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Toxicity of Some Heavy Metals to Copepods *Acartia spinicauda* & *Tortanus forcipatus*

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Copper was most toxic to the species tested followed by cadmium and zinc. The estuarine species *A. spinicauda* was more sensitive to the toxicants than the marine species *T. forcipatus*. The 48 hr LC_{50} values are presented.

Information on toxicity of heavy metals to marine zooplankton is mainly restricted to larvae of benthic forms. Relatively little is known of this aspect on holoplankton and apparently no study has been reported from Indian waters. The importance of the sensitivity of these animals to heavy metals stems from their role in marine food chains and the direct effect on fish and fish larvae which feed on them. Difficulty in maintaining culture of holoplanktonic zooplankton[1] over extended periods poses a major constraint in experimenting with them.

In the present study toxicity effects of cadmium, zinc and copper have been studied on 2 species of copepods. Of these, *Acartia spinicauda* Giesbrecht is a common high saline estuarine form and *Tortanus forcipatus* Giesbrecht occurs in the coastal waters.

Both species were collected at the mouth of the Zuari estuary, Goa (15°25'N; 73°50'E) where they commonly occur during the saline premonsoon months (February-May). Experiments were conducted twice in April 1979, and test animals were collected using a Heron-Tranter net (mesh size-300 μm). Tows were of 1-2 min duration and animals were immediately transferred to large plastic buckets containing sea water collected from the mouth of the estuary (sal. 33.1 to 34.2‰) and transported to laboratory. They were acclimatised for 12 to 15 hr in larger tanks containing filtered sea water before the experiments. Only actively swimming animals (mostly females or late copepodites) were selected for the tests.

Eight concentrations for each metal ranging from 0.001 to 1 mg/litre were used. Test solutions were prepared by diluting stock of cadmium chloride ($CdCl_2.2.5\ H_2O$), zinc sulphate ($ZnSO_4.7\ H_2O$) and copper sulphate ($CuSO_4.5H_2O$). Twenty animals were used in each of the 8 metal concentrations and control. For each concentration animals were divided into 2 groups of 10 individuals (in duplicate) in 500 ml beakers containing 400 ml of test solution. Adequate controls were also maintained in duplicate. Well aerated filtered sea water was used in all tests. Animals observed to be weak immediately after transferring were replaced. Test animals were starved and experimental beakers were not aerated during the tests.

Each test lasted 48 hr and mortality was noted every 5, 10, 18, 26, 34, and 48 hr. Death of individuals was determined from absence of movement even when prodded gently. Mortality in control was negligible ($< 10\%$).

A computerised probit analysis[2] was carried out after correcting the percentage mortality for any control mortality. Probit regressions against log concentration were made for each metal-species combination and LC_{50} values were calculated.

Derived LC_{50} values, slopes and intercepts of the individual regression lines are presented in Table 1. Tests with copper for *A. spinicauda* and cadmium for *T. forcipatus* showed steeper slopes indicating larger change in percentage mortality for small variations in concentration. The 48 hr LC_{50} values showed copper

Table 1—Derived Lethal Concentrations (mg/litre), Slopes and Intercepts of Probit Regression Lines for Each Species-Metal Combination

Species	Metal	LC_{50} and 95% confidence limits	Slope and 95% confidence limits	Intercept
A. spinicauda	Cd	0.05 (0.01-0.17)	0.42 (0.16-0.67)	4.71
T. forcipatus	Cd	0.13 (0.05-0.31)	0.61 (0.34-0.87)	4.33
A. spinicauda	Zn	0.39 (0.07-1.98)	0.41 (0.20-0.62)	4.35
T. forcipatus	Zn	0.75 (0.11-5.34)	0.44 (0.11-0.76)	4.18
A. spinicauda	Cu	0.01(0.005-0.03)	0.67 (0.25-1.09)	4.91
T. forcipatus	Cu	0.04(0.003-0.63)	0.33(−0.09-0.75)	4.78

to be the most toxic followed by cadmium and zinc. The estuarine copepod *A. spinicauda* was more sensitive than the marine form *T. forcipatus* for all the metals tested. LC_{50} values were about twice for *T. forcipatus* compared to *A. spinicauda* in cadmium and zinc whereas it was 4 times in copper.

Arnott and Ahsanullah[3] testing the acute toxicity of these metals on 3 species of copepods obtained trends similar to the present study where copper was most toxic and cadmium more toxic than zinc. However, the 24 hr LC_{50} values obtained by them showed higher dose of the 3 metals (0.66 to 2.71 mg/litre for Cd, 1.09 to 1.86 mg/litre for Zn, 0.18 to 0.20 mg/litre for Cu). 24 hr LC_{50} values for copper on copepod nauplii and 5 species of copepods obtained by Reeve *et al.*[4] ranged from 90 to 311 μg/litre. But 24 and 48 hr LC_{50} values are not strictly comparable since the stress to the animals tested under experimental conditions can increase manifold over extended periods. Stress could result from starvation or physiological changes caused by the toxicant. The 5 hr LC_{50} value of copper for *Acartia clausi* has been estimated[5] to be as high as 2 mg/litre. The present findings are more in agreement with the copper 48 hr LC_{50} value of 0.034 mg/litre obtained[6] for *A. clausi*.

Plankton are capable of concentrating heavy metals from sea water. The average heavy metal content in zooplankton from north west Mediterranean is reported to be 2.5, 268 and 32.6 $\mu g\, g^{-1}$ dry weight for cadmium, zinc and copper respectively[7] where the average metal concentration in water is 0.1-0.22 μg/litre for cadmium, 1.9-7 μg/litre for zinc and 0.2-0.7 μg/litre for copper[8]. The average content of zinc is about 12.1 μg/litre and copper 4.8 μg/litre at the mouth of the Zuari estuary[9] from where the animals were collected for the present bioassay.

It has been demonstrated that sublethal effects of heavy metal toxicity can alter the physiological functions of zooplankton[6, 10, 11]. Acute toxicity levels of the same species from different populations may also vary[4]. The environmental characters of a particular locality from where a species is collected can also alter the response to the toxicant used. The 48 hr LC_{50} values of *A. clausi* collected from a 'clean' station was 0.034 mg Cu/litre whereas it was 0.082 mg Cu/litre for specimens collected from a polluted area[6].

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