Oxygen Consumption Under Copper and Zinc Stress in *Perna viridis*

K. N. PRABHUDEVA and N. R. MENON
School of Marine Sciences, University of Cochin, Cochin-682 016

The rate of oxygen consumption by *Perna viridis* pre-exposed to copper and zinc was studied. Those test individuals pre-exposed to various zinc concentrations showed variability in oxygen consumption irrespective of concentrations and pre-exposure period. While those animals pre-exposed to various copper concentrations registered decrease in oxygen consumption at concentrations above 0.06 p.p.m. copper, pre-exposure to concentrations below 0.02 p.p.m. copper did not result in any clear cut change in the rate of oxygen consumption.

Rate of oxygen consumption has been used as a very useful tool by many workers to study the sub-lethal effects of metal toxicity. It is also an index of energy expenditure to meet the demands of environmental alterations. Most of the heavy metals whether essential or otherwise function as enzyme inhibitors above their optimum levels (Valee & Walker, 1970). Oxygen consumption is a product of two important factors, namely, ventilation volume and the quantity of gas withdrawn from each litre of water. Therefore, fluctuations noticed in the case of oxygen consumption are due to variations in the quantity of water propelled through the gills and changes in oxygen uptake from the waters by the animal. Brown & Newell (1972) working with *Mytilus edulis,* incapacited to close the valve, found reduced rate of oxygen consumption and suggested that this reduction was because of reduced rate of energy requirements caused by suppression of ciliary activity in the presence of copper and zinc ions. Reports on the rate of oxygen consumption under metal stress are available (Mathew & Menon, 1983; Murthy, 1982; Mohan *et al.* 1984).

Materials and Methods

The test individuals *Perna viridis* (Lin) and seawater were collected from an unpolluted area at the Someswar rocky shore (12° 47′N; 74° 51′E). Before use, the experimental animals were maintained under laboratory conditions (salinity 34 ± 1‰, temperature 30± 1°C, oxygen 5.4—6.0 ml/l, pH 8.2–8.4). Aged seawater after filtering and aeration was used for the experiments. Animals were not fed during the course of the experiments.

Zinc chloride ($ZnCl_2$ $2H_2o$) and copper sulphate ($CuSO_4$ $5H_2o$) were the source of zinc and copper respectively. The experimental vessels were conical flasks of 2 litre capacity containing 2 litres of test solutions.

The animals employed for the experiments were prepared in the following manner. Selected specimens were subjected to zinc and copper stress for periods ranging from 24 to 96 h. From this lot, batches of 8 individuals were transferred to clean seawater in 2 litre conical flask every 24 h, and their oxygen uptake was estimated every 2 h interval over a period of 6–10 h. Gas exchange between the test medium and the atmosphere was avoided by sealing the experimental vessels with inert liquid paraffin. The water was siphoned out using a flexible polythene tube for estimating oxygen, by Winkler's method. After the experiment, animals were disected and the soft tissues removed on pre-weighed aluminium foils, dried at 65°C and dry weight taken to constancy. The results are expressed in $\mu g\ 0_2\ mg^{-1}\ h^{-1}$. The results

obtained are from four series of experiments using animals pre-exposed to 24 h, 48 h, 72 h and 96 h under different levels of zinc and copper.

Results and Discussion

Pre-exposure to zinc at concentrations ranging from 0.025 to 0.150 p.p.m. did not conspicuously affect oxygen consumption subsequently (Fig. 1). Those animals pre-exposed to 0.06 and 0.08 p.p.m. of copper showed reduction in the rate of oxygen uptake (Fig. 2). While those animals pre-exposed to copper for a period of 96 h, in general did not respire from 6th to 10th hour indicating permanent valve closure.

