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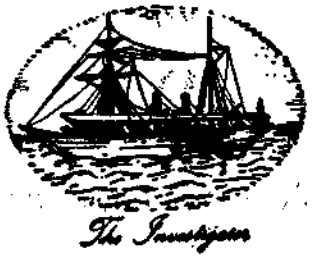

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OXYGEN CONSUMPTION IN PEARL OYSTER *PINCTADA FUCATA* (GOULD) AND *PINCTADA SUGILLATA* (REEVE)

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ABSTRACT

The rate of oxygen consumption of pearl oysters *Pinctada fucata* and *P. sugillata* from different localities namely pearl culture farm, pearl banks and near-shore waters of Tuticorin in the Gulf of Mannar has been studied. In *P. fucata* oxygen consumption was 1339 µl/hr. for oyster size range 40-50 mm; 1650 µl/hr for 50-60 mm and 1810 µl/hr for 60-70 mm. The rate of oxygen consumption of *P. sugillata* from the pearl banks as well as from the near-shore waters showed a linear relation with size of oyster. The rate of oxygen consumption of *P. sugillata* from pearl banks (depth 12-21 m) was less when compared to that in the oysters of the near-shore waters (depth 0.5-1.5 m). *P. fucata* from pearl culture farm survived after 21 hours of exposure to air. *P. fucata* from pearl culture farm could survive upto 19 hours, upto 24 hours in the case of *P. sugillata* from near-shore waters and upto 27 hours in *P. sugillata* from pearl banks, in anaerobic conditions. In all the oysters there was remarkable increase in shell activity and shell gape when there was a decline in the oxygen level.

INTRODUCTION

PEARL OYSTERS occur in the intertidal region of Gulf of Kutch and at a depth of 12-21 m in the pearl banks of Gulf of Mannar. The settlement of pearl oysters on the granite stones at Tuticorin Harbour at a depth of 0.5-1.5 m was first recorded by Nayar *et al.* (1978). The physiology of respiration of bivalves such as *Cerastoderma edule*, *C. glaucum* (Boyden, 1972), *Arctica islandica* (Taylor, 1976), *Donax cuneatus*, *D. faba* (Rao and Kutty, 1968), *Gryphaea virginica* (Korringa, 1952) and the pearl oyster *Pinctada fucata* (Uemoto, 1968; Itoh, 1976) have been studied in detail. Cahn (1949) reported the role of oxygen during conditioning of the pearl oyster *P. martensii*. Okawa (1959) studied the oxygen consumption in relation to the feeding of *P. martensii*. The present paper deals with the oxygen consumption of the Indian pearl oysters *Pinctada fucata* and *P. sugillata*, their survival in anaerobic conditions and exposure to air. These findings have practical utility in conditioning and transporting of oysters.

I express my deep sense of gratitude to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute, Cochin for his encouragement and to Dr. K. Alagarswami of the Institute for his guidance and offering valuable suggestions. My thanks are also due to Shri K. Nagappan Nayar for extending all facilities and to Dr. K. Alagaraja, Central Marine Fisheries Research Institute, Cochin, Dr. M. Narayanan Kutty and Dr. N. Sukumaran, Fisheries College, Tuticorin for their helpful suggestions in the analysis of the data.

MATERIAL AND METHODS

Pinctada fucata were collected from the pear banks at a depth of 12 m and reared in the pear culture farm in Tuticorin Harbour. *Pinctada sugillata* were obtained from the same area and also from the near-shore waters of Tuticorin Harbour at a depth of 1 m.

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Twenty five oysters of *P.fucata* and 35 oysters of *P. sugillata* were used in this study. *P. fucata* from the farm ranged from 47 to 60 mm in dorsoventral measurement (DVM) (2.3-4.4 g in wet weight), *P. sugillata* from pearl banks varied between 10.0 and 66.3 mm in DVM (0.01-5.5 g in wet weight) and *P. sugillata* from near-shore waters ranged from 22.5 to 57.4 mm in DVM (0.09-3.9 g in wet weight). The rate of oxygen consumption was estimated by Winkler's method and expressed in terms of μl of O_2/hour. The 'b' values were determined by using the equation,

$$Y = a + bX.$$

During the experiment, initial conditioning time, shell activity, shell gape and behaviour of oysters were also recorded.

P.sugillata from pearl banks (21.8-54.0 mm DVM) and from near-shore waters (36.0 — 71.4 mm DVM), and *P.fucata* from pearl culture farm (30.0 — 54.5 mm DVM) were used to study the survival rate in anaerobiosis. The oysters were kept in anaerobic medium for different durations of 6, 9, 12, ... and 33 hours. Instead of releasing the oysters directly to oxygen-free water, they were allowed to respire in a medium with known oxygen level. The level of oxygen in the medium was estimated at intervals and the time at which the medium contains zero oxygen was noted. The survival rate was then calculated from this level.

