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Toxicity of Zinc, Copper and Lead to *Idotea baltica* (Crustacea, Isopoda)*

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Abstract: The acute toxicity of zinc, copper and lead to the marine invertebrate *Idotea baltica* (Crustacea, Isopoda) was evaluated by static bioassays, calculating the LT_{50} (lethality time for 50%) for males and females. Survival time decreased with increasing concentrations of zinc, copper and lead. Zinc was more toxic to *Idotea* than copper and lead. Lead was the least toxic of the metals tested.

Key Words: Zinc, copper, lead, survival time, lethality time, *Idotea baltica*, bioassay.

Çinko, Bakır ve Kurşun'un *Idotea baltica* (Crustacea, Isopoda)'lara Toksisitesi

Özet: Deniz omurgasızlarından *Idotea baltica* (Crustacea, Isopoda) kullanılarak çinko, bakır ve kurşunun akut toksisitesi statik biyolojik deneylerle ölçülmüş ve hem erkek hem de dişi bireyler için öldürücü zaman (LT_{50}) hesaplanmıştır. Hayatta kalma süreçleri, çinko, bakır ve kurşun konsantrasyonlarının artmasıyla azalmıştır. Çinko, bakır ve kurşundan daha toksik bulunmuştur. Denenen bu metallerden en az toksik olanı ise kurşundur.

Anahtar Sözcükler: Çinko, bakır, kurşun, hayatta kalma süresi, öldürücü zaman, *Idotea baltica,* biyolojik deney.

Introduction

Marine pollution studies were started in the 1970s, by which time considerable base–line data for the marine ecosystem were available. Most marine pollution is caused by domestic wastes, industrial wastes, oil wastes, pesticides, insecticides, radioactive wastes and metals. Coastal waters in particular are increasingly affected by such pollutants, some of the most important of which are metals. Some heavy metals such as iron, cobalt, copper and zinc are essential to many organisms, while others such as cadmium, lead and mercury are never benefical and are often harmful or toxic. Whether essential or not, most metals are potentially harmful at some levels of exposures. This study, investigates and compares the effects on the isopod *Idotea baltica* of copper and zinc, which are essential in trace quantities, but markedly toxic even at quite low concentrations, and of lead which has no known benefical effects at any level of exposure.

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Heavy metals are in widespread industrial use and in recent years have been found in increasing quantities as contaminants in all components of the biosphere, hence the need to investigate not only the short–term toxic effects of these substances but also the long–term implications of low levels of exposure for the structure and balance of ecosystem.

An important way in which the study of heavy metal pollutants differs from the study of synthetic pollutants such as pesticides and detergents is that metals occur naturally in the environment and are present in trace quantities in the atmosphere, in the soil and in fresh and salt water.

When studying the effects of discharged pollutants on organisms, it is important to consider a number of aspect, including the effects on survival, growth and reproduction. For sensitive species, the adverse effects of exposure to a particular pollutant may be immediately obvious, whereas in other cases accumulated pollutants, particularly metals, may be stored in a form which has little or no effect on the target species but which may be extremely toxic to the next trophic levels in the food chain of coastal waters. Of the target species, the isopod *Idotea baltica* is widely distributed in shallow marine waters of Europe from Northern Norway into the Gulfs of Bothnia and Finland and South of the Black Sea (1, 2, 3). They are also very sensitive to heavy metal toxicities (4, 5, 6, 7). This benthic isopod, inhabiting seaweed on lower shores and in shallow waters, is a detritus feeder and the prey of many marine invertebrates and vertebrates. *Idotea baltica* is also used as a biomonitor organism for coastal metal pollution (8). Therefore, in the present study the acute toxicity of zinc, copper and lead on mortality and sex ratio of the crustacean isopod *Idotea baltica* (Pallas) were determined by static bioassays.

Materials and Methods

Several hundreds samples of *Idotea baltica* were collected at the same location from the mediolittoral zone of the Bay of Sinop Peninsula, Black Sea, Turkey (Fig. 1). They were occasionally found in large numbers on shore–washed decaying seaweed. After being collected, the animals were transported in aerated sea water to the laboratory, where they were placed in plexiglass experimental tanks (30 x 30 x 20 cm) at 16°C. Before the trials, males (12–15 mm long) and females (8–11 mm long) were acclimated to laboratory conditions for a week, during which time all animals were fed with fresh sea–lettuce *Ulva lactuca*. Mean dry weights were 12 mg (42 mg wet wt) for males and 6 mg (19 mg wet wt) for females. The colours of the animals were uniformly green on brown but often with white spots or longitudinal lines. Females were often darken than males.

