Toxicity of Chromium, Copper and Zinc to Freshwater Clam (*Galatea paradoxa* (Born, 1778) (Bivalvia, Donacidae))

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Abstract

The toxicity of copper (Cu), chromium (Cr) and Zinc (Zn) on freshwater clam, *Galatea paradoxa* Born (= *Egerea radiata* Lamarck), was investigated in three static bioassays for 96 hours. The three toxicants were introduced at 0.5, 1.0, 5.0, 10.0 and 15.0 mgL^{-1} concentrations in river water to twelve (12) clams (mean weight: 250 ± 0.2 g) in 10 litre capacity plastic basins. Three other basins devoid of any of the metals were used as controls. The result revealed that deaths occurred in the water treated with toxicants but no deaths occurred in the control experiment, indicating that all deaths recorded were due to the toxicants. The 96 h LC_{50} values obtained were 2.51 mgL^{-1} for copper, 91.2 mgL^{-1} for chromium and 4.37 mgL^{-1} for zinc indicating that copper was most toxic to the clams followed by zinc and chromium.

Key words: Toxicity, clam (*Galatea paradoxa*), 96 h LC_{50}, toxicant.

Introduction

The freshwater clam (*Galatea paradoxa*) serves as food and is a good substitute for meat. It provides energy and materials for growth and repair of worn tissues as well as encourages proper mental development and formation of fat (Biswas, 1990). The occurrence in aquatic ecosystems of metal contaminants especially the heavy metals, in excess of natural loads, has become a problem of increasing concern. The rapid growth of population in Nigeria, increasing urbanization and expansion of industrial activities have contributed to the rapid increase of heavy metals in Nigerian aquatic systems because of increased dumping of heavy metal-containing wastes in the environment.

Environment of metals in water was reported to influence the uptake of any metal by the freshwater clam, *G. paradoxa* (Al-Debbas et al., 1984). This in turn makes it problematic to use *G. paradoxa* as a bio-indicator (Combs, 1970; George and Combs, 1970; Al-Debbas *et al.*, 1984). Clams have also been recognized as sentinel organisms for monitoring trace metal pollution of coastal marine waters (Odiete, 1979; Anandraj et al., 2002) and are referred to as bioaccumulators. Fleischer et al. (1974) reported that heavy metals such as lead, mercury, cadmium and chromium produce unhealthy effects in small doses and are intoxicating at threshold doses to various terrestrial and aquatic animals. Among the aquatic fauna, fish (shell fish or finfish) is the most susceptible to these toxicants (Mathias and Kevern, 1975) and is more vulnerable than other aquatic fauna. The susceptibility to copper of three populations of common guppy (*Labistes reticulatus*) decreased with increasing body weight while the rate of toxic action, adjusted with the size factor showed significant difference in the ratio of 2.20 : 1.50 : 1.00 (Eisler and Gardner, 1973). The workers maintained that the rate to toxic action/median survival time did not show much difference between male and females. Ahsanullah *et al.* (1981) also reported an initial absorption of zinc at the external gill mucus followed by an inward diffusion and absorption at unspecified internal binding sites. Although acute concentration of zinc probably altered gill structure and gaseous exchange and eventually killed fish, Ahsanullah *et al.* (1981) deduced that such damages are probably due to zinc absorption.

Very little work has been done on the toxicity of heavy metals on *G. paradoxa*. The little available information includes a preliminary laboratory observation of *G.*

paradoxa by Purchon (1963), the toxicity of cadmium, lead and lindane by Udoidiong and Akpan (1991) and the biometrics of the clam (King, 1998). Against this background, this research was carried out to further investigate the resistance and susceptibility of *G. paradoxa* to copper, chromium and zinc.

Material and Method

Experimental procedure: A total of 216 specimens of *Galatea paradoxa* (mean weight 250 ± 0.2 g) were collected from Oku-Iboku in Itu Local Government Area of Akwa Ibom State. The specimens were obtained from local fishermen who obtained them through hand-picking or burrowing with their feet. Specimens collected were placed in plastic basins containing river sand and water to reduce stress due to transportation. Additional quantity of sand and water were placed in six (6) plastic buckets with covers and transported to the research laboratory of the Zoology Department, University of Uyo, Akwa Ibom State.

