

## Tolerance and respiration of a fouling dreissinid bivalve *Mytilopsis sallei* (Recluz) (Pelecypoda: Dreissinidae) exposed to chromium at different salinities

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Received 19 June 1998, revised 31 August 1999

Chromium tolerance and metabolic rate in *Mytilopsis sallei*, a fouling bivalve which inhabits Visakhapatnam harbour were studied at different salinities such as 10, 15, 25, 32 and 35‰. The LC<sub>50</sub> values were found to increase with increasing salinities indicating a decrease in toxicity. However, low salinities did not affect the toxicity of chromium. The metabolic rate of the control animals (without toxicant exposure) showed an increasing trend up to 32‰ followed by a decrease at 35‰. In general, different concentrations of chromium (1.9 to 14.4 ppm) inhibited the metabolic rate at all salinities studied.

To protect aquatic ecosystem from heavy metals, water quality criteria have been developed from controlled laboratory bioassays. However, the toxicity of heavy metals varies with physical and chemical characteristics of the receiving waters as has been pointed out in several reviews<sup>1</sup>. Among the physical characteristics, salinity is an important parameter since it is subject to steep gradients with the changing environmental conditions. The solubility of certain pollutants may be affected during the change of environmental conditions<sup>2</sup> influencing the toxicity and metabolism of animals. These bivalves are also found attached to the bottom of the ships. Therefore, they are highly susceptible to leached chromium since this metal is an important component of anti-fouling paints. The objective of the present study is to determine the effect of salinity on chromium tolerance and respiration of a fouling dreissinid bivalve *Mytilopsis sallei* (Recluz) (Pelecypoda: Dreissinidae).

### Materials and Methods

*Mytilopsis sallei* were collected from wooden panels and different structures such as jetties, pyres, fenders and wharves of Visakhapatnam harbour (lat 17° 41' N and long 83° 20' E), east coast of India. The harbour is a highly polluted environment having the influence of industrial discharges, shipping activities and sewage.

The mussels were brought from the harbour and acclimated in aerated seawater under laboratory conditions (27±1°C, 25‰) 48 h before use. They were not fed before or during the experiment to avoid

contamination by excrements in the test solution. Only active animals of about the same size (1 to 1.5 cm) were selected for all the experiments.

The LC<sub>50</sub> values were calculated by following the static renewal bioassay method as per the standard procedure<sup>3</sup> at each salinity (10, 15, 20, 25, 32 and 35‰). Desired salinities were obtained by diluting seawater with distilled water or by adding 100% pure sodium chloride. The salinities of the samples were determined by titration with silver nitrate and the values were obtained using Knudsen's table. The metal salt used for the test was Cr<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>·6H<sub>2</sub>O (analytical grade) and it was dissolved in distilled water to prepare a stock solution. Preliminary screening tests were conducted to ascertain the exposure concentrations of the metal. Five different concentrations were used at each salinity and they were prepared by adding a calculated volume of stock solution in 3 litres of seawater. A parallel control without toxicant was used with all the experiments. Salinity, temperature and pH were monitored in the control as well as experimental containers. Twenty animals were kept in each container for different bioassay experiments. The whole set was aerated continuously. Mortality was recorded at intervals of 24 h for a period of 96 h. Dead animals (those who did not close their valves by a touch with a blunt needle) were removed daily from the test solution. All the animals survived in the control. The experiment was repeated three times at each salinity and average mortality rates were considered.

Oxygen uptake measurements were made using a respiratory chamber (310 ml) equipped with an oxygen electrode (UC-12 Digital DO/O<sub>2</sub>/Temp. Meter). Single animals were used for all the experiments. Initially, the measurements were made at ambient salinity (25‰) and then at different salinities mentioned above. At each salinity, experiments were carried out without toxicant initially and then the measurements were made at various concentrations of chromium i.e., LC<sub>0</sub>, LC<sub>10</sub>, LC<sub>25</sub>, LC<sub>50</sub>, LC<sub>75</sub> and LC<sub>90</sub> ranging from 1.9 to 14.4 ppm as determined above.

The seawater used for all the experiments was filtered with Whatman 42 filter paper and it was air-saturated (4.5 to 5 ml O<sub>2</sub>/l). Oxygen consumption measurements were carried out for a period of 2 h at each concentration. The average hourly rates of oxygen consumption were calculated. The results were expressed as the average of eight experiments i.e., eight animals at each concentration of chromium at each salinity.

LC<sub>50</sub> values together with the 95% fiducial limits were calculated by Probit analysis<sup>3</sup>, and different tolerance values were compared using 't' test<sup>4</sup> at all the salinities.

