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Toxicity of Arsenate and DDT to the Cladoceran *Bosmina longirostris*[1,2]

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Confronted with the increasing array of environmental contaminants being detected in the Great Lakes (Konasewich et al. 1978; Hesselberg and Seelye 1982) and the need to rapidly evaluate their potential harm to the aquatic biota, we have been investigating the suitability of native freshwater zooplankton species for bioassays of these contaminants. Ecological significance, availability, ease of culturing and testing, and sensitivity to contaminants should be characteristics of a suitable species. Although Daphnia magna and D. pulex are commonly accepted as standard organisms for such tests (American Society for Testing and Materials 1980), they are not particularly common in large, freshwater systems such as the Great Lakes. Recently we developed culturing and testing methods for the cladoceran Bosmina longirostris (Novak et al. 1982), a widespread, ecologically significant food organism for larval fish of the Great Lakes. Our objectives were to measure the acute toxicity to B. longirostris of arsenate and DDT, which are representative inorganic and organic contaminants of the Great Lakes, and to determine the relative sensitivity of B. longirostris and D. pulex to these contaminants.

MATERIALS AND METHODS

We isolated B. longirostris from field collections in Frains Lake, MI (42°20'N, 83°38'W), and reared stock cultures in appropriate test water (Table 1), using modified standard procedures for rearing daphnids (American Society for Testing and Materials 1980). The organisms were fed a mixture of three species of green algae (cells/mL)--Chlorella vulgaris (32×10^3); C. pyrenoidosa (63×10^3); and Chlamydomonas epiphytica (6×10^3)--and cerophyl medium[3] (0.3 ng/mL). The

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cerophyl medium contained bacteria and fungi, which were eaten by the cladocerans. To obtain neonates (<24h old) for bioassays, we put gravid females in the flow-through brood apparatus described by Novak et al. (1982).

Table 1. Chemical and physical characteristics of test water.

Characteristic and units	Softened well water[a]	Reconstituted hard water[b]
Hardness (as $CaCO_3$), mg/L	120	160
Alkalinity (as $CaCO_3$), mg/L	320	115
Dissolved oxygen, mg/L	9.5	9.5
pH	6.8	7.3
Temperature, °C	17	17

[a]1:3 mixture of laboratory well water with well water softened by passing it through a cation exchange column.
[b]Reconstituted hard water (ASTM 1980).

For the 96-h static bioassays of B. longirostris with arsenate, we dosed the test water (softened well water, Table 1) with a solution of $Na_2HAsO_4 \cdot 7H_2O$ before adding the organisms. The organisms were fed once at 48 h. In the 48-h tests of D. pulex with arsenate, the organisms were not fed. Each test consisted of a water control and five doses of arsenate with 10 organisms per test tube. Using nondestructive neutron activation, the Phoenix Memorial Laboratory, University of Michigan, analyzed water samples for elemental arsenic (Nicholson and Rengan 1979). For 12 samples collected from the exposure vessels after 96 h, the concentration of arsenic was 101.0% (SE = 1.3) of the nominal value.

Static bioassays of DDT in both softened well water and reconstituted hard water were 48 h in duration. We dosed the test water with p,p'DDT stock solutions dissolved in acetone (≤0.5 mL/L) before adding the organisms. Each test consisted of a water control, an acetone control (0.5 mL/L), and four to six doses of DDT with 10 organisms per container. To determine the actual concentration of DDT at the beginning of the test, we took samples from the exposure vessels, extracted them immediately with iso-octane and analyzed the organic phase by gas chromatography (Hesselberg and Nicholson 1981). The measured concentration in test water spiked with p,p'DDT was 97.3% (SE = ± 3.4%, n = 8) of the nominal value. In separate tests of our system, we measured a 45% decrease in p,p'DDT in 48 h.

[3]Cerophyl Laboratories, Inc., Kansas City, MO. Use of trade names or manufacturers' names does not imply U.S. Government endorsement of commercial products.

We analyzed the bioassay data by probit analysis (Finney 1952) with a computer program (a modified version of the IBM SSP package) from Dow Chemical Company, Midland, MI.

RESULTS AND DISCUSSION

The immobilization in the controls was 10% or less in all experiments. The mean 96-h EC50 (immobilization) for B. longirostris was 0.85 ± 0.12 mg arsenate/L (± SE), and the 48-h EC50 for D. pulex was 49.6 ± 9.0 mg arsenate/L (Table 2). In other tests of arsenate, the 48-h LC50's reported were 7.4 mg/L for D. magna (Biesinger and Christensen 1972) and 3.6 mg/L for D. pulex (Jurewicz and Buikema 1980). The difference between our EC50's and the LC50's of Jurewicz and Buikema (1980) may have been due to differences in test water (the characteristics of their test water were not reported). Although there were differences in test duration, our data suggest that the sensitivity of B. longirostris to arsenate was substantially greater than that of the two daphnids.

Table 2. Toxicity ($\bar{x}$ ± SE, measured as immobilization); number of tests is shown in parentheses.

Diluent water and organism[a]	48-h EC50	
	µg p,p'DDT/L	mg Arsenate/L
Bosmina longirostris, S	1.72 ± 0.23 (5)	0.85 ± 0.12[b] (4)
Bosmina longirostris, H	0.63 ± 0.03 (7)	
Daphnia pulex, S	2.67 ± 0.17 (4)	49.6 ± 9.0 (3)

[a]S = softened well water; H = reconstituted hard water.
[b]96-h EC50.

For B. longirostris the difference in 48-h EC50 values of DDT in the two diluent waters (Table 2) was highly significant ($P < 0.001$, Student's t test). In addition to greater sensitivity of B. longirostris in reconstituted hard water, the results were more reproducible, as suggested by the lower value for standard error. The difference between 48-h EC50 values for B. longirostris and D. pulex is also highly significant, indicating that the sensitivity of Bosmina exceeds that of D. pulex. The toxicity of p,p'DDT to D. magna (Anderson 1945, 1960, Macek and Sanders 1970) ranged from a 48-h EC50 of <1 to 4.0 µg/L in reconstituted water and Lake Erie water. Sanders and Cope (1966) reported a 48-h EC50 of 0.36 µg/L for D. pulex in reconstituted soft water. Our EC50 values for B. longirostris and D. pulex fall within this range of values.

For teleosts, Macek and McAllister (1970) reported 96-h LC50's of 2 to 131 µg/L for p,p'DDT suggesting that the sensitivity of Bosmina to DDT exceeds that of most fish. Water quality criteria sufficient to protect Bosmina should therefore also provide adequate protection for fish.

Judging by these results and the semiautomatic rearing, counting, and testing methods (Novak et al. 1982) that we have developed for this sensitive, ecologically important crustacean, we conclude that Bosmina longirostris is a suitable zooplankton species for toxicological evaluation of contaminants and recommend consideration of B. longirostris as an additional or alternate species to D. magna and D. pulex for standard bioassays.

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