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Temperature-Toxicity Relationships of Fluvalinate (Synthetic Pyrethroid) on *Procambarus clarkii* (Girard) Under Laboratory Conditions

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Synthetic pyrethroids are presently manufactured and registered as alternatives to organochlorine, organophosphate, and methylcarbamate insecticides because of their improved potency and stability as well as their low mammalian toxicity.

Although the new synthetic pyrethroids have been shown to be highly effective in controlling unwanted animal life such as mosquitos, pestiferous midges, and agricultural pests, they are also toxic to non-target organisms at field application concentrations. Studies by Jolly et al. (1978), McLeese et al. (1980), Kumaraguru and Beamish (1981), and Friesen (1981) demostrated that some pyrethroids are highly toxic to fish and other aquatic organisms.

Insecticide toxicity is affected by a variety of factors including temperature. Recent studies have shown a negative temperature coefficient for several of the pyrethroids (Gammon and Holden 1980; Henrick et al. 1980; Hinks 1985) but, a recent study observed a distinctly positive temperature coefficient for some pyrethroids bioassayed (Sparks et al. 1982; Sparks et al. 1983).

This paper reports the effects of four temperatures (12, 18, 22, and 27 °C) on the toxicity of fluvalinate to *Procambarus clarkii*.

MATERIALS AND METHODS

Adult intermolt specimens of the crayfish *Procambarus clarkii* (Girard 1852) were used to carry out the toxicity tests. They were reared in the Department of Animal Physiology of the Faculty of Biological Sciences of Valencia University and maintained at 22 °C with a daily diet of pork liver. The crayfish ranged in size from weights of 15 to 25 g. and were randomly selected for the test.

The insecticides used were fluvalinate, alpha-cyano-3-phenoxybenzyl 2-[2--chloro-4-(trifluoromethyl) anilino] -3-methylbutanoate, an experimental insecticide with pyrethorid-like activity, currently being developed and registered by Zoecon Corporation as "Mavrik".

Fluvalinate was dissolved in acetone to give a stock solution of 1 µg/mL; dilutions were made from stock using reagent grade acetone to give a range of 5 concentrations projected to give 5-95% response.

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Groups of 10 crayfish were kept in 20-L glass aquaria containing 15 L of water; each aquarium was treated with 1 mL of a given concentration of fluvalinate. Control aquaria received 1 mL of acetone.

The test tanks were checked every 24 h to 96 h to record and remove dead animals in order to avoid cannibalism. The lack of movement by the pleopods and antennae when gently prodded was used as the criterion for animal death.

Unfiltered Lake Albufera water (natural conditions) and dechlorinated drinking water (experimental conditions) were used for tests. Hardness, alkalinity, pH, and suspended solids determination were 250 ppm as $CaCO_3$, 4.1 mmol/L, 7.8, and <10 mg/L respectively for all tests in experimental conditions. In natural conditions, hardness, alkalinity and pH were 350 ppm as $CaCO_3$, 3.7 mmol/L and 8.4, respectively, and suspended solids were 30 mg/L.

Test temperatures (12, 18, 22, and 27°C ± 0.5°C) were maintained by constant-temperature water baths surrounding the aquaria.

Three replicates were carried out at each dosage and temperature combination with one of the two different media.

Static bioassays were conducted in glass aquaria. Aeration and food were not provided for the test animals during exposure. Other procedures or methods not specified, followed the basic static acute toxicity method described by the Commitee on Methods for Toxicity Tests with Aquatic Organisms (U.S. Environmental Protection Agency 1975). The animals were acclimatized to the test conditions for at least 2 days at each temperature. During acclimatization period all aquaria were aerated.

The percentages of mortality were calculated in each concentration after 24, 48, 72, and 96 h of exposure and converted to probits (Fisher and Yates 1963); the fluvalinate concentrations were converted to Logarithms. The concentration causing 50% mortality of the test animals (LC50) and 95% confidence limits were calculated using the method of Litchfield and Wilcoxon (1949).

RESULTS AND DISCUSSION

The acute toxicity results of fluvalinate in natural and experimental media at various temperatures are given in Table 1, showing the 96-h LC50 values with 95% confidence limits. These LC50 values are based on the nominal concentration of pyrethroid; after 96 h the concentrations may have been rather less than those used initially.

Results from this table suggest that fluvalinate is very highly toxic to the aquatic organism, *Procambarus clarkii*, and it has a more toxic effect in experimental than natural medium. This could be due to the different physico-chemical characteristics of water. Perhaps, the most important characteristics are the suspended solids and the microbial population and water hardness (Tabata 1969; Kaufman et al. 1977; Sharom and Solomon 1982).

Fluvalinate, applied to *Procambarus clarkii* at four temperatures, 12, 18, 22, and 27°C, exhibited a positive temperature coefficient of toxicity in both experimental and natural medium (ratio > 1).

Table 1. The 96-h LC50 values, expressed in µg/L, 95% confidence limits (in brackets) and the temperature coefficient (TC) which is expressed as the ratio LC50 12°C/LC50 x°C. Ratio < 1 denotes a negative temperature coefficient and the ratio > 1 denotes a positive temperature coefficient.

