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Toxicity Response of *Emerita analoga* (Stimpson, 1857) Collected from Beaches of South Central Chile

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Studies on organisms that populate the sandy beaches of Chile are limited, although this habitat is extensive, extending throughout the 4600 km of Chilean coastline (Hernández et al. 1998). Currently, there is a growing interest in developing new methods and programs to assess the ecotoxicological impact of industrial and municipal effluents onto the Chilean coast. In this context it is relevant to carry out studies to identify indicator species, to ensure that the assimilative capacity of the marine coast is not exceeded by human activity.

Species selected as bioindicators should meet certain minimum requirements (Phillips 1980, 1990). Additionally, Chapman (1995) suggested working with native species, emphasizing the need to select groups of individuals which demonstrate a similar response, independent of collection site, this is termed positive control.

Emerita analoga is an abundant decapod crustacean frequently encountered along the Pacific coastal zone (Tam et al. 1996; Jaramillo 1987, 1994; Hernández et al. 1998). It extends from Alaska (58°N) to Falsa Bay in Argentina (55°S) (Wenner 1988). *Emerita* sp. is increasingly becoming a standard species for pollution biomonitoring (Mohan et al. 1984; Wenner 1988; Suresh et al. 1995).

The southern central coast of Chile, where this study was conducted, is composed of a group of temperate embayments with different physical characteristics, e.g. Concepción Bay, San Vicente Bay, and the Gulf of Arauco (Ahumada et al. 1989; Rudolph and Rudolph 1993; Rudolph 1995). In these sites there are detectable levels of cadmium resulting from human activity (Salamanca et al. 1988; Carrera et al. 1993; Ahumada 1994), which could be influencing the local biota. Cadmium is the second most important toxic trace metal in sea water after mercury. Its toxicity is due to alterations in cellular permeability (Viarengo 1989).

We conducted this study to determine if individuals of *E. Analoga*, coming from beaches in Southern Central Chile with differing degrees of human alteration, exhibit different responses to the toxic effect exerted by cadmium sulfate, and to evaluate whether *E. analoga* could be used as a bioindicator for South Pacific coasts.

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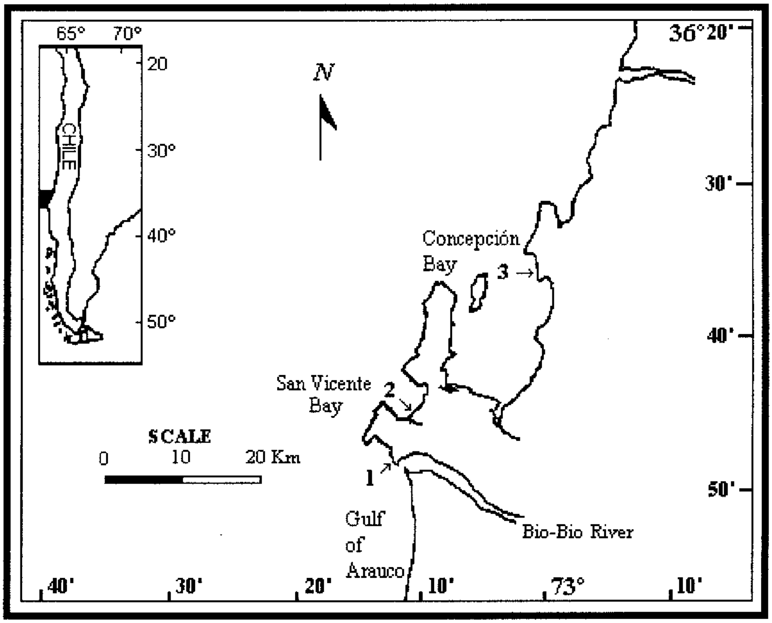

Figure 1. Sampling sites (arrows) in Gulf of Arauco (**1**), San Vicente Bay (**2**) and Concepción Bay (**3**).

MATERIALS AND METHODS

During the austral summers of 1995 and 1996, *E. analoga* and sediment samples were manually obtained from two beaches: **(1)** North Gulf of Arauco and **(2)** Southwest of San Vicente Bay. During the austral summer of 1996 *E. analoga* and sediment samples were obtained from **(3)** Northeast of Concepción Bay beach (Fig. 1). The salinities of the collection sites were 31.0; 34.2; 34.6 UPS respectively.
The individuals were acclimated in the laboratory during days with filtered sea water (1.92 μm) at same original site salinity and a pH of 8.2 ± 0.05. The water was changed every 48 hr, obtained at the same sampling. During acclimation and the experiment the water was constantly aerated to maintain the concentration of oxygen at saturation. The individuals were fed until 24 hr before the beginning of the experiment. Survival of *E. analoga* in the tanks was 100% prior to the experiment.

A static bioassay was made in triplicate for each study site (Reisch and Oshida 1987) using juveniles between 1 and 1.5 cm in cephalothorax length. The individuals were randomly divided into groups of 6 individuals each, and placed into tanks 700 mL of filtered seawater (with the same characteristics as the water used in acclimation) and 210 g of wet sand. The sand came from each of the respective sample sites so that individuals were maintained near to their specific field conditions, although this sand was previously rinsed repeatedly with distilled water, dried, then rinsed with filtered seawater. This process was done to extract organic materials and other components that might influence the experiment).