## Results

The values of LC<sub>0</sub>, LC<sub>50</sub> and LC<sub>90</sub> for *M. sallei* exposed to chromium for 96 h at different salinities are presented in Table 1. The 96 h LC<sub>50</sub> values were found to increase with increasing salinities indicating a decrease in toxicity. The LC<sub>50</sub> value at optimum salinity (25‰) was 4.90 ppm while at high salinities (32 and 35‰), the values were 8.21 and 7.73 ppm respectively and they were found to be significantly ( $P < 0.05$ ) high (Table 1). However, low salinities did not affect the chromium toxicity since the LC<sub>50</sub> values obtained at optimum (25‰) and low salinities (10 and 15‰) were almost similar (Table 1).

The effect of salinities on metabolic rate of *M. sallei* exposed to chromium was presented in Fig. 1. In general, all the concentrations of chromium inhibited the metabolic rate at different salinities studied and the inhibition was significant ( $P < 0.05$ ) at LC<sub>50</sub> and LC<sub>90</sub>. The pattern of decrease was found to be similar at all the salinities. However, the initial metabolic rate without toxicant (control) showed an increasing trend up to 32‰ (1.60 mg/g/hr) beyond which there was a decrease at 35‰ (1.01 mg/g/hr) (Fig. 1).

## Discussion

The results of this experiment indicate that salinity alters the toxicity of chromium in bivalve, *M. sallei*. As shown in *M. sallei*, several other studies also showed an inverse relationship between salinity and toxicity of metals in aquatic organisms<sup>5-7</sup>. This observation can be explained in different ways a) increase in the availability of metal at low salinity<sup>8,9</sup> because of the increased free metal ion level<sup>10</sup>, b) increased influx of the metal as a result of decreased osmolarity of the solution<sup>11</sup>.

Low susceptibility of *M. sallei* to chromium was observed at high salinity. It has not been determined if this is due to the interaction between the metal and the variety of salts in the seawater resulting in a non-toxic

Table 1—Lethal concentrations ( $\pm$  standard error) and 95% fiducial limits for *M. sallei* exposed to chromium at different salinities

| Salinity (‰) | LC <sub>0</sub> (ppm)          | LC <sub>50</sub> (ppm)         | LC <sub>90</sub> (ppm)            |
|--------------|--------------------------------|--------------------------------|-----------------------------------|
| 10           | 1.90 $\pm$ 0.35<br>(1.21-2.60) | 5.34 $\pm$ 0.22<br>(4.91-5.77) | 10.35 $\pm$ 1.07<br>(8.26-12.44)  |
| 15           | 3.32 $\pm$ 0.33<br>(2.67-3.97) | 6.57 $\pm$ 0.18<br>(6.23-6.92) | 10.18 $\pm$ 0.61<br>(8.99-11.36)  |
| 25           | 1.95 $\pm$ 0.21<br>(1.54-2.38) | 4.90 $\pm$ 0.26<br>(4.38-5.42) | 8.81 $\pm$ 0.74<br>(7.37-10.25)   |
| 32           | 5.28 $\pm$ 0.14<br>(5.01-5.56) | 8.21 $\pm$ 0.16<br>(7.90-8.51) | 10.88 $\pm$ 0.35<br>(10.20-11.57) |
| 35           | 2.92 $\pm$ 0.34<br>(2.26-3.59) | 7.73 $\pm$ 0.30<br>(7.14-8.32) | 14.40 $\pm$ 1.14<br>(12.16-16.64) |

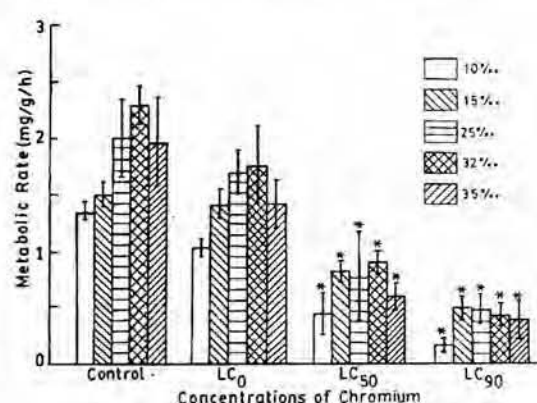


Fig. 1—Effect of salinity on metabolic rate in *Mytilopsis sallei* exposed to chromium. The vertical lines represent the standard deviation. (\*Significantly different from their respective controls at  $P < 0.05$ ).

