The Influences of Size, Sex and Temperature on the Toxicity of Mercury to Two Species of Crayfishes

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Mercury compounds are being released into the environment through various manufacturing and industrial processes. In addition, large quantities of mercury are lost to the environment through the combustion of fossil fuels. In 1953, the accumulation of mercury in food chains leading to man was demonstrated in Minamata Bay, Japan where many of the inhabitants began showing symptoms of acute mercury poisoning. It was found that many fish and shell fish in the Bay contained high levels of methyl mercury (IRUKAYAMA, 1966). Since then, many species of fishes throughout the world have been shown to accumulate mercury in their tissues. Mercury concentrations in fish tissues exceeding 0.5 ppm are now considered to be dangerous for human consumption.

In various parts of the world and especially in the Southern United States, crayfishes make up an integral part of the human diet for at least part of the year. In addition, crayfishes occupy an important niche in many fresh water ecosystems. To date there has been a dearth of information on the effects of mercury on crayfish, or on their uptake of mercury from the environment (DOYLE et al., 1976; VERMEER, 1972).

It was the purpose of this investigation to determine the effects of various concentrations of inorganic mercury on the edible crayfish, Procambarus clarki, and the smaller ecologically important crayfish, Faxonella clypeata, under conditions likely to be encountered in their environment.

MATERIALS AND METHODS

Two species of crayfishes, the larger Procambarus clarki and the much smaller Faxonella clypeata, were

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collected from roadside ditches in various locations near the north shore of Lake Pontchartrain, LA. Prior to the start of each experiment the crayfishes were maintained in the laboratory in separate acid cleansed finger bowls filled to just above the carapace level with pond water for one week. Water was changed twice daily and all of the animals were maintained on a diet of Purina dog chow. Glass covers were placed over each bowl to prevent evaporation. The crayfishes were maintained at a constant temperature and were given 12 hours of darkness each day, the light being turned on at 9 AM. The temperature used as noted below depended upon the particular experiment performed. In each, the time in days during which 50% of the crayfish, maintained in solutions containing between 10^{-2} M - 10^{-8} M $HgCl_2$, died was determined for each group of crayfish. These molar values correspond to the following concentrations of mercury.

10^{-2}	M =	2000	µg/ℓ
10^{-3}	M =	200	µg/ℓ
10^{-4}	M =	20	µg/ℓ
5×10^{-5}	M =	10	µg/ℓ
10^{-6}	M =	0.2	µg/ℓ
10^{-7}	M =	0.02	µg/ℓ
10^{-8}	M =	0.002	µg/ℓ

The concentration of mercury in the finger bowls was verified by flamless atomic absorption spectrophotometry.

RESULTS

Two male and female Faxonella clypeata were chosen from each of the following five size groups, thus providing a total of 10 crayfish of each sex.

Group	Length (cm)	Wet Weight (g)
A	15-20	0.199
B	20-25	0.388
C	25-30	0.560
D	30-35	0.860
E	35-40	1.164

Two male and female Procambarus clarki were also chosen from size groups A-D below. In addition, one male and one female were chosen from groups E and F. Thus a total of 10 Procambarus of each sex were selected.

Group	Length (cm)	Wet Weight (g)
A	20-30	0.536
B	30-40	0.859
C	40-50	2.395
D	50-60	8.202
E	60-70	12.72
F	70-80	21.64

