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# Proportion of Surviving and Physiological Changes of Granular ark, *Tegillarca granosa* to Air Exposure

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## ABSTRACT

Proportion of *Tegillarca granosa* surviving after 2-6 hrs air exposure with 12 hrs interval at 20℃ and 28℃ for 20 days showed 85-100%, 80-100%, respectively. The survival rate was somewhat lower at high temperature but not significant ($p < 0.05$). Subsequent exposures for 7-9 days showed survival rate of 8.0-24.1% at 20℃ and 28℃. Oxygen consumption rates and filtration rates were significantly higher for 4 to 6 hrs exposures, compared with the preceding exposures. On the other hand, at 28℃, oxygen consumption rates in adult granular ark for 6 hrs exposure during 20 days had significantly decreased. Filtration rates in study groups increased a little over extended period of exposure, compared with those in control groups, and were similar irrelevant to the time of exposure and size of experimental animals. It is concluded, in view of their viability and oxygen consumption rate during air exposure, that ark shells have quite a high resistance to air exposure with their limited range of responses.

**Keywords:** *Tegillarca granosa,* Temperature, Proportion of surviving, Oxygen consumption, Filtration.

## INTRODUCTION

Granular ark, *Tegillarca granosa* is one of the species which live in the tidelands of mud and are directly affected by air exposure at ebbs. Deaths occur during air exposure during the ebbs and flows in cold winters and hot summers. Especially in summer, viability of granular ark is related to water temperature and frequent exposures. Resistance to air increases during that time (Demers and Guderley, 1994). Usually, shellfishes which live in upper tidal flats go through a long time of air exposure, temperature changes, desiccation and restriction on the time available for feeding (Widdow and Shick, 1985). Among those, mussel has decreasing growth rate depending on environmental changes. It is known that mussels adapt themselves differently to environmental conditions, resultantly showing differences in developmental shapes: for instance, *Perna canaliculus* which lives in upper tidal flats has a thick shell. Cockle has physiological mechanism to survive from low oxygen state from air exposure by using biochemical substances (Shick *et al.,* 1986; Zange *et al.,* 1989). Shell gaping, resulting from specific behavior mechanism, is probably one of the responses that can increase viability in organisms living in upper tidal flats (Kennedy, 1976; Marsden and Weatherhead, 1998).

There are many of studies on air exposures of shellfishes, mainly on mussel (Zandee *et al.,* 1986; Famme *et al.,* 1981; Widdows and Shick, 1985; Huang and Newell, 2002; Marsden and Weatherhead, 1998), and some on cockle (Boyden, 1972) and abalone (Wells and Baldwin, 1995). No studies on granular ark growing in Korea which have haemoglobin within their body fluid, unlike other clams, and presumably higher resistance during air exposure can be found.

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The species, easily found just below the surfaces of tidal flats, are very susceptible to natural conditions, have thick shells to endure the severe circumstances, are closed underdry states to prevent moisture loss to the maximum while taking oxygen within the shells, and stay on until the flows start again. It is therefore expected that such an ecological adaptability slows down the growth of granular ark. (Broom, 1982, You *et al.,* 2002)

This study intends to examine physiological responses whereby granular ark can survive during air exposure at high temperature considering their ecological features.

## MATERIALS and METHODS

Specimens of the granular ark, *Tegillarca granosa* were collected in the intertidal zone of Jangdo sea area, Beolgyo-eup, Korea from May to August 2001. These were transferred to the experimental lab and cultivated in 0.5 ton capacity water tank and used in experiments after having been acclimatized in test temperatures for ten days. *Tetraselmis* sp. was used as feeds. Salinity was adjusted to 33.5 psu and the illumination to 12 L : 12 D. Stagnant water and circulated water methods were used concurrently as experimental methods. Experimental temperature was 20 and 28℃. The shell length of experimental animals was 30 ± 2 mm in adult group and 20 ± 2 mm in juvenile group. The water in the tank was drawn out for the clams to be exposed to the air for 2, 4 and 6 hrs at 20℃ or 28℃, and then filled back. This procedure was repeated for every 12 hrs according to the tidal rhythm. The continuous air exposures were performed for nine days at 20℃ and seven days at 28℃. In order to prevent mortality caused by an excessive dryness when the experimental animals were exposed to air, we placed a wet towel at the bottom of the water tank. Animals of control group were in the ordinary sea water during the experimental period of 20 days. Each experimental group was composed of 20 clams, and the experiments were performed three times. Proportion of surviving was calculated by examining the number of dead animals. Measurement of oxygen consumption rate was measured by oxygen measurement apparatus (YSI 5000), while filtration rate was measured with Cole and Hepper (1954) method using 0.001% neutral red. Statistical comparisons were made using ANOVA and Duncan's multiple range test

## RESULTS

Depending on the exposure time, proportions of granuar ark surviving were 85-100% for 2 to 6 hrs at 20℃ water temperature, 80-100% for 6 hrs at 28℃, respectively (Table 1). The percentage were somewhat lower at high temperature but not significant ($p < 0.05$).