Twelve (12) weighed clams (mean weight 250 ± 0.2 g each) were stocked in each of 18 different basins of 10 litre capacity. Each basin was lined with river sand 7 cm deep (for the specimens to burrow) and the sand covered with 4 litres of river water. The specimens were acclimated for 12 hours before the addition of graded concentrations (0.5, 1.0, 5.0, 10.0 and 15.0 mgL^{-1}) of the toxicants. For the experiment proper, 5 basins were assigned to each of the three toxicants and a basin was used for each level of concentration for each type of toxicant while three basins were assigned to the control to which no toxicant was added. Periodic observations of the clams to check for dead clams and the behaviour of digging into the sand to avoid the effect of the toxicants were made at six-hourly interval for 96 hours. Some physicochemical parameters of the water namely: temperature, alkalinity, salinity and free carbon (IV) oxide were determined. Water temperature (mean, 31.0 ± 0.58º C) and pH (mean, 6.5 ± 0.07) of the water were measured with mercury-in-glass thermometer and a pH meter respectively. Total alkalinity as calcium carbonate (mean 35.03 ± 0.05), salinity (mean, 0.05 ± 0.004‰), free carbon dioxide (mean, 5.7 ± 0.91) and dissolved oxygen (mean 6.1 ± 0.3 ppm) were each determined by titration (AOAC, 1995). The probit values were determined from the probit model developed by Finney (1952) for biological assays:

$$P_i = F_{(zi)} = \frac{1}{\sqrt{2\pi}} \int^{Z_i = bo + b_i x_i \ldots b_n x_n} \exp \frac{(s^1)}{2} ds$$

for $-\infty < z < \infty$ and $z_i = x_i\beta$

where P_i = the probability that the ith fish absorbs the toxicant;

$F(z_i)$ = the unobservable level of stimulus;

s = random variable which is normally distributed with the mean zero and unit variance.

Statistical analysis: Bioassay data generated were analyzed using a log-probit procedure as specified by Goldstein *et al.* (1974), and Ufodike and Onwuzurike (1990). Regression analysis method was used to plot the regression line on the scatter diagram using Microsoft Excel computer package at 95% probability ($P < 0.05$). From the plot, LC_{50} values were determined (Parker, 1979).

Results

The results from this study are shown in Figures 1 – 3 and Tables 1. No deaths were recorded throughout the 96-hours duration of the experiment in the three control basins. The clams remained active in the controls whereas those exposed to the toxicants became less sensitive as determined by the number of dead individuals (USEPA, 1987) than the clams in control basins. The clams in toxicant-treated basins moved around less, dug more into the sand to avoid the effect of the metals toxicants (Woodword *et al.*, 1995) than those in control containers. Their inactivity increased as the toxicants concentration increased.

Table 1 shows the percentage mortality of clams subjected to graded concentrations of copper. Mortality followed a dose-dependent pattern, increasing from 5 (41.67%) in 0.05 mgL^{-1} to 9 (75.0%) in 15 mgL^{-1}. The higher the concentration, the less the time 50% of population died. An LC_{50} value of 2.5 1 mgL^{-1} was obtained for copper (Fig. 1). Out of 60 specimens of *G. paradoxa* treated with copper metal concentrations, 33 died.

Table 1 shows the same trend of increased mortalities with increasing

Table 1: Probit kill of *Galatea paradoxa* at various concentrations of copper, chromium and zinc

Concentration (mgL^{-1})	Number	Percentage mortality
	Copper	
0.5	5	41.67
1.0	5	41.67
5.0	6	50.00
10.0	8	66.67
15.0	9	75.00
	Chromium	
0.5	1	8.33
1.0	1	8.33
5.0	2	16.67
10.0	3	25.0
15.0	3	25.0
	Zinc	
0.5	2	16.67
1.0	3	25.0
5.0	5	41.67
10.0	7	58.33
15.0	10	83.33

concentrations of chromium. The mortality ranged from 1 (8.3%) in $0.5mgL^{-1}$ to 3 (25%) in15.0 mgL^{-1}. Out of 60 specimens treated with chromium toxicant, only 10 died. None of the chromium concentrations recorded up to 50% mortality and an LC_{50} value of 91.2 mgL^{-1} was obtained (Fig. 2).

Table 1 also shows that the mortality of the species in zinc followed the same graded trend, increasing from 16.67% (2 deaths) with 0.5 mgL^{-1} to 83.33 (10 deaths) with 15 mgL^{-1} chromium. However, it took a longer time for 50% mortality to be recorded as zinc concentration increased from $0.5mgL^{-1}$ to $15.0mg L^{-1}$. This was in contrast with the observations made with copper. Out of 60 specimens treated with zinc metal, 27 died. The pattern of mortality against toxicant concentration produced an LC_{50} value of 4.37 mgL^{-1} for zinc (Fig. 3).

