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TOXIC EFFECTS OF BOTH ZINC AND COPPER ON SIZE AND SEX OF PORTUNUS PELAGICUS (L) (CRUSTACEA : DECAPODA)

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ABSTRACT

The toxicities of zinc and copper to **Portunus pelagicus** (L.) were evaluated on an acute basis. The effects of the metal concentrations on survival were measured quantitatively. Mature individuals were found to be less sensitive to both zinc and copper toxicities than immature ones. Copper was shown to be far more toxic than zinc. This important conclusion was obtained from the data of the concentrations of Zn or Cu required to kill more than 50% of the organisms during 96 hours.

INTRODUCTION

The most important aspects of the pollution of the marine environment are the hazards to the edible invertebrates caused by consuming some heavey metals.

Zinc and copper are two important metals in marine waters. Their concentration factors from sea-water very considerably from species to species, but factors amounting to several hundreds or thousands are common (Bryan, 1971).

Concerning the toxicity of zinc and copper to marine invertebrates, many workers have been made. Several investigators have reported heavy metal effect on decapod crustaceans (Raymont and Shields, 1964; Eisler, 1971; Vernberg and G'hara, 1972).

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Zinc and copper were chosen as the test metals because of the growing awareness of their toxic properties, their persistent mature, and their increasing occurrence in the environment. Moreover, they are essential trace elements in the respiratory physiology of marine crustacea.

The carb **Portunus pelagicus** (L) of the coasts of the Mediterrenean sea was chosen as an experimental animal on the basis of some important criteria. The organism is representative of an ecologically important group (in terms of taxonomy, trophic level or realized niche). It also occupies a position within a food chain leading to man or other important species.

The prime object of this study was to determine the relative toxicities of zinc and copper and their effects on both sexes of immature and mature stages of **Portunus pelagicus** (L).

MATERIAL AND METHODS

Crabs were collected from an unpolluted area, near Al-Maadia district of Alexandria. In the laboratory, specimens were sexed sized, weighed and carapace widths (distance between tips of the two lateral spines) were detrmined (Table 1).

The experimental animals maintained in aerated and filtered sea water which was collected from the same area and were fed pieces of frozen prawns.

TABLE (1)

Weights and comparable carapace widths of immature and mature individuals of **Portunus pelagicus** (L) used in the bioassays.

Size	Weight range in gm	Carapace width (range, in Cm)
Immature (Os + Os)	60-80	9-10
Mature (Os + Os)	190-210	14-15.6

Prior to testing crabs were acclimatized in the laboratory in rectangular glass tanks (30X40X100 cm) for approximately four days. Crabs were not fed for nearly 24 hours preceeding and during a test. Mortality was negligable for the carbs during the entire acclimatization period. Physicochemical characteristcs of water a quaria were constant (table 2).

TABLE (2)

Experimental conditions of the tests carried on the toxicity of zinc and copper to **Portunus pelagicus.**

Salinity %	Dissolved oxygen (% saturation)	Temperature (° C)
36.7	81	17 ± 2

Static acute biooassay tests were carried out for the determainations of 96h LC_{50} of the crabs. All tests were carried out in the same containers where crabs have been acclimatized. Bech container was applied with 25 liters of sea water number of crabs and was provided with the filtering and aerating aquipments.

Both zinc and copper solutions were respectively made from zinc sulphate ($ZnSO_4 . 7H_2O$) and copper sulphate ($CuSO_4 . 5\ H_2O$) in distilled water; cupric sulphate solution was acidified with a drop of 6N HCL to prevent precipitation (McKim and Benoit, 1971). 17 and 15 concentrations of zinc and copper (respectively) were prepared (Table 3). The number of mortalities and survivals were recorded at 24 hr intervals over a 96 hr period. Crabs that died during the test period were removed from the containers at the end of every hour. Crabs were considered to be dead when no movement of any appendage could be obselved.

RESULTS

The bioassays on **Portunus pelagicus** (L) indicated that there may be some differences in sensitivity to zinc and copper. The influences of the two metals on survival of both sexes of immature and mature individuals of **Portunus pelagicus** (L) at each concentration of both toxicants during the 96 hour exposure are summarized in tables (4 and 5).

TABLE (3)

Matal concentrations used in bioassays.