Table 2—Safe concentrations (calculated) of chromium for *M. sallei* at different salinities

| Salinity (‰) | Safe concentration (ppm) |
|--------------|--------------------------|
| 10           | 0.0534                   |
| 15           | 0.0657                   |
| 25           | 0.0490                   |
| 32           | 0.0821                   |
| 35           | 0.0773                   |

precipitate in proportion to the salinity<sup>12</sup> or if the direction of the osmotic gradient in the higher salinities reduces the rate of entry of the metal.

In freshwater and marine environments, the prediction of safe levels of a pollutant or effluent for pollution control purposes is usually based on the results of acute toxicity tests<sup>13</sup> particularly while discerning the effect of synergism because the safe concentration of a particular toxicant becomes lethal to the species at a period of reduced salinity<sup>14</sup>. But in the present investigation, it was observed that the calculated safe concentrations<sup>15</sup> of chromium (Table 2) which is calculated as 1/100th of LC<sub>50</sub> at various salinities were well below the toxic level.

In the present investigation on *M. sallei* the metabolic rate showed an increasing trend up to 32‰ followed by a sharp decrease outside the postulated optimal range (25‰) indicating the effect of salinity. Heavy metals are known to depress the respiratory rate, possibly direct metabolic inhibition<sup>16,17</sup>. It appears from the results that in *M. sallei*, different concentrations of chromium inhibited the metabolic rate at all salinities studied. The pattern of decrease induced by chromium at all salinities was similar and this indicates that different concentrations of chromium have the same effect at high or low salinity.

A perusal of the literature in molluscs reveals that the decrease in oxygen consumption in the presence of synergistic stress of metal combined with salinity

variation is affected through several mechanisms like inhibition of ciliary activity, closure of shell valves, avoidance reaction and anaerobic shift<sup>18-20</sup>. With the limited knowledge available on physiology of *M. sallei*, it is possible that these mechanisms might be operating to some extent for the decrease in oxygen consumption. In conclusion, the present investigation demonstrates that salinity influences the toxicity of chromium in *M. sallei*.

### Acknowledgement

One of the authors (VUD) is grateful to University Grants Commission, New Delhi for the financial aid and also thank the Head of Department of Zoology, Andhra University for the research facilities.

### References

- 1 Hudson P V & Sprague J B, *J Fish Res Board Can*, 32 (1975) 1.
- 2 Jamila P & Tresa V F, *Indian J Mar Sci*, 24 (1995) 211.
- 3 Finney D J, *Probit analysis*, Third Edition, (Cambridge University Press, Cambridge) 1971, pp. 333.
- 4 Snedecor G W & Cochran W G, *Statistical methods*, (The Iowa State University Press, Iowa) 1967, pp. 593.
- 5 Mc Lusky D S & Bryant V, *Estuaries*, 8 (1985) 123.
- 6 Mukhopadhyay M K, Ghosh B B & Bagchi M M, *Geobios*, 21 (1994) 13.
- 7 Linton T K, Foster L, Mayer T I, Simin J A & Leif L M, *Envi Toxicol Chem*, (1994) 85.
- 8 Wolfe D A & Coburn C B, *Health Physiol*, 18 (1970) 449.
- 9 Phillips D J H, *Mar Biol*, 38 (1976) 59.
- 10 Luoma S N, Daniel J C & Johansen C, *Hydrobiology*, 129 (1985) 109.
- 11 George S G, Pirid B J S, Cheyne A R, Coombs T L & Grant P T, *Mar Biol*, 45 (1978) 147.
- 12 Bryan G W, *Proc R Soc Lond, Ser B*, 177 (1971) 147.
- 13 Thain J E, *Mar Envi Res*, 12 (1984) 285.
- 14 Vernberg F J, Guram M S & Savory A, in *Physiological responses of marine biota to pollutants*, edited by Vernberg F J, Calabrese A, Thurberg F P & W B Vernberg, (Academic Press, New York) 1977, pp. 37.
- 15 Kameswara Rao K, *Mahasagar- Bull Natn Inst Oceanogr*, 7 (1974) 79.
- 16 Spicer J I & Weber R E, *Comp Biochem Physiol*, 100C (1991) 339.
- 17 Uma Devi V, *Water Air & Soil Pollut*, 81 (1995) 295.
- 18 Mani Kumar D, *Effect of pollutants on marine prawn *Penaeus merguensis**, Ph. D. thesis, Marathwada University, India, 1986.
- 19 Stirling E A, *Mar Poll Bull*, 6 (1975) 12.
- 20 Wilson G, Mc Mahon J & Robert F, *Comp Biochem Physiol*, 70 (1981) 139.