RESULTS

Rate of oxygen consumption

Pinctada sugillata of similar size groups collected from the two ecologically varying

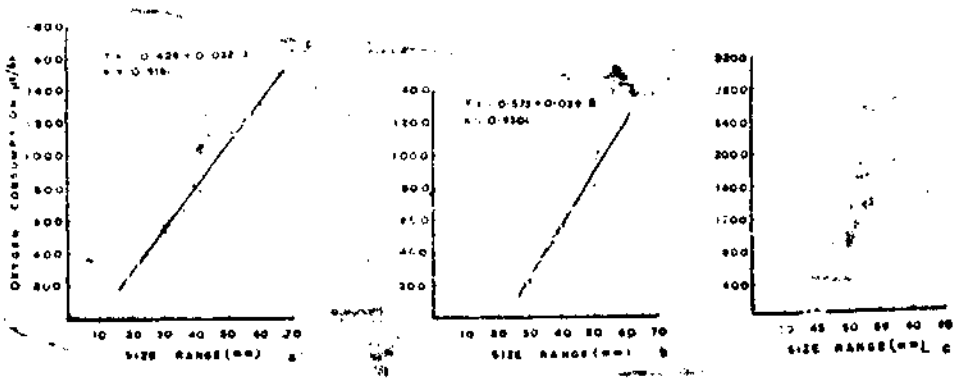

Fig. 1. Oxygen consumption in : a. *Pinctaaa sugillata* from near shore waters (depth 1.0 m) at Tuticorin Harbour basin, b. *Pinctada sugillata* from pearl banks in the Gulf of Mannar (depth 12 m) and c. *Pinctada fucata* from the pearl culture farm at Tuticorin Harbour (depth 3 m).

P. fucata tested for oxygen consumption were kept out of water for different durations of 6, 9, 12, 15, 18, 21, 24 and 30 hours and the post-exposure rate of oxygen consumption was estimated based on wet tissue weight in varying temperature from 26.0°C to 29.4°C (Mean 27.9°C).

conditions held their characteristic metabolic rate and indicated linear trend in both the cases with high positive correlation (Fig. 1 a, b). The rates of oxygen consumption of different size groups of *P.sugillata* from pearl banks and from near-shore waters and *P. fucata* from pearl culture farm are given in Table 1.

TABLE 1. *Oxygen consumption (µl/hour) of* Pinctada sugillata *and* Pinctada fucata

Species & locality	Size Groups (mm)					
	10-20	20-30	30-40	40-50	50-60	60-70
Pinctada sugillata						
From pearl banks	..	255	345	588	1045	..
From nears hore waters	618	828	510	879	1170	1361
Pinctada fucata						
From pearl culture farm	..	..	..	1339	1650	1810

In the case of *P. fucata* linear trend cannot be seen because of the smaller size groups which were experimented (Fig. 1 c).

Rate of oxygen consumption prior to and after aerial exposure

P. fucata exposed to 9, 12 and 18 hours showed higher rate of oxygen consumption during the first hour on reimmersion and became normal from second hour (Fig. 2 b, c, d). *P. fucata* exposed to 6 and 21 hours showed lesser rate of consumption during the first hour on reimmersion (Fig. 2 a, e).

Survival rate after exposure to air

Pinctada fucata kept out of water for 21 hours were experimented for determining the post-exposure rate of oxygen consumption. 100% survival of these oysters could be recorded after this treatment. The oysters exposed to 24 hours were also treated in the same manner. They exhibited a few shell activities on reimmersion to sea water and then died.

Tolerance limit of pearl oysters in anaerobiosis

P. fucata was found to be less tolerant to anaerobic conditions than *P. sugillata*. Mortality of *P. fucata* in anaerobic medium set early from 19th hour. In the case of *P. sugillata* from near-shore waters the mortality began from 24th hour. *P. sugillata* from the pearl banks were found to tolerate upto 27 hours in anaerobiosis.

Behaviour in air

During exposure to air *Pinctada fucata* were kept in a tray with right valve down. After 6 hours of exposure, though the valves were closed, shell activity was noted intermittently. After 9 hours the valves showed partial gaping and after 12 hours the valves widely separated and the mantle edges withdrew from the shell edges. Voluntary shell movement was observed upto 18 hours of exposure and it ceased on further exposure. The measure of shell gape was found proportional to the duration of exposure.

Behaviour on return to sea water

The oysters exposed for 6 hours showed normal closing and opening of shell valves on return to sea water. Few oysters, after 18 hours of exposure, exhibited partial closure of valves for 1 to 3 hours and normal shell closure commenced afterwards. The oysters after 21 hours of exposure closed their valves on immersion and opened in a few minutes. In this case partial closure of valves persisted throughout the experiment. Such response ceased beyond 21 hours of exposure.

