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Impact of cadmium on the total protein, carbohydrate and lipid contents of the mangrove crab *Sesarma brockii* De Man

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Abstract

The larval stages of the mangrove crab, *Sesarma brockii* was exposed to different concentrations of cadmium. The survival of the larvae decreased with increasing concentration of cadmium. The intermoult duration was prolonged with increased test concentrations. The protein, carbohydrate and lipid content of the larval stages decreased with increase in cadmium concentrations. The possible reason for the decrement of organic constituents are discussed.

Introduction

Cadmium is readily accumulated by marine biota, sometimes it reaches a concentration factor as high as 10-6 and it appears to be highly concentrated in plankton from near shore areas (Fowler and Benayoun, 1974). The deleterious effects on aquactic biota exposed to metals at very low concentrations were also reported (Calabrese *et al.*, 1973). Compared to heavy metals such as lead and mercury less attention has been paid to the toxic effect of cadmium on the larval development of crustaceans. Information on the changes in biochemical constituents due to sublethal effect of cadmium is still meager. Therefore, in the present study, changes in the biochemical components due to cadmium exposure were traced during the larval development of the mangrove crab, *Sesarma brockii.*

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Material and methods

Collection of berried crabs and maintenance of the larvae in the laboratory were described elsewhere (Kannupandi *et al.*, 2001a). The stock solution of cadmium was prepared by dissolving 1.792 g (which contain 1 g of cadmium) of analytical grade cadmium chloride ($CdCl_2$) salt in 100 ml of deionized water. Ten ml of this stock solution was further diluted with 90 ml of deionized water to prepare the secondary stock solution (concentration - 10 ug/1). From this solution the required concentrations were prepared by serial dilution. Based on the first zoeal 96 h LC_{50} value (125 µg/l) 3 chronic concentrations *viz.*, 12.50, 60.75 and 91.13 µg/1 were selected to estimate the effect on the protein, carbohydrate and lipid contents. The analytical procedure are same as described in Kannupandi *et al.* (1996). The data were processed using student 't' test, ANOVA and mutliple range test.

Results

Survival

In the control, the overall survival rate was 100%. The overall survival rate in other test concentrations was lower as the concentration increased the survival rate decreased (Fig. 1).

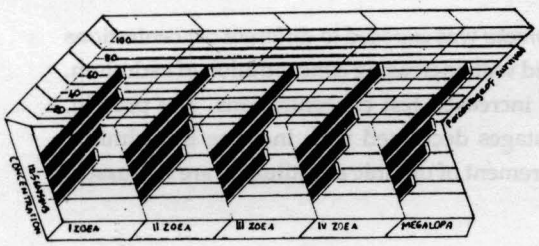

Fig. 1. *Percentage of survival rate during the larval development of Sesarma brockii at various test concentrations of cadmium*

Intermolt duration

The mean days of molting of each larval stages in different test concentrations and the statistical analysis are given in Fig. 2. The intermolt duration was prolonged with increased test concentrations. The 'F' values are statistically significant at $P<0.05$ level. Multiple range test showed the accept in all the concentrations during the larval development.

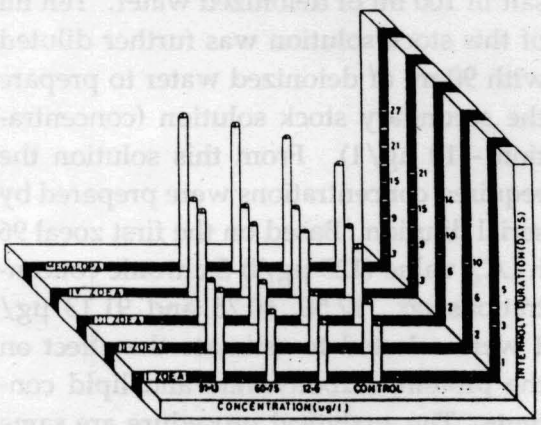

Fig. 2. *Mean intermolt duration of larval development of S. brockii to different concentration of cadmium*

Protein

The mean protein level in larval stages exposed to different concentrations of cadmium is shown in Table 1. The 't' value showed that the protein content decreased significantly in all the test concentrations of cadmium. The analysis of variance also showed a similar singificant decrease, except I and IV stages. The multiple range test showed the accept in almost all the test concentrations in I, II, IV and megalopa stages except III zoeal stage which showed the reject in all the test concentrations.

Table 1. *The protein content during the larval development of S. brockii under exposure of various test concentrations of cadmium for 24 h (Values expressed in mg./g/wet weight). Each values is the mean of the 5 sample ± S. D.*

Stages	Control	Concentrations (µg/l)		
		12.50	60.75	91.13
I Zoea	15.162 ±0.41	14.566* ±0.67	12.252* ±0.42	9.454* ±0.50
II Zoea	16.134 ±0.09	15.523* ±0.55	13.094* ±0.14	10.678* ±1.20
III Zoea	7.496 ±0.19	12.184* ±0.29	14.204* ±0.12	12.058* ±0.13
IV Zoea	19.613 ±0.19	18.886* ±0.39	16.144* ±0.92	13.340* ±0.38
Megalopa	18.321 ±0.18	16.123 ±0.07	14.740* ±0.05	11.002* ±0.02

* indicate statistically significant difference from control value ($P < 0.05$).