Stock solutions of MERC grade chemicals, zinc chloride ($ZnCl_2$), copper (II) sulphate ($CuSO_4.5H_2O$) and lead (II) nitrate Pb $(NO_3)_2$ were prepared in sea water and diluted as required. Concentrations of 0.01, 0.05, 0.1, 0.5, 1, 10 and 20 mg l^{-1} of zinc, copper and lead were tested and the eighth beaker was used as a control (clean sea water). Three replicated series of experiments were carried out simultaneously for zinc, copper and lead. All control and test solutions were aerated by Rambo EP–8500 air pumps. Preliminary tests were carried out to establish suitable concentration ranges. The nominal zinc, copper and lead concentrations were in the range 0.001 to 100 mg l^{-1}, 0.001 to 50 mg l^{-1} and 0.001 to 32 mg l^{-1}, respectively.

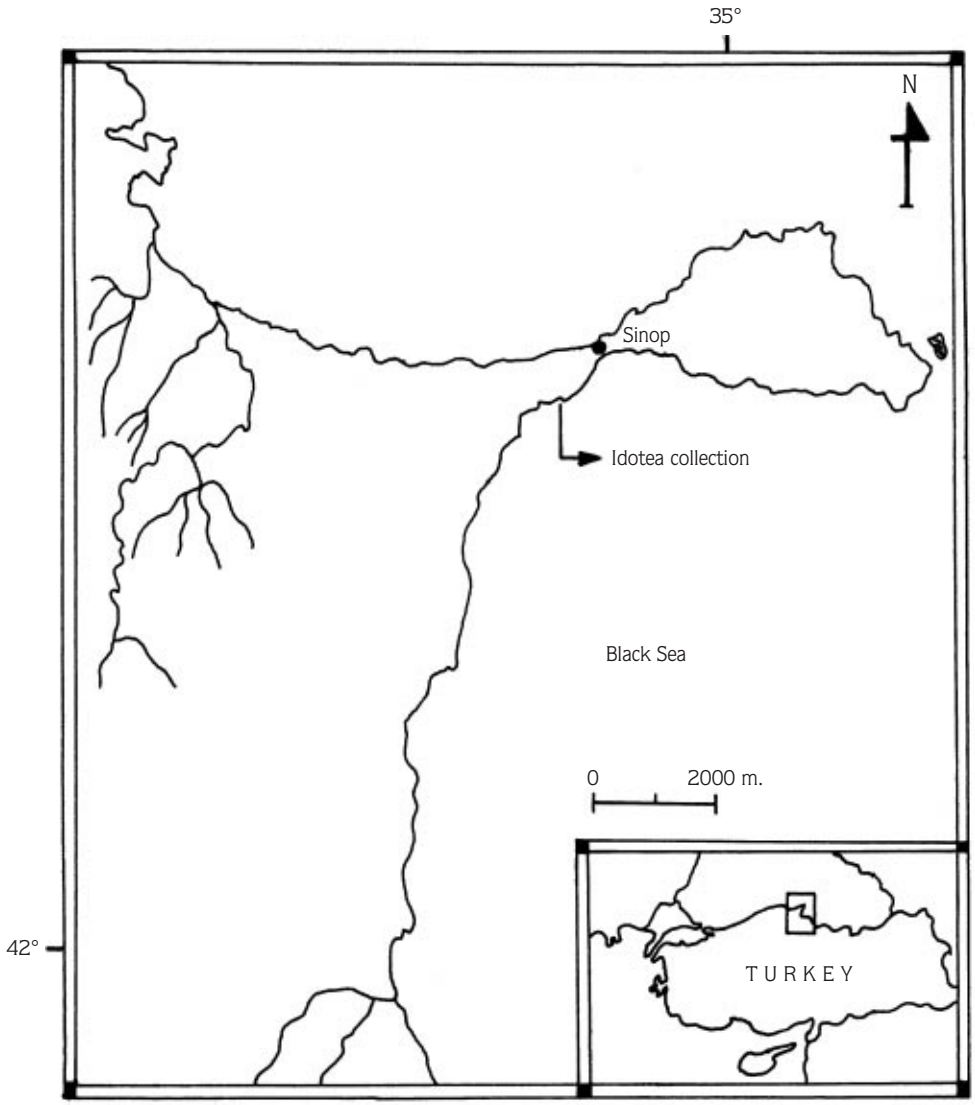


Figure 1. Map showing the location for collection of Idotea baltica.