The mantle which was withdrawn from the shell valve edges after 12 hours of exposure

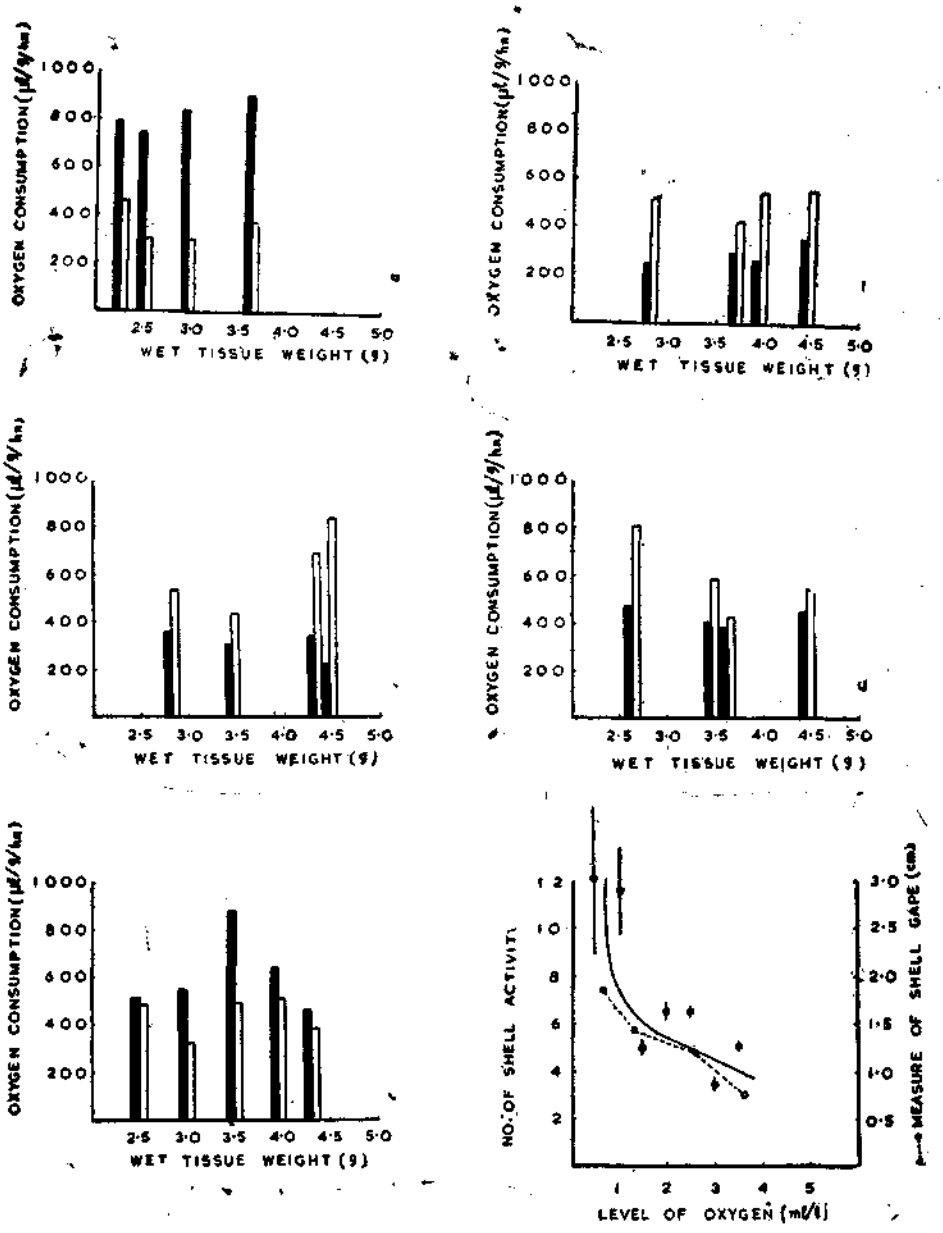

Fig. 2. Pre-(solid block) and post-exposure (hallow block) rate of oxygen consumption in *Pinctada fucata* for the first hour on immers on: a. after 6 hours of exposure, b. after 9 hours of exposure, c. after 12 hours of exposure, d. after 18 hours of exposure, e. after 21 hours of exposure and f. The measure of shell gape (open circles) and shell activity (closed circles) in relation to various level of oxygen concentrations. Each point in shell activity is a mean of 3-8 values (± S.E.).

took 2.45 to 3.30 hours to attain normal position. The same process required 5 hours in the case of oysters exposed to 21 hours. On the contrary the gill on reimmersion came to normal functioning within two hours and the movement of particles were clearly seen over the gills.