Zinc	Copper
56	19.9
52	15.8
48	12.5
44	10.0
40	7.9
36	6.3
32	5.0
28	4.0
24	3.15
20	2.50
16	2.0
10	1.6
8	1.25
6	1.0
4	0.0
2	0.0
0 (control) mg/l	0.0

It is observed that the survival of both sexes of immature and mature crabs decreased strikingly as the concentrations of both zinc and copper increased. Mature crabs, in particular, were found less sensitive to both toxicants, and of all tested crabs, mature females were the more tolerable to both toxicants. Concentrations of zinc and copper from 36-44 mg Zn^{++}/L and from 6.3-I0 mg Cu^{++}/L (respectively) caused 100 %, 100 % mortalities in immature females and 88.3 %, 85 % in mature ones.

Consequently comulative mortality rates had occurred among all tested crabs in other applied concentrations of both metals (4-36 mg Zn^{++}/L and I-25 - 6.30 mg Cu^{++}/L).

It is obvious also from tables (4 and 5) that within 96 hour exposure period concentrations of both zinc and copper less than 4 and I.25 mg/L (respectively) had no detectable influence on the survival of both sexes of immature and mature crabs.

Also, it is of interest to find that copper was far more toxic than zinc. Table (6) clearly showed that in both sexes of immature and mature individuals of **Portunus pelagicus** (L) copper was about 6-7 times as toxic as zinc. For example the 96-Hr LC_{50} of zinc for immature females and

TABLE (4)

Percent survival of both sexes of immature and mature crabs exposed to graded concentrations of Zn^{++} as $Zn\ SO_4$ for 96 hours.

Concentrations of zinc	log concentrations	Mean (a no. of immature survival ± S.D.(b)		Percent Survival		Mean (a no.of mature survival ± S.O.(b)		Percent survival	
4 4	1.64	0.0 ± 0.00	0.0 ± 0.00.0 ± 0.00						
4 4	1.64	0.0 ± 0.00	0.0 ± 0.00	000	000	0.0 ± 0.00	0.0 ± 0.00	000	000
4 0	1.60	0.0 ± 0.00	0.0 ± 0.00	000	000	0.4 ± 0.13	0.0 ± 0.00	010	000
3 6	1.56	0.0 ± 0.00	0.2 ± 0.11	000	005	1.0 ± 0.70	0.4 ± 0.22	25	10
3 2	1.50	0.0 ±0.00	0.6 ± 0.38	000	015	1.0 ± 0.46	0.6 ± 0.38	25	15
2 8	1.45	0.4 ± 0.13	0.6 ± 0.18	010	015	1.6 ± 0.95	0.8 ± 0.72	40	20
2 4	1.38	0.6 ± 0.16	1.0 ± 1.20	015	025	1.8 ± 0.80	1.4 ± 0.61	45	35
2 0	1.30	1.0 ± 0.20	1.2 ± 0.80	025	030	2.2 ± 0.43	2.0 ± 1.42	55	50
1 6	1.20	1.4 ± 0.31	1.6 ± 1.13	035	040	3.0 ± 0.17	2.4 ± 0.65	75	60
1 0	1.00	2.4 ± 1.10	2.4 ± 1.91	060	060	3.4 ± 0.93	2.6 ± 1.66	85	65
8	0.90	2.8 ± 0.80	2.6 ± 0.60	070	065	3.6 ± 1.21	3.6 ± 1.38	90	90
6	0.78	3.4 ± 1.12	3.2 ± 2.10	085	080	4.0 ± 0.00	4.0 ± 0.00	100	100
4	0.60	3.6 ± 1.30	3.8 ± 0.60	090	095	4.0 ± 0.00	4.0 ± 0.00	100	100
2	0.30	4.0 ± 0.00	4.0 ± 0.00	100	100	4.0 ± 0.00	4.0 ± 0.00	100	100
0	0.00	4.0 ± 0.00	4.0 ± 0.00	100	100	4.0 ± 0.00	4.0 ± 0.00	100	100

TABLE (5)

Percent survival of both sexes of immature and mature crabs exposed to graded concentrations of Cu^{++} as $Cu\ SO_4$ for 96 hours.