All experiments with isopods were conducted under static test conditions in 1–litre beakers containing 800 ml of solution. Active and apparently healthy individuals were selected from the stock tanks. Three replicate beakers each containing 10 males or 10 females or 5 males and 5 females were exposed to each of the zinc, copper and lead concentrations and the control water.

The water quality measurements showed that the average temperature of the water was 15±1 °C, salinity 17±1‰, pH 8.0±0.2 and dissolved oxygen 6.8±0.3 mg l^{-1}.

Animals were checked daily for mortality. The criterion for death was the absence of movement when the test organisms were prodded. Dead individuals were removed after each observation, but not replaced. Moreover, all test organisms were periodically examined under a stereomicroscope in order to detect possible morphological modifications.

Lt_{50} is the time elapsed from the beginning of the experiment to the death of half the individuals tested.

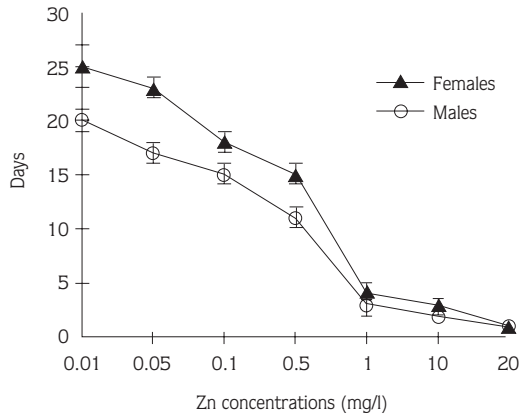
Statistical analysis of data was performed by the one–way analysis of variance (ANOVA) to compare the mortality rate of the different experimental groups and sexes for zinc, copper and lead (9).

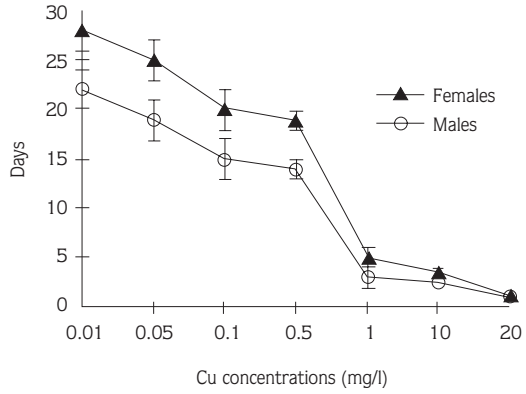
Results and Discussion

In the control animals the mean LT_{50} values were 85±8 days for females and 80±6 for males, the difference between sexes was not statistically significant. Survival decreased with increasing zinc, copper and lead concentrations in sea water. The mean LT_{50} values and relative standard errors (SE) for *Idotea* females and males are shown in Figure 2. Lead, which is a non–essential metal, is significantly less toxic to *Idotea* females and males than either zinc or copper, which are essential metals. These results agree with toxicity sudies on *Idotea baltica* and other invertebrates (5, 6, 7, 10). This may be due in part to geography since the sites have high background concentrations of metals (5) and invertebrates like *Idotea* may have developed either a physiological or genetic adaptation or a combination of both to same metals (7, 11, 12). In the present study, the results of LT_{50} values also showed that zinc was more toxic than copper or lead. Similarly, De Nicola *et al.* (7) showed that zinc pollution strongly affected the frequencies of some genotypes in *Idotea*.