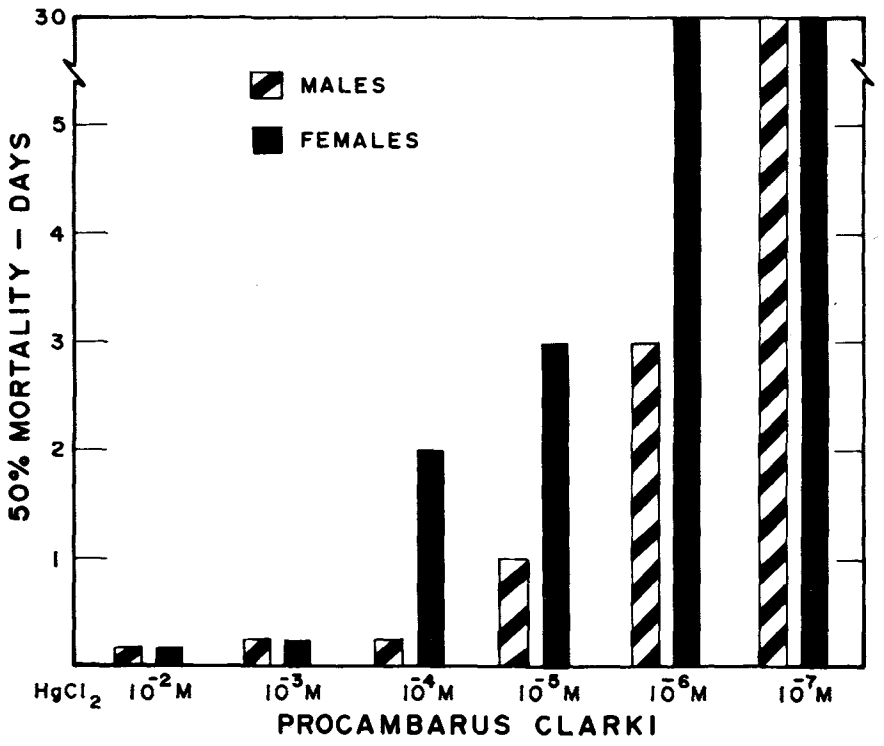

Fig. 1. Determination of the lethal mercuric chloride concentration for male and female Procambarus clarki.

The ten selected male and females of each species of crayfishes were placed in solutions of mercuric chloride at 20°C ranging from 10^{-2} M - 10^{-8} M. A comparison was made between the ability of male and female crayfish to withstand these concentrations of mercury as expressed in days to cause 50% mortality (LC_{50}). In 10^{-6} M $HgCl_2$, 50% of the male Procambarus clarki perished within 3 days, while the females appeared healthy to the end of the experiment, 30 days (Fig. 1). Males and females both survived until the end of the experiment, 30 days, when maintained in the 10^{-7} M $HgCl_2$ solution. The females, therefore, seem better able to withstand the effects of mercury. The same sexual difference was observed with the much smaller male and female Faxonella clypeata (Fig. 2). However, male Faxonella were not able to survive in either the 10^{-6} M or the 10^{-7} M $HgCl_2$ solutions, whereas the females appeared healthy in both solutions. Only in the 10^{-8} M solution, were male Faxonella able to survive until the conclusion of the experiment.

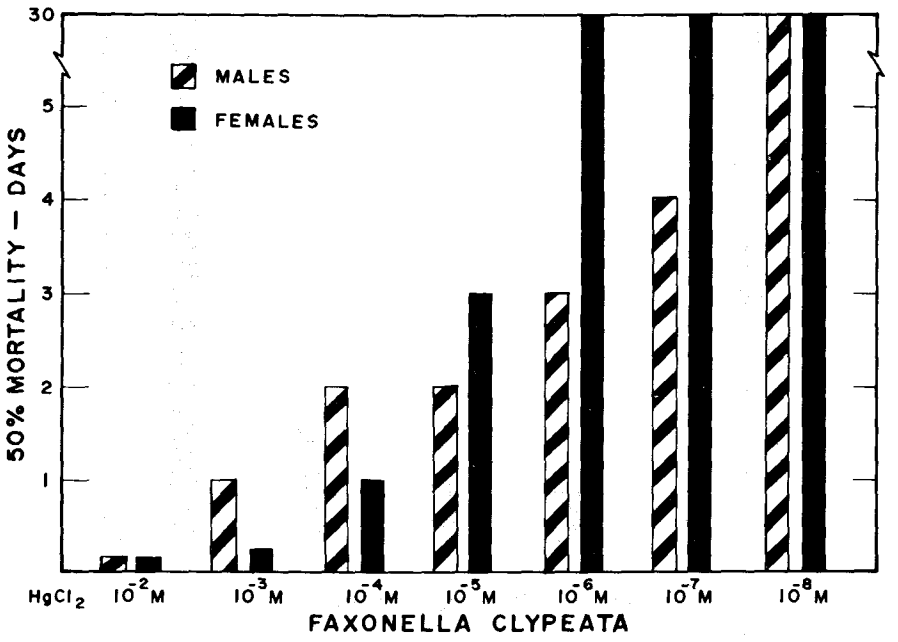

Fig. 2. Determination of the lethal mercuric chloride concentration for male and female Faxonella clypeata.