Carbohydrate

The mean value of carbohydrate in the larval stages decreased with the increase in exposure concentration of cadmium and the results are shown in Table 2. The 't' test and 'F' values were significant at P<0.05 level showing reduction in carbohydrate level. Mutliple range test showed, the 'accept' in almost all the test concentration in I, II, III zoeal and megalopal stages except IV zoeal stage which showed the 'reject' in all the test concentrations.

Lipid

The mean lipid content of the larval stages decreased with the increse in cadmium test concentration. The mutliple range test showed both the 'accept' and 'reject' in all the test concentrations in the different stages of development (Table 3).

Table 2. *The Carbohydrate content during the larval development of S. brockii exposure of various test concentrations of cadmium for 24 h. (Values expressed as mg./g. wet weight). Each values is the mean of 5 sample ± S. D.*

Stages	Control	Concentrations (µg/l)		
		12.50	60.75	91.13
I Zoea	0.734 ±0.062	0.714* ±0.012	0.699* ±0.380	0.559* ±0.088
II Zoea	0.863 ±0.085	0.748* ±0.030	0.722* ±0.030	0.696* ±0.040
III Zoea	1.062 ±0.014	0.981* ±0.010	0.910* ±0.090	0.698* ±0.160
IV Zoea	1.110 ±0.018	1.095* ±0.190	1.062* ±0.010	0.814* ±0.020
Megalopa	0.928 ±0.024	0.874* ±0.015	0.701* ±0.023	0.562* ±0.128

* indicate statistically significant difference from control value (P<0.05).

Table 3. *The Lipid content during the larval development of S. brockii exposure of various test concentrations of cadmium for 24 h. (Values expressed as mg./g. wet weight). Each values is the mean of 5 sample ± S. D.*

Stages	Control	Concentrations (µg/l)		
		12.50	60.75	91.13
I Zoea	1.142* ±0.07	1.142* ±0.07	1.088* ±0.04	1.0108* ±0.09
II Zoea	0.981* ±0.620	0.981* ±0.620	0.800* ±0.010	0.760* ±0.030
III Zoea	0.725* ±0.030	0.725* ±0.030	0.588* ±0.040	0.354* ±0.060
IV Zoea	0.590* ±0.020	0.590* ±0.020	0.466* ±0.040	0.270* ±0.030
Megalopa	0.581* ± 0.010	0.581* ±0.010	0.434* ±0.030	0.223* ±0.020

* indicate statistically significant difference from control value (P < 0.05).

Discussion

In the present study, cadmium was found to influence the survival and intermolt duration (Pasupathi and Kannupandi, 1989; Kannupandi *et al.*, 2001b) as well as alter the organic composition of the larvae of *S. brockii* during development. In cadmium - exposed animals energy intake, assimilation and the eventual utilization of the assimilated energy for growth were altered during larval growth (Johns and Miller, 1982). The alteration in the organic composition in metal treated larvae might be due to the cellular damage, as reported in the crab *Carcinus maenas* (Wright and Brewer, 1979). The exposure of cadmium brings about inhibition of acetylcholineesterase causing death by paralysis of respiration and depression of the respiratory centers (Combs *et al.*, 1972). The cadmium has

only slight effect on major plasma electrolytes like sodium and chloride. These ionic disturbances may cause tissue damage in crab larvae as well as in the fish (Larsen, 1975). Cadmium influence on plasma calcium and potassium can be compared to certain pathological conditions in animals (Larsen and Haux, 1982). Thus *hypocalcemia* is known to cause neuromuscular disturbances like hyperexcitability, paralysis and tetony. The excess body burden of metals may trigger demineralization of skeleton and will also induce nerve malformation (Bengtsson, 1975). Larson (1975) reported that the cadmium induced hyperglycemia might also be a result of an impaired insulin production.

The pollutants usually block the phosphorylation site in the enzymes by binding to the - SH groups (Wright and Brewer, 1979). Membrane - pumps transport and store protein as compartmentalization in intracellular vesicles which control or buffer intracellular concentration of essential metals. The metals besides affecting the essential enzyme may also regulate the "detoxification" process (Fowler and Benayoun, 1974).

When the crabs are exposed to cadmium, the uptake is mainly through adsorption into the exoskeleton and then the cadmium enters the soft tissues (Jennings and Rainbow, 1979). Fowler and Benayoun (1975) reported that 50% of absorbed cadmium in crustacean *Lysmata seticandata* was lost on moulting. Renfroo *et al.* (1975) found that about 60% of zinc was lost in *C. maenas* on moulting due to adsorption. This was associated with reduction in protein values by 65%, since cadmium was found to be bound with protein (Renfroo *et al.*, 1975). Perhaps this may explain the reduction in the content of protein as well as carbohydrate and lipid.

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