Idotea baltica females had longer survival than males even at the lowest concentrations (0.01 mg l^{-1}) of zinc, copper and lead (Fig. 2), whereas at higher concentrations (1–20 mg l^{-1}), no significant differences were observed among the LT_{50} values of zinc, copper and lead. The analysis of the comparison of metal toxicity between sexes is shown in Table 1. Survival was significantly lower in males than those in females for 0.01–0.5 mg l^{-1} of all three metals. Consequently, males were more sensitive than females, suggesting that the sex–linked toxicity could modify the population structure. The results show that *Idotea* appears sensitive to metal contaminated with sea water. The protection of a marine habitat from damage due to these metals requires an understanding of the sensitivity of invertebrates to metals and their ecological requirements. *Idotea baltica* is widely distributed in coastal waters from the Baltic to the Black Sea and is an important component of the benthos ecosystem.

The present study has confirmed the potential of *Idotea* for toxicity tests. These species met most of the criteria required (given by De Nicola Gidudici *et al.* (11), De Nicola Gidudici and Guarino (6) for suitable sea water toxicity test organisms. Ideally, a toxicity test should be rapid,





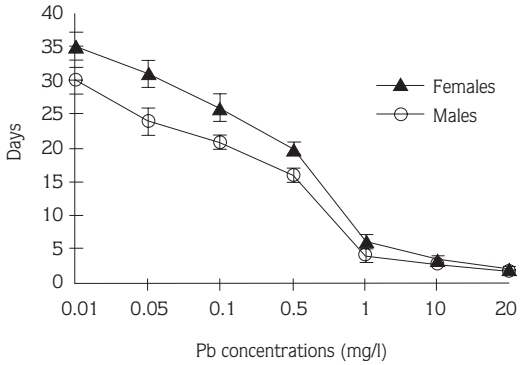


Figure 2. LT_{50} values and related SE of *Idotea baltica* females and males at different concentrations (mg/l) of Zn, Cu and Pb.

Table 1. Statistical analysis of one–way ANOVA of *Idotea baltica* survival in sea water contaminated with zinc, copper and lead concentrations with comparison of males and females.

Metal concentraitons ($mg\ l^{-1}$)	Zn			Cu			Pb		
	N	F	*p*	N	F	*p*	N	F	*p*
0.01	60	13.3	<.01	60	14.2	<.01	60	12.4	<.01
0.05	60	16.2	<.01	60	9.89	<.01	60	13.2	<.01
0.1	60	10.5	<.05	60	11.6	<.01	60	5.56	<.05
0.5	60	15.0	<.01	60	8.55	<.05	60	6.98	<.05
1	60	0.42	n.s.	60	2.15	n.s.	60	0.45	n.s.
10	60	0.31	n.s.	60	1.53	n.s.	60	1.65	n.s.
20	60	1.75	n.s.	60	1.56	n.s.	60	2.45	n.s.

n.s.: Not significant.

simple and inexpensive. Fulfilling these requirements, *Idotea baltica* can be considered a useful biomonitor organism. The Sinop coast of the Black Sea is not contaminated (8), but it is likely that uptake of metals by *Idotea* could have significant impact on higher trophic levels.

Jones (13) and Bryant *et al.* (14, 15) have pointed out that metal toxicity to marine crustacea including isopods varies with environmental conditions such as temperature, salinity and metal type, and it would be useful to repeat these experiments on *Idotea* over a range of these variables. Thus information on the toxicity of metals to biomonitors, particularly in invertebrates, can help in the determination of maximum permissible levels of metals that may be discharged into coastal waters.

Conclusions

Many experimental studies on the effects of pollutants, especially heavy metals on aquatic invertebrates have mainly been bioassays to determine acute and chronic toxic concentrations of pollutants. This type of bioassay is usually carried out in laboratory conditions, and the validity of defining safe levels on the basis of these results is questionable. However, more recently many researchers have investigated the sublethal effects of pollutants on organisms (especially the effects on growth and development and the sex ratio). The results of such bioassays are much more meaningful than those of acute toxicity tests. However, the application of the results in often difficult because they refer to organisms in isolation and in controlled laboratory conditions. Moreover, there is little information on the ways in which pollutants are likely to affect the structure of ecosystem as a results of interaction between affected and unaffected species.

The main objective of the present study was to develop a bioassay procedure as well as to investigate the effects of the heavy metals zinc, copper and lead on *Idotea baltica* males and females which are ecologically important. The aim of this approach was to derive results which are applicable to practical pollution problems.

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