The individuals were then exposed for 96 hr to one of the following treatments: 0.0, 1.6, 3.2, 6.4, and 12.8 ppm of cadmium sulphate solutions, with 3 replicates in each treatment. The experiment was conducted at 13 ± 1°C and a photoperiod of 12:12 hr.

The mean lethal concentration was evaluated (LC 50-96 hr) using the TOXSTAT version 2.1 (Gulley et al. 1988). Survival percentages for each experimental unit were transformed ($y=\arcsin\sqrt{x/100}$) previous to the analysis (Zar 1996). Data were statistically assessed using analysis of covariance (ANCOVA) using the STATISTICA 5.1 software, using concentration as the variable and locality-year as the covariable. A common lineal regression for all sites was calculated and plotted (Sokal and Rohlf, 1995).

RESULTS AND DISCUSSION

Mortality of *E. analoga* was not observed in controls during the assays. There was a positive lineal relationship between the mortality percentage accumulated at 96 hr and cadmium concentration, with slopes significantly different from zero ($p < 0.001$) for all the sites and periods.

Table 1. Results of the analysis of covariance.

Source	*df*	*SS*	*MS*	*F*	*p-level*
Adjusted Mean	5	19.215	4.804	2.241	0.085
Error	23	49.299	2.143		

No significant differences were observed between slopes for mortality curves at 96 hours (Table 1). This indicates that differences between years.and sites studied did not influence the toxicity response of *E. analoga* to the cadmium as a toxin. A common lineal equation for all sites was calculated (Fig. 2), which had a slope significantly different from zero ($p < 0.0001$), indicating a mortality rate of 6.7% for every 1 ppm increase in cadmium concentrations.

A mean lethal concentration of 8.31 ppm of cadmium was estimated. Although the three study sites exhibit distinct concentrations of cadmium in surface sediments (Table 2), we did not observe difference in the toxicity response of *E. analoga* collected from the different areas, possibly because the concentrations reported in the sediments were always less than the estimated LC 50 reported in the present study. It should be noted that the estimated LC 50 was much higher than that reported by Mohan et al. (1984), which was 1.35 ppm for cadmium in *Emerita* sp. The difference could be due to the use of different species of *Emerita*, as Mohan (1984) does not specify beyond genera. Furthermore,

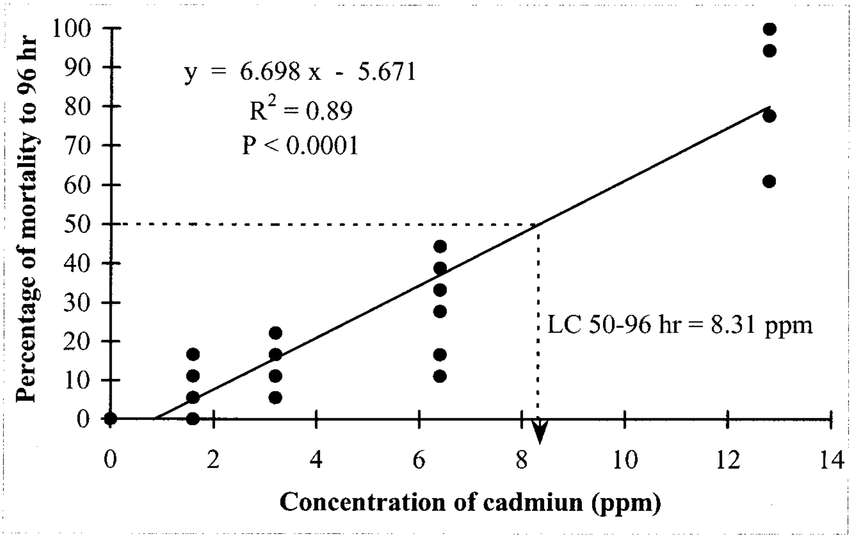

Figure 2. Curve of common lineal regression between the cadmium concentration and percentage of mortality at 96 hr. The arrow indicates the value of the mean lethal concentration at 96 hr.

differences could be attributed to the capability of the organism to adapt to toxic conditions (Carro and Mennickent 1992), and because both the tolerance and resistance may vary depending on the exposure history over an organism's life cycle for different populations (Chapman 1995).

Table 2. Concentration of cadmium in water and surface sediments in Concepción Bay, San Vicente Bay and Gulf of Arauco

Area	*water ug L^{-1}*	*Surface sediments ppm*
Concepción Bay	0.10 – 0.35 (1)	6.27 ± 2.04 (3)
San Vicente bay	0.14 – 0.66 (2)	3.06 ± 1.42 (3)
Gulf of Arauco	---	2.24 ± 1.33 (3)

(1) Carrera et al. 1993
(2) Ahumada 1994
(3) Salamanca et al. 1988

Given the homogeneity in the toxicity response of *E. analoga* coming from the different beaches studied in South Central Chile, the use of this species is proposed as a native bioindicator for the environmental monitoring of beaches in the studied region of the South Pacific coast. Regarding cadmium as a toxin present in this environment, more studies are needed with respect to its sublethal effects, since, at low concentrations, it possesses a high capacity to be bioaccumulated and transferred through the trophic chain (Román et al. 1994). Ahumada (1994) has already shown this bioaccumulation for other benthic invertebrates in San Vicente Bay.

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