Concentrations of Cu^{++}(mg/L)	Log concentrations	Mean (a no. of immature survival ± S.D.(b)		Percent survival		Mean (a no. of mature survival ± S.D.(b)		Percent survival	
12.50	1.1	-	-	-	-	0.00 ± 0.00	0.0 ± 0.00	000	000
10.00	1.0	-	-	-	-	0.2 ± 0.31	0.0 ± 0.00	005	000
7.90	0.9	-	-	-	-	0.6 ± 0.22	0.2 ± 0.16	015	005
6.30	0.8	-	-	-	-	1.0 ± 0.53	0.6 ± 0.22	025	015
5.00	0.7	-	0.4 ± 0.54	-	10	1.4 ± 0.65	1.0 ± 0.81	035	025
4.00	0.6	0.4 ± 0.33	0.8 ± 0.26	10	20	2.0 ± 1.07	1.6 ± 0.52	050	040
3.15	0.5	1.0 ± 0.21	1.2 ± 0.34	25	30	2.4 ± 0.97	2.2 ± 1.81	060	055
2.50	0.4	1.6 ± 0.62	1.8 ± 0.54	40	45	3.4 ± 2.50	2.8 ± 1.60	100	070
2.00	0.3	2.2 ± 1.20	2.0 ± 1.30	55	50	4.0 ± 0.00	3.0 ± 0.53	100	075
1.60	0.2	2.6 ± 1.81	2.4 ± 0.93	65	60	4.0 ± 0.00	3.6 ± 0.87	100	090
1.25	0.1	3.4 ± 2.93	3.4 ± 2.71	85	85	4.0 ± 0.00	4.0 ± 0.00	100	100
1.00	0.0	4.0 ± 0.00	4.0 ± 0.00	100	100	4.0 ± 0.00	4.0 ± 0.00	100	100
0.00	0.0	4.0 ± 0.00	4.0 ± 0.00	100	100	4.0 ± 0.00	4.0 ± 0.00	100	100

TABLE (6)

Median lethal concentrations ($LC_{50}s$) for immature and mature *Portunus pelagicus* (L) exposed to zinc and copper at 96 hours.

Size	Sex	96-hr (mg / L)	
		Zinc	Copper
Immature	Females	12.16	2.16
	Males	12.49	1.04
Mature	Females	22.38	3.89
	Males	18.62	3.27

males were 12.16, 12.59 mg/L (respectively) and the comparable values of the 96-hr LC_{50} of copper were 2.16, 2.04 mg/L (respectively).

A similar comparison of test results between the 96-hr $LC_{50}s$ of zinc and copper for mature females and males demonstrates the nearly same ratio as in immature ones.

DISCUSSION

Most of the available information on the acute toxicity of zinc and copper pertains to fish. Relatively few toxicity experiments have been performed on aquatic invertebrates, particularly crustaceans. Spehar (1976) found the 96-hr LC_{50} value for juvenile flag fish (**Jordanella floridae**), exposed to zinc to be 1500 Mg/L. Thorp and Lake (1974) determined the 96-hr LC_{50} of zinc for the fresh water shrimp (**Paratya tasamaniensis**). They found that it was I.I mg/L. In soft water, Cairns and Scheier (1958) found the 96-hr LC_{50} of zinc for snails ranged from 0.79-I.27 mg/L, whereas in hard water the result was 2.66-5.57 mg/L. Prediction of copper toxicity to fish has been uncertain despite many studies. O'Hara (1971) pointed out that 96-hr exposure (LC_{50} s) for fish has a wide range, from 0.01 to 10 mg/L for total copper.

From the foregoing data and those of the present study, it is clear that the response of the **Portunus pelagicus** (L) to zinc and copper was substantially different from that reported by other wortkers using different species of marine organisms. So we can generally conclude that crustaceans are less sensitive to both zinc and copper toxicities than fish.

The important reason for the unsimilarity of date is that the animals may be long lived, and variation in response to a toxicant may reflect systematic differences due to age, size, life stage, reproductive stage, etc.

The most interesting findings from the toxicity study are the values of LC_{50}s of both metals for the immature crabs. They were always lower than those of mature ones. Many factors affect organism sensitivity to toxicants and accordingly the LC_{50}(Sprague, 1969, 1970, 1971; Filov et al) 1979. Some examples are stage of moult (Conklin and Rao, 1978; Lee and Buikema, 1979), age, life stage, or size (Hall, et al., 1978). Buikema and Benfield (1979) reported that immatures of insects and crustacea are the most sensitive life stage.

The LC_{50} s for different metals with the same test organism and test conditions can yield information on relative toxicity or organism sensitivity, the higher the LC_{50}, the lower the toxicity or sensitivity. Despite this apparent simplicity, the acute toxicity test has provided a large amount of cost-effective and reliable information of this kind. The LC_{50} is most useful as a tool in comparison.

In the present study differential responses of sensitivity to both toxicants were found between sexes of immature and mature crabs. This also has been demonstrated for crayfish but the pattern was masked by size differences (Heit and Fingerman, 1977); generally females survived best.

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