The effects of differences in body size and weight on the ability to withstand various concentrations of $HgCl_2$ were determined in the second series of experiments. A generally lethal concentration of mercury, 5×10^{-6} M $HgCl_2$, 20°C, was used throughout the experiment. The ability of larger Faxonella crayfish to withstand the effects of mercury is illustrated in Fig. 3. Only the largest of the Faxonella, group E, were

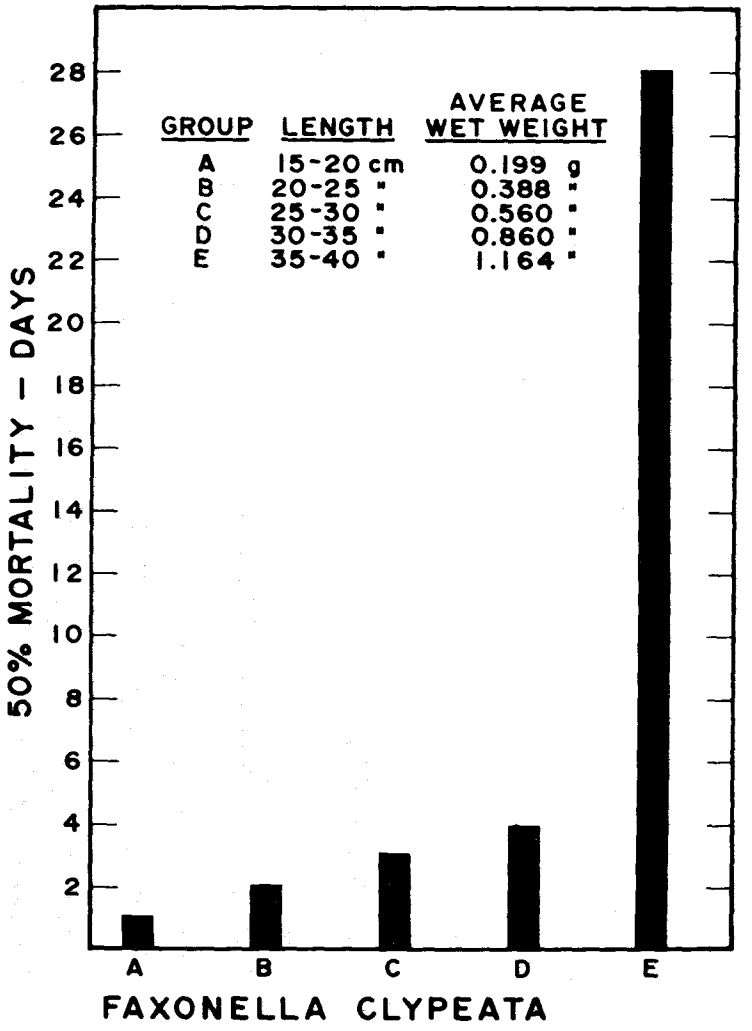

Fig. 3. The effects of size on the mortality of Faxonella clypeata in 10 μg/ℓ mercuric chloride solution.

able to withstand this concentration of mercury until the end of the experiment, 28 days. All smaller animals perished within 4 days, however, a trend of increasing ability to withstand this mercury concentration with increasing body size is seen in groups A-D. A similar trend is shown for Procambarus in Fig. 4. Results were similar for both male and female Procambarus and Faxonella.