	Experimental Medium		Natural Medium	
T (°C)	LC50 (µg/L)	TC	LC50 (µg/L)	TC
12	0.51 (0.34 - 0.75)	1	1.08 (0.86 - 1.34)	1
18	0.46 (0.32 - 0.68)	1.11	0.72 (0.61 - 0.86)	1.50
22	0.31 (0.21 - 0.44)	1.64	0.64 (0.51 - 0.80)	1.69
27	0.23 (0.16 - 0.33)	2.27	0.50 (0.37 - 0.68)	2.16

In Figures 1 and 2 the differences that exist between 24 h and 48; 72; and 96 h LC50 values can be seen, especially at low temperatures. However, there were no significant differences ($p>0.05$) between 48, 72, and 96-h LC50 values, in both media. The results suggest that the greatest effect was obtained with 48 h LC50 values. This data is in agreement partialy with Miyamoto (1983), who proposed the greatest effect in a time less than 24 h.

In this study on crayfish an increase in fluvalinate toxicity was observed associated with increasing water temperature (Fig. 1, 2), although in other studies on a number of insects and some pyrethroids it has been observed that lethal toxicity varied inversely with temperature (Sparks et al. 1982; Sparks et al. 1983; Kumaraguru and Beamish 1981). There appears to be a great deal of variation in pyrethroid toxicity relative to temperature, and temperature coefficient may also vary within an insect species for different compounds.

There is no simple, obvious explanation for these differences. Presumably they reflect variations in the interactions of the factors that contribute to the net toxic effect; rates of absorption, distribution, penetration of organs, detoxification, excretion, and differential target site interactions (Hinks 1985; Scott and Georghiou 1984)

Slight changes in the structure of the pyrethroid can also have a marked effect on both toxicity and temperature coefficient. Sparks et al. (1982) and Sparks et al. (1983) concluded that those pyrethroids having an alpha-cyano group had only slightly negative or positive temperature coefficients of toxicity. This is in agreement with our results on *Procambarus clarkii*. Nevertheless, Henrick et al. (1980) report a negative temperature coefficient on *Heliothis virescens*.

Although application of laboratory data to field conditions is always difficult, the results of this study suggest that the application of this pyrethroid with high environmental temperatures would be more hazardous to *Procambarus clarkii*.

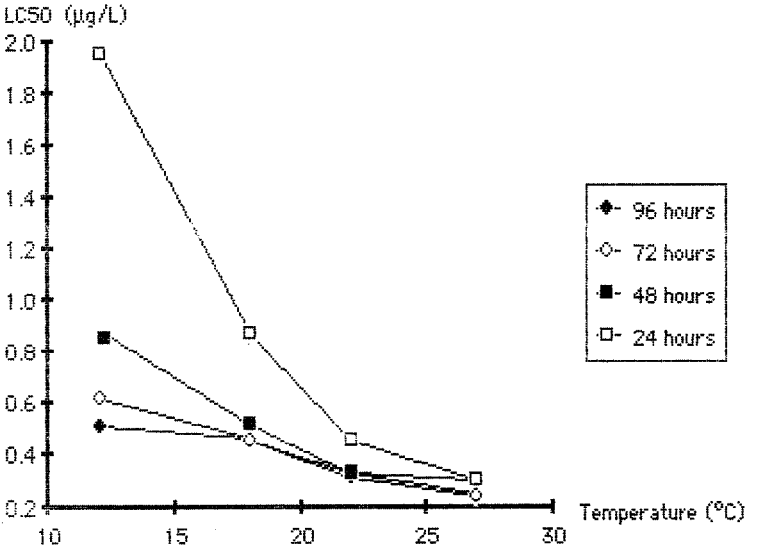

Figure 1. Influence of temperature on the variation of LC50 values at four time intervals, in the experimental medium.

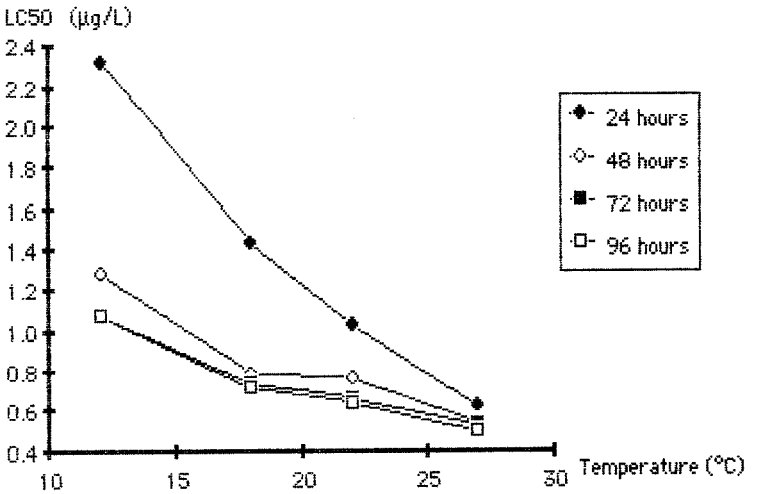

Figure 2. Influence of temperature on the variation of LC50 values at four time intervals, in the natural medium.

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