment to study the changes in oxygen consumption and biochemical composition of the marine fouling dreissinid bivalve, *Mytilopsis sallei* (Recluz), when exposed to mercury. Taylor *et al.* (1995) designed an experiment for studying the anoxic survival, oxygen consumption, and haemocyanin characteristics in the protobranch bivalve, *Nucula sulcata* Bronn. Clausen and Riisgard (1997) suggested that there was no physiological regulation of the filtration rate to nutritional needs, and that od uptake in nature was characterized by the full exploitation of the capacity of the bivalve filter-pump in the mussel *Mytilus edulis*. Hicks *et al.* (2002) examined the respiratory responses to increasing temperature and progressive hypoxia, relative to temperature acclimation in the non-indigenous, brown mussel, *Perna perna* (Mytilidae).

Riisgard *et al.* (2003) reported that the regulation of opening state and filtration rate in filter-feeding bivalves (*Cardium edule, Mytilus edulis* and *Mya arenaria*) had significant response to low algal concentration. In this study, specimens of *Anadara granosa bisenensis* were subjected to different water temperatures and salinity levels in order to monitor oxygen consumption and filtration rate.

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MATERIALS AND METHODS

1. The sample

Anadara granosa bisenensis individuals were collected by boat from the inshore area of Yosu City, Korea. The samples were then separated into two groups according to size: a large-sized group (shell length: 34.58 ± 2.23 mm, body weight: 12.43 ± 0.44 g) and a small-sized group (shell length: 20.60 ± 0.85 mm, body weight: 4.41 ± 2.30 g). (Table 1)

Anadara granosa bisenensis were cultured at four different temperature (10℃, 15℃, 20℃, and 25℃) and four different salinity levels (20, 25, 35, and 40 psu).

2. The measurement of filtration rate and oxygen consumption

When measuring the filtration rate, the method of Cole and Hepper (1954) was consulted. 0.15 g red stain was added to 15 liter filtered seawater. Then the solution was filtered with 0.45 μm filter membrane. This seawater was poured into the holding tank and then the specimens were placed into it. The tank was kept in the dark for 2 hours. A 50 ml portion was removed and 5 drops of 5% HCl were added to it. At the same time, a solution of neutral red seawater without specimens was used as a control. After one hour, the OD (optical density) of the reaction and control solutions was measured using the spectrophotometer. The filtration rate can be calculated as the following formula:

$$F = (\text{Log } C_o \quad \text{Log } C_t) \times M \;/\; \text{Log}_e \times t$$

F: Filtration rate; C_o: OD of control solution; C_t: OD of reaction solution; M: the volume of total neutral red solution; Log_e: 0.434; *t*: reaction time.

Furthermore, the DO (dissolved oxygen) meter was used to measure the oxygen consumption of this species.

RESULTS

1. At different water temperatures

As the temperature increased, the oxygen consumption and filtration rate of the two groups increased (Fig. 1). The filtration rates of the small-sized group were 0.0957 l/g/hour (10℃), 0.0943 l/g/hour (15℃), 0.1173 l/g/hour (20℃), and 0.1701 l/g/hour (25℃), respectively. The filtration rates of the large-sized group were 0.046 l/g/hour, 0.0844 l/g/hour, 0.0945 l/g/hour, and 0.1033 l/g/hour at the same four temperatures respectively. With regards to oxygen consumption, at the above temperatures, the amounts for the small-sized group were 0.3354 mg/g/hour, 0.3964 mg/g/hour, 0.4470 mg/g/hour, and 0.4925 mg/g/hour respectively, while those of the large-sized group were 0.1264 mg/g/hour, 0.2647 mg/g/hour, 0.3073 mg/g/hour, and 0.3960 mg/g/hour respectively (Fig. 2).

2. At different salinities

The values of filtration rate and oxygen

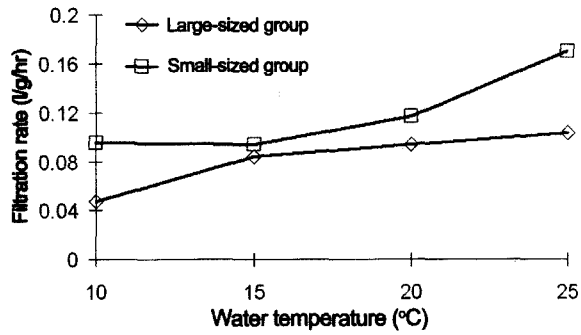

Fig. 1. Filtration rate of *Anadara granosa bisenensis* according to body size at different water temperatures.

Table 1. Measurement of *Anadara granosa bisenensis* used in the experiment.

Body size	Shell length (mm)	Shell height (mm)	Shell breadth (mm)	Total weight (g)
Large-sized group	34.58 ± 1.33	28.41 ± 1.33	23.72 ± 0.98	12.43 ± 0.44
Small-sized group	20.60 ± 0.85	16.68 ± 1.09	14.38 ± 1.02	4.41 ± 2.3

Data presented as mean ± SD

consumption at different salinity levels followed the same trend as those at different water temperatures. At salinity levels of 20 psu, 25 psu, 35 psu, and 40 psu, the filtration rates of the small-sized group were 0.0037 l/g/hour, 0.0222 l/g/hour, 0.1486 l/g/hour, and 0.1813 l/g/hour respectively. The filtration rates of the large-sized group were 0.0013 l/g/hour, 0.0040 L/g/hour, 0.1321 l/g/hour, and 0.1759 l/g/hour respectively (Fig. 3). With regards to oxygen consumption, the amounts for the small-sized group were 0.0487 mg/g/hour, 0.1559 mg/g/hour, 0.4920 mg/g/hour, and 0.5376 mg/g/hour respectively. Those of the large-sized group were 0.0385 mg/g/hour, 0.0650 mg/g/hour, 0.3645 mg/g/hour and 0.5142 mg/g/hour respectively (Fig. 4).