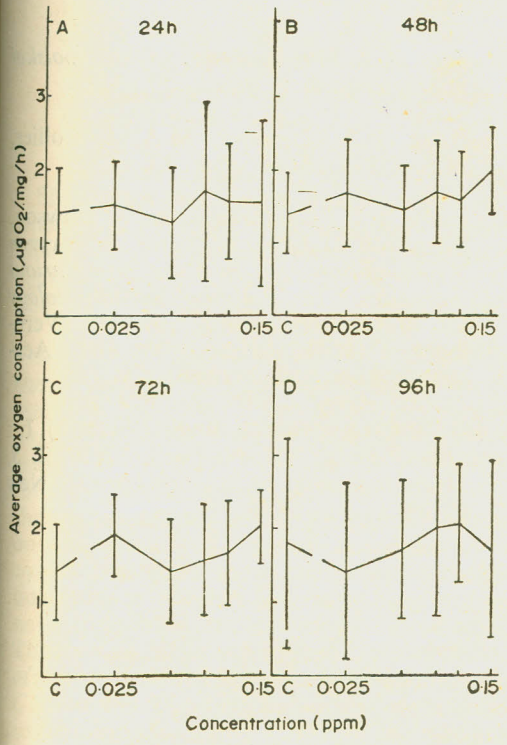

Fig. 1 A to D. Average oxygen consumption (μg/mg/h) by *Perna viridis* pre-exposed to 24 to 96 h to various concentrations of zinc. Vertical bars show standard deviation.

Zinc was found to be a respiratory depressant in the case of *Meretrix casta* (Mathew & Menon, 1982), although this was not so in the case of *P. viridis*. Heavy metals are known to inhibit enzyme activity. Rythmic

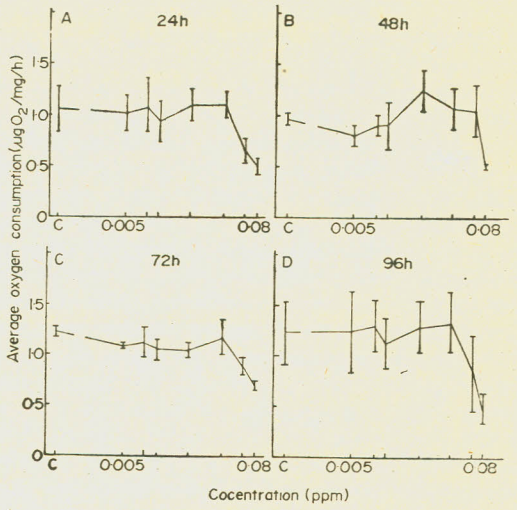

Fig. 2. A to D. Average oxygen consumption (μg/mg/h) by *Perna viridis* pre-exposed to 24 h to 96 h to various concentrations of copper. Vertical bars show standard deviation.

shell movement in bivalves is closely related to respiration and filtration rate. Therefore, fluctuations noticed in the case of oxygen consumption are probably due to variations in the quantity of water that moved through the gills which in turn could have been affected by irregular valve movements. Brown & Newell (1972) working with *Mytilus edulis,* reported that reduced rate of oxygen consumption was due to suppression of ciliary activity caused by reduced rate of energy demand. Interpretation of metal induced change is complicated and alterations differ from metal to metal and species to species (Thurberg *et al.* 1974).

During the present investigation, the rate of oxygen consumption showed a decidedly reduced trend by animals pre-exposed to concentrations above 0.04 p.p.m. copper, which is in near about of LC50 levels of copper for *P. viridis*. In the case of *Carcinus maenus* and *Cancer irrosatus,* copper had no influence on respiration (Thurberg *et al.* 1973), while in the case of *Meretrix casta* and *Mytilus edulis* copper functioned as respiratory depressant (Mathew & Menon, 1982; Scott & Major, 1972). This according to the above authors, was due to the passive binding of cupric ions with organic ligands. Respiratory depression in *Mytilus galloprovincialis* according to Shapiro (1964)

is due either to valve closure or to direct metabolic effect. Anaerobic respiration in *Scrobicularia plana* when subject to 0.5 p.p.m. of copper for a shorter duration was reported (Akberali & Black, 1980). In the present investigation depression in the oxygen consumption was uniform in all the pre-exposed animals from 0.04 to 0.08 p.p.m. of copper. This indicates cellular damage of gills and cilia bearing cells during the exposure and that such changes are probably irrevocable ultimately leading to death of the organism. This study clearly indicates that transfer of *P. viridis* from highly metal polluted areas or pollution free situations might not significantly help in regaining physiological normalcy by such animals if the metal load of the polluted areas is above sub-lethal levels.

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