In the final set of experiments, the effects of temperature on the crayfishes ability to withstand mercury was also investigated. Ten male and 10 female Procambarus clarki and Faxonella clypeata were placed in 5×10^{-6} M $HgCl_2$ solutions at three different temperatures, 5°C, 20°C and 30°C. The lowest and highest temperatures used represent the approximate minimum and maximum expected within the habitat of these crayfishes

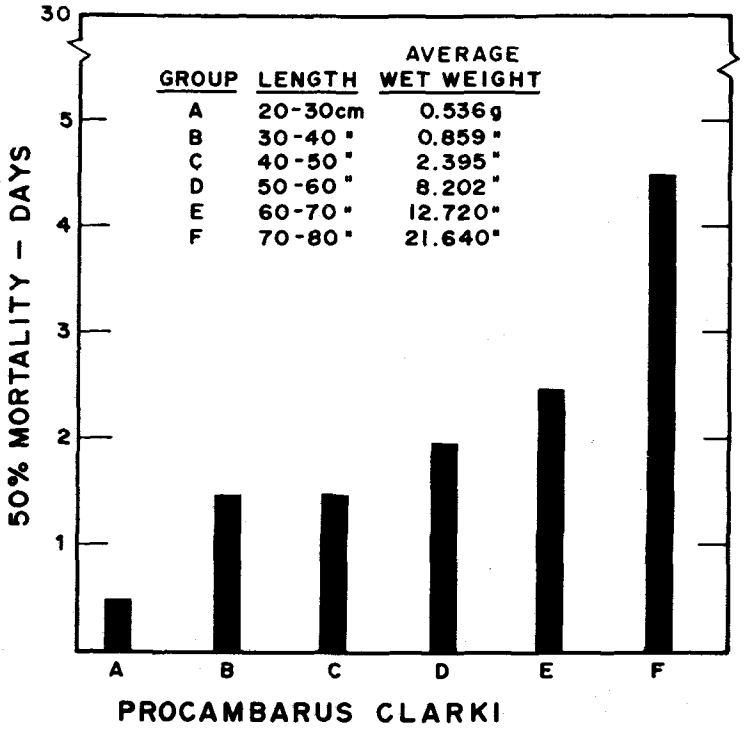

Fig. 4. The effects of size on the mortality of Procambarus clarki in 10 μg/ℓ mercuric chloride solution.

in southern Louisiana. In Fig. 5, it can be readily observed that as the temperature decreases from 30°C to 20°C to 5°C the ability of both species of crayfishes to withstand this mercuric chloride concentration was higher.

The effects of temperature on the survival of crayfish in $HgCl_2$ were also determined in another fashion (Fig. 6). Ten male and female Faxonella, 25-30 cm in length and averaging 0.560 g in weight, were