Discussion

The freshwater clam (*Galatea paradoxa*) exhibited varied patterns of response to the toxicants concentrations, an indication of its tolerance to the different substances that were applied. Whereas the clams were slightly, susceptible to 0.5 - 1.0 mgL^{-1} of chromium (Cr) and zinc (Zn), respectively, they were most devastated by copper (Cu) of the same concentrations. Similar toxicity of copper compared to zinc and lead have

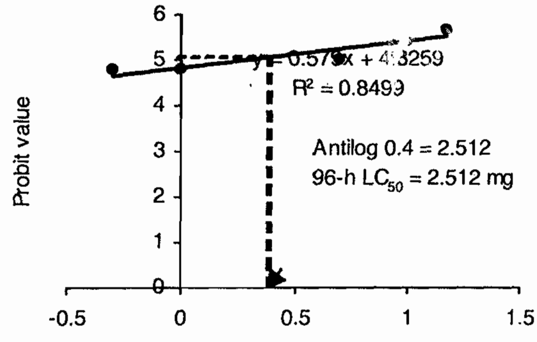

Fig. 1 96-h LC50 of Copper (Cu) for the freshwater clam (*Galatea paradoxa*).

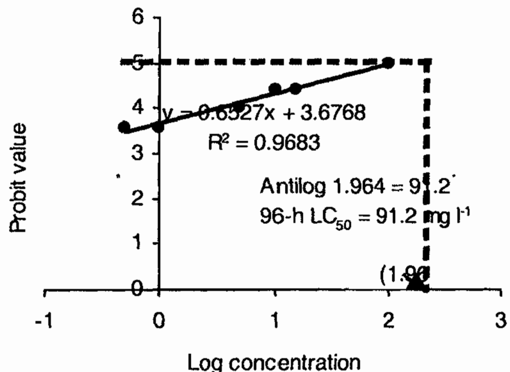

Fig. 2 96-h LC_{50} of copper (Cu) for the freshwaer clam (*Galatea paradoxa*).

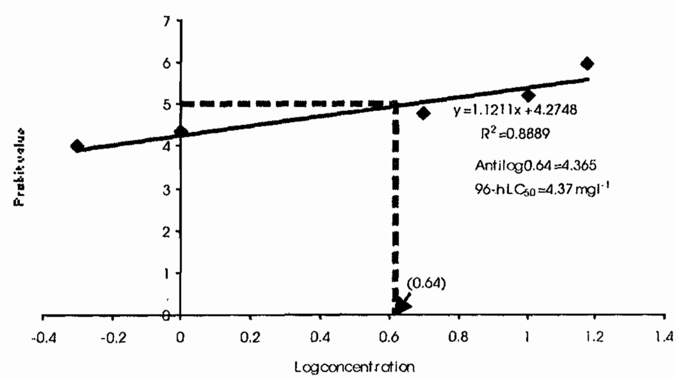

Fig. 3 96-h LC_{50} of Zinc (Zn) for the freshwater clam (*Galatea paradoxa*).

been reported for some invertebrates (Bat *et al.,* 1999). The result suggests some degree of tolerance of *G. paradoxa* to certain heavy metals in the aquatic system and conforms to that reported for the Asiatic clams (*Egeria radiata*) Lamarck (Udoidiong and Akpan, 1991). Udoidiong and Akpan, (1991) found that *Egeria radiata* had preferential tolerance of chromium, copper and zinc. Considering the probit kills of *G. paradoxa* by the three heavy metals (Cu, Cr and Zn), 50% mortality was recorded for chromium. However, the present findings disagree with the assertion that *G. paradoxa*, a recent entrant to freshwater habitat would display less resistance to chromium and copper than the long-standing faunal community (Purchon, 1963). In addition, the overall mortality (38.9%) in the bioassay resulting from the three heavy metals in this study is comparable to the 41% observed with *E. radiata* (Udoidiong and Akpan, 1991).

The LC_{50} value (2.51 mgL^{-1}) for copper reveals that copper was the most toxic of the three substances, followed by zinc (4.37 mg L^{-1}). However, bioassay information of copper, zinc and chromium on clams was inaccessible although, studies reveal that the mixture of salt of metals especially copper and zinc, produced a more-than–additive toxicity in teleosts like trouts (*Salmo gairdneri*) and Atlantic salmon (*Salmo salar*) (Eisler and Gardner, 1973). Similar results were obtained by the authors for mummichog (*Fundulus heteroclitus*) using the salts of copper and zinc within 96 hours. The mummichogs when singly compared to freshwater teleosts were apparently quite resistant to Cu^{2+} with only 30% dead in 96 hours at a concentration of 8 mgL-1 of Cu^{2+}.

Conclusion: The tolerance displayed by *G. paradoxa* for some heavy metals is highlighted in this study. Chromium is better tolerated by the clam, *G. paradoxa* than copper at the concentrations studied.

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