Subsequent exposures for 7-9 days showed viability rate of 8.0-24.1% at two different temperatures (Table 1). During 2 hrs exposures, oxygen consumption rates were consistent in both adult granular ark and immature ones at 20℃ however, 4 to 6 hrs exposures resulted in significantly high oxygen consumption rates, compared with the preceding exposures. Oxygen consumption rates were more conspicuous in immature granular ark than in adult ones (Fig. 1). As

**Table 1.** Proportions of *Tegillaca granosa* surviving after various periods of exposure to the air.

| Exposure time | Experimental duration (day) | Temperature (℃) | Survival (%) | |
|---|---|---|---|---|
| | | | Adult | Juvenile |
| 6 hrs / 12 hrs | | | 100.0 | 85.0 |
| 4 hrs / 12 hrs | 20 | 20 | 100.0 | 95.0 |
| 2 hrs / 12 hrs | | | 100.0 | 100.0 |
| whole day exposure | 9 | | 8.0 | 24.1 |
| 6 hrs / 12 hrs | | | 80.0 | 85.0 |
| 4 hrs / 12 hrs | 20 | 28 | 100.0 | 100.0 |
| 2 hrs / 12 hrs | | | 100.0 | 95.0 |
| whole day exposure | 7 | | 10.0 | 16.0 |

the exposure time increased, filtration rates in both groups also increased, higher in 4-6 hrs exposures than in 2 hrs exposures, more obviously in adult granular ark (Fig. 2).

On the other hand, at temperature of 28℃, oxygen consumption rates were higher in 4-6 hrs than for 2 hrs group during 5 days of exposure (Fig. 3), and yet showed no difference during the extended period of exposure ($p < 0.05$). However, oxygen consumption rates in adult granular ark for 6 hrs exposure for 20 days had significantly decreased (Fig. 3). Filtration rates in study groups increased a little over during the extended period of exposure, compared with those in control groups, and were similar irrelevant to the time of exposure and size of experimental animals (Fig. 4).