Initial conditioning time and shell activity

Initial conditioning time is referred to as the duration between the time of immersion and the first opening shell valves. The conditioning time of the oysters freshly collected from the farm ranged from 2 to 65 minutes whereas the oysters exposed for 9 to 21 hours took hardly 0 to 15 minutes.

The amplitude of shell activity of unexposed oysters was accelerated below ambient oxygen concentration and was maximum at 1 ml/litre of oxygen (Fig. 2 f). Further retention of oysters in hypoxic medium resulted in the complete closure of valves. A minimum shell activity was recorded in normoxic conditions.

Shell gaping

The measure of shell gape was found to vary inversely to the amount of oxygen in the medium. The shell gape over various levels of oxygen is given in Fig. 2 f. At lower oxygen level the shell opened to the maximum extent, thus exposing the gills fully to the medium. The oysters under well-aerated conditions kept their valves open only narrowly.

Discussion

The average dissolved oxygen content of the surface and bottom waters of pearl banks have been recorded as 4.22 and 4.37 ml/l respectively and that of the pearl culture farm in Tuticorin Harbour were 5.05 and 4.77 ml/l respectively. In the present study *P. sugillata* from the pearl banks showed lesser rate of oxygen consumption than those from the nearshore waters. The data reflect on the characteristic low metabolism of the benthic forms.

In *Pinctada fucata* the rate of oxygen consumption of the size groups 40-50 mm was 1339 µl/hour, 50-60 mm 1650 µl/hour and 60-70 mm 1810 µl/hour. Oxygen availability at these rates should be taken into account while conditioning the oysters before nucleus implantation for pearl production.

A batch of 25 *P. fucata* and 24 *P. sugillata* were taken from Tuticorin to Dhauli and brought back without any mortality. During the above transportation by train over a distance of 1896 km and time of 43.25 hours the pearl oysters were intermittently immersed in seawater for a while and covered with wet gunny bag. Korringa (1952) indicated that at low temperatures *Ostrea edulis* can withstand upto 24 days of exposure and complete recovery was possible after 18 days of exposure. The survival time of *Donax cuneatus* exposed to air at room temperature (30°C) was found to be 69 hours and *D. faba* in the same condition survived for 94 hours (Rao and Kutty, 1968). *P. fucata* in the present study, withstood exposure upto 21 hours.

The onset of mortality in *Pinctada fucata* started from 19th hour in anaerobic medium. It is probable that in aqueous medium the metabolic end products might readily be released which in turn caused deleterious effect on the oysters. Korringa (1952) stated that the edible oyster *Gryphaea virginica* excretes measurable quantities of organic acids such as lactic acid which would release CO_2 from the oyster shell thus increasing the level of CO_2 in the medium.

The post-exposure rate of oxygen consumption in *P. fucata* after 6 and 21 hours of exposure was less than the pre-exposure period. During the period of 6 hours of exposure the oysters closed their valves tightly and hence 'Oxygen debt' might not have been incurred. After 21 hours of exposure the indebtedness might have crossed the safe level and, after 3 more hours (24 hours of exposure), cent per cent mortality

sets in. An increase in cardiac and respiratory activity of the bivalve *Arctica islandica* following the periods of shell closure has frequently been interpreted as representing the repayment of 'Oxygen debt' incurred during anaerobiosis (Taylor, 1976).

In *Pinctada fucata* a higher rate of oxygen consumption was recorded during the first hour on reimmersion and normal rate of consumption resumed afterwards. Taylor (1976) reported a similar trend in *Arctica islandica* in which the rate of oxygen consumption on reimmersion was about three times faster than normal and declined to say more or less constant for about 20 hours. Boyden (1972) has opined that the increase in oxygen uptake after exposure reflects increased activity to flush nitrogenous excretory products from the tissues. The initial conditioning time of the exposed oysters revealed an urgency to open their shell valves for the purpose of respiration.

Under hypoxic conditions the oyster tries to obtain the same amount of oxygen normally required. Hence it has been forced to exhibit more shell activity either to replenish the medium or to ventilate the respiratory organs for the supply of adequate oxygen. Similar effect was reported by Taylor (1976) in *Arctica islandica*. He also suggested that the change over to anaerobic metabolism may take place at low oxygen tension but before the medium is completely devoid of oxygen. Various workers have established that bivalves can metabolise anaerobically during the periods of aerial exposure or hypoxia.

Information on the relationship between the shell gaping in pearl oysters and the oxygen tension in the medium has much value in the controlled culture of oysters in the laboratory. The measure of shell gape has been recognised as an indicator of the level of oxygen in the medium and it is inversely proportional to oxygen level.

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