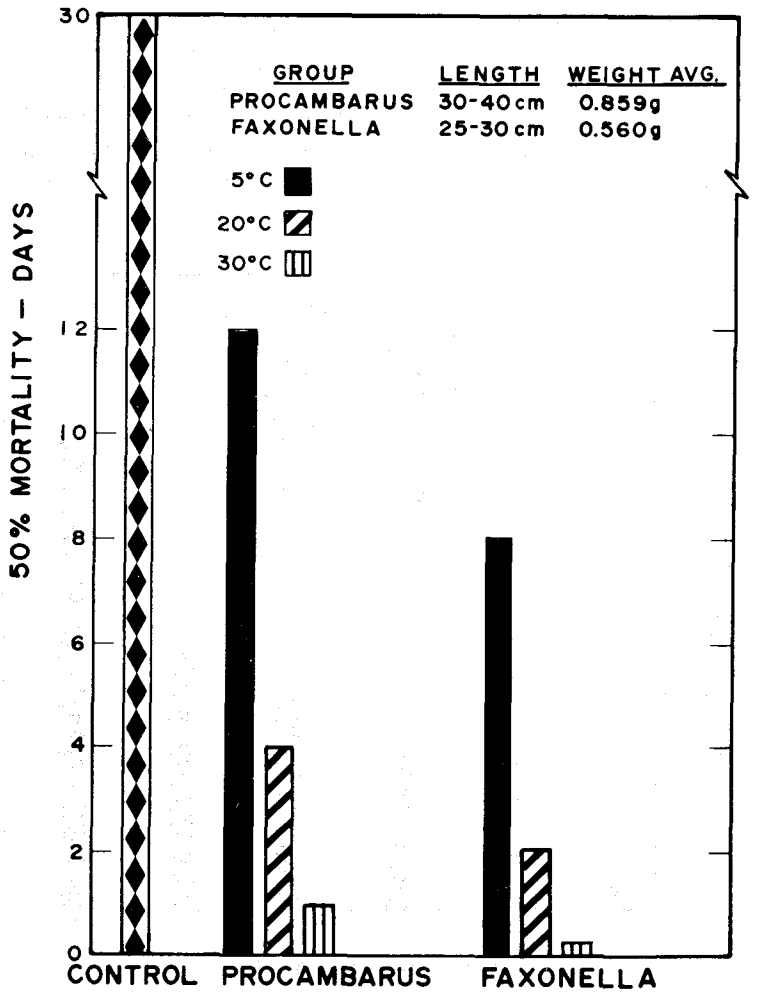

Fig. 5. The effects of temperature on the mortality of Procambarus clarki and Faxonella clypeata in 10 µg/ℓ mercuric chloride solution.

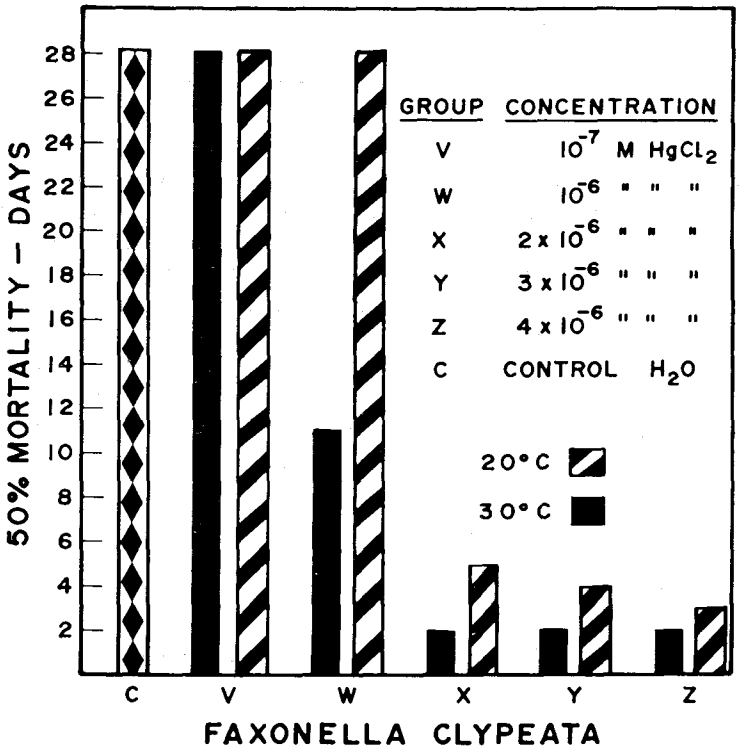

Fig. 6. The effects of two temperatures on the mortality of Faxonella cylpeata when placed in mercuric chloride solutions varying in concentration from 10^{-7} M to 4×10^{-6} M.

placed in solutions varying between 10^{-7} M and 4×10^{-6} M $HgCl_2$. As the concentration was increased above the lethal concentration of 10^{-7} M $HgCl_2$, those crayfish maintained at 20°C had a greater number of survivors than those at 30°C. This is particularly apparent for group W, in which the crayfish were maintained in the 10^{-6} M solution.

DISCUSSION

These results demonstrate that both species of crayfishes used in these experiments are affected by mercury in their environment. It would appear that the

ability to cope with inorganic mercury depends greatly on the species of crayfish, its size and sex and perhaps most importantly, the external temperature. Thus, crayfishes inhabiting environments which are contaminated with mercury during cooler portions of the year would be expected to better withstand its toxic effects than if the insult occurred during the late spring or summer. These temperature effects may be due to changes in the metabolic rate of the crayfishes and hence, the lower the external temperature the lower the rate of active uptake of mercury from the environment. These results would also indicate that studies on the toxicity of mercury, and perhaps other substances, may be biased if conditions of temperature and size and sex of the organism are not uniform throughout the experimental regimes.

Acknowledgement

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REFERENCES

DOYLE, M., S. KOEPP, and J. KLAUNIG: Bull. Environ. Contam. Toxicol. 16: 422-424 (1976).

IRUKAYAMA, K.: Adv. Wat. Poll. Res. 2: 153-165 (1966).

VERMEER, K.: Can. Field-Nat. 86: 123 (1972).