## DISCUSSION

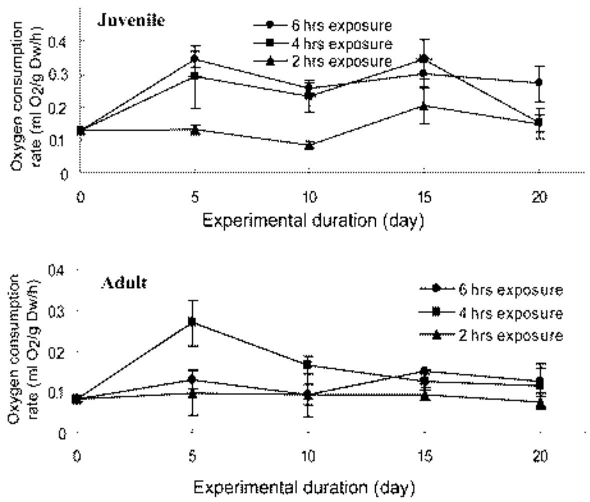


**Fig. 1.** Changes of oxygen consumption rate of *Tegillaca granosa* to the air exposure at 20℃.

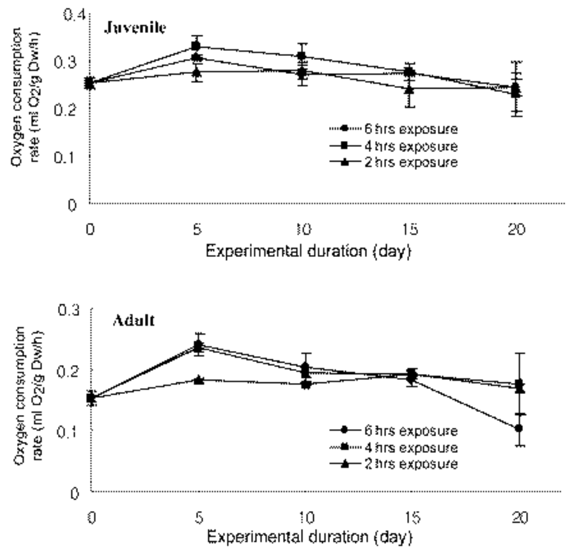


**Fig. 3.** Changes of oxygen consumption rate of *Tegillaca granosa* to the air exposure at 28℃.

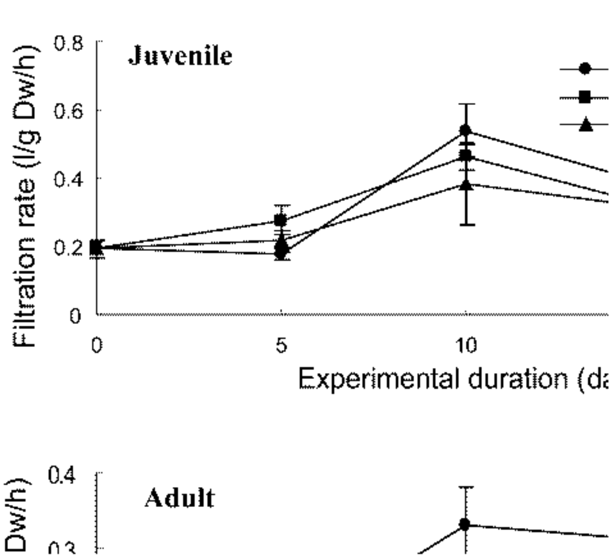


**Fig. 2.** Filtration rate changes of *Tegillaca granosa* to the air exposure at 20℃.

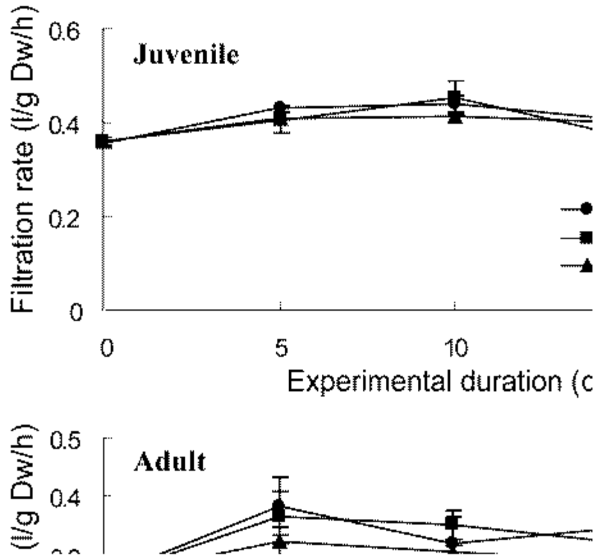


**Fig. 4.** Filtration rate changes of *Tegillaca granosa* to the air exposure at 28℃.

Demes and Guderly (1994) reported that *Mytilus edulis* had acclimation 14 days after an exposure to intertidal conditions, showing higher resistance to exposure at lower temperature. And for cockle, *Cerastoderma edule,* its resistance to air exposure was dependent on water temperature (Boyden, 1972). As water temperature increases, especially *Mytilus edulis* had increasing rate of respiration within its physiological range and decreasing rate at fatal temperature (Read, 1962). Ark shells living in tidelands assumed that more than 80% of the clams to be survive in the condition of 2-6 hrs exposure per day at high temperature above 20℃ and specific change in metabolism rate over 20 days of exposure from the present study. It can be, therefore, inferred that the species have higher resistance to air exposure. Generally, mussel has resistance to air exposure relying on a combination of three strategies decrease in metabolic rate during valve closure in air (Widdows and Shick, 1985; Storey, 1988), anaerobic metabolism leading to the accumulation of opines, such as strombine, alanopine, and octopine, as well as succinate, propionate and certain volatile fatty acids (Zwaan, 1977), and intermittent use of air breathing such as gaping (McMahon, 1988).

Physiological mechanism for viability is represented by the following responses; It is reported that for example, mussels can reduce oxygen consumption rate by 5%, lower than in normal conditions (Famme *et al.,* 1981), and *Choromytilus meridionalis* (Griffiths, 1981) can lessen 80% of oxygen consumption rate during aerial exposure, however, cockle, *Cerastoderma edule,* has increasing oxygen consumption rate during aerial exposure that results from increased activities in the water, not from physiological compensation for oxygen debt, and has its behavior pattern for air breathing at low tides (Boyden, 1972). However, *Mya arenaria* and *Mytilus edulis* don't have their adaptabilities to air breathing but build up oxygen debt from air exposure (Schlieper, 1957), and require more oxygen when returned into the water. On a basis of air exposure time and water temperature, oxygen consumption rates in ark shells were different. The longer the exposure time at 20℃ was, the higher the oxygen consumption rate showed. It is thought that they have their limited range of strategies to air conditions (Gilmor, 1982). Ark shells had constant rates of oxygen consumption during 2 hrs exposure, compared with those prior to air exposure, with their gills different from those of mussels that have their physiological mechanism depending on oxygen debt. It can be inferred that ark shells have resistance to air exposure while doing intermittent air breathing given that they live in tidal flats of mud exposed at ebbs and do gaping while being exposed. However, considering that an increase in oxygen consumption rate during exposure of 4 hrs, they have resistance within their limited physiological range in physiological compensation for oxygen debt. It is concluded, in the view of their viability and oxygen consumption rate during air exposures, that ark shells have quite a high resistance to air exposure with their limited range of responses.

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