DISCUSSION

The ark shell, *Anadara granosa bisenensis*, which has been assigned to Lamellibranchia, Pterimorphia, Arcoida, Arcidae, is of high yield and economic value for human consumption. Its flesh has a high protein and vitamin B_{12} content. The shell itself can be commercially used. The shell has much $CaCO_3$, so it can be used in making lime and chinaware (Wang, 1993). As the consumption of this species steadily increases, some further investigation is necessary. In this study, as the water temperature increased (10℃, 15℃, 20℃, and 25℃), the filtration rate of small-sized and large-sized groups increased gradually from 0.0957 l/g/hour to 0.1701 l/g/hour, and from 0.046 l/g/hour to 0.1033 l/g/hour (Fig. 1). At the same time, the values for oxygen consumption showed the same trend, which was from 0.3354 mg/g/hour to 0.4925 mg/g/hour for the small-sized group and from 0.1264 mg/g/hour to 0.3960 mg/g/hour for the large-sized group (Fig 2). It is reported that the optimum temperature for ark shell growth is 5-25℃ (Wang, 1993). According to the above results, it can be inferred that within this optimum growth temperature, as the temperature increased, the physiological activity of *Anadara granosa bisenensis* increased. With regard to the different salinity levels, which increased from 20 psu to 40 psu, the filtration rate and oxygen consumption increased also (Figs. 3 and 4). It indicated high metabolic activity at high salinity.

As can be seen from Fig. 1, 2, 3, and 4, the

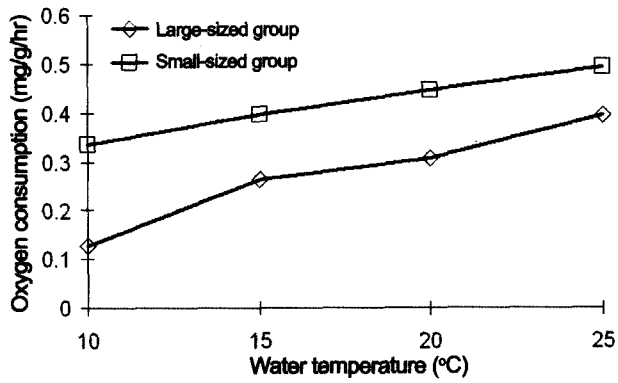

Fig. 2. Oxygen consumption of *Anadara granosa bisenensis* according to body size at different water temperature.

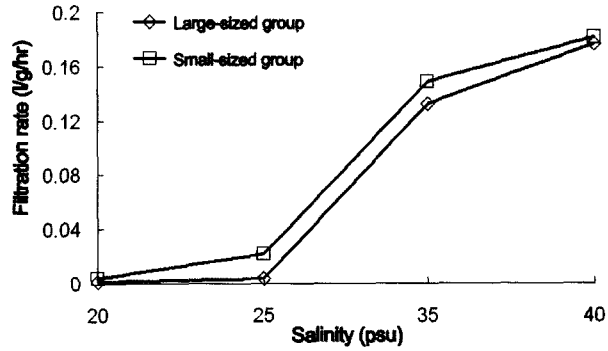

Fig. 3. Filtration rate of *Anadara granosa bisenensis* according to body size at different salinity.

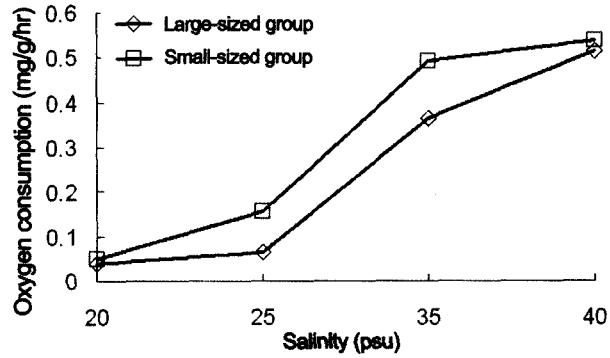

Fig. 4. Oxygen consumption of *Anadara granosa bisenensis* according to body size at different salinity levels.

increased trend of filtration rate and oxygen consumption at different water temperatures, which are within the optimum growth temperature range, is stable and gradual. The dependence of filtration rate and oxygen consumption on salinity is also relatively significant. The optimal salinity for *Anadara granosa bisenensis* is reported to be 26-32 psu. Outside this range, the physiological activity may show certain inadaptability, with an acute increase in filtration rate and oxygen consumption. Hicks *et al.* (2002) reported that, as the temperature increased, the respiratory responses of *Perna perna* (Bivalvia: Mytilidae) increased. This corresponds with our results. Inoue and Yamamuro (2000) also investigated the relation between respiration rate and temperature in the bivalve *Musculista senhousia*, and obtained the same result. In our study, with regard to the groups of different size, the values of the small-sized group were consistently higher than those of the large-sized group. It showed that, the small-sized individuals had a higher metabolic rate than the large-sized ones. However, the rate of variation of both groups was almost the same. It can be inferred that the sensitivity and dependence of the small-sized shells to temperature and salinity has scarcely any difference in comparison with the large-sized individuals. These results indicate that the filtration rate and oxygen consumption of the ark shell, *Anadara granosa bisenensis,* depend on environmental conditions, especially on water temperature and salinity.

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