PREVIOUS FEEDING HISTORY AS A FACTOR IN THE EFFECTS OF TEMEPHOS AND CHLORPYRIFOS ON MIGRATION OF *GAMMARUS FASCIATUS* (AMPHIPODA, CRUSTACEA)

ANN THAYER AND ERNEST RUBER

Biology Department, Northeastern University, Boston, Mass. 02115

ABSTRACT. This paper extends the study of side-effects of temephos and chlorpyrifos on *Gammarus fasciatus* in a simple laboratory stream. An exploration is made of the significance of the presence or absence of food in the stream on the behavior of the organism. The effects of starvation for 48, 72, and 96 hr on the organisms' migratory responses in the presence or absence of the insecticides is also reported.

INTRODUCTION. In a previous study, Ruber and Kocor (1976), a simple indoor "stream" was shown to be a useful device for detecting certain sublethal effects of pesticides on *Gammarus fasciatus*. Since Hughes (1970) had shown that food in streams affected upstream migration in *G. pulex*, we suspected the possibility of similar responses in our experiments. We considered, further, that pesticides might be applied under different conditions of food availability in nature, in which case, the susceptibility of the organism might be affected. In this study we examine the effects on upstream migration of previous feeding or starvation and the presence or absence of food in the stream at the time of testing.

METHODS. Methods used were the same as described by Ruber and Kocor (1976). However, stream flow rates used were lower, 2 and 5 cm/sec and lower concentrations of temephos (Abate®), 0.5 ppm and chlorpyrifos (Dursban®), 0.0008 ppm, were used since lower LD_{10} values were obtained than previously.

Gammarus fasciatus were collected from the Taunton River, south of Boston, Mass. near the intersection of Route 24 and Route 44. *Gammarus* were fed or starved from 48 to 96 hours, subjected to temephos or chlorpyrifos or no pesticide during the last 24 hr, and placed in streams with or without food. Effects on upstream migration were measured. Instead of giving values in cm/sec, the numbers of *Gammarus* which finished a run were given. This simply consists in using the number finishing in the equation given in Ruber and Kocor (1976) without converting to velocity values. Each result is based on three runs of 100 each so the numbers given are interpreted relative to this maximum base potential of 300.

RESULTS. We attempted to answer several questions which we felt would help in understanding how to use our artificial stream with significant variables controlled and also in understanding the factors which may significantly vary the outcome of pesticide applications in the field. The questions were:

1. a) Do fed *G. fasciatus* migrate differently from starved ones?
   b) Does the length of the food deprivation period affect migration?
2. a) Does the presence or absence of food in the stream affect migration?
   b) Does previous feeding or starving affect this?
3. Are the answers to the questions above different if the organism is treated with temephos or chlorpyrifos?

Table 1 summarizes the results of all experiments. Fed animals do seem to migrate differently from starved if there *is* food in the stream. Temephos/fed animals migrated significantly more than temephos/starved; Untreated/fed migrated a little more than untreated/starved. With chlorpyrifos the trend was reversed, chlorpyrifos/fed migrated somewhat less than chlorpyrifos/starved (each of the cited differences is statistically significant at least p .01 in a chi-square test). When there is *no* food in the stream there are no significant differences between untreated/fed and untreated/starved and chlorpyrifos/fed and chlorpyrifos/starved. However, temephos/fed still migrate significantly more than temephos/starved although the difference is not as pronounced as when there *is* food in the stream.

As can be seen in Table 2 the period of starvation affects the different treatment groups differently. Temephos/starved migrate at about the same level whether starved for 48, 72, or 96 hours. Chlorpyrifos/starved migrated at greater rates after 48 hr, dwindling to very low rates after 96 hr. Untreated/starved organisms reversed their behavior according to whether there was food in the stream

Table 1. Migration of *Gammarus* in response to insecticides: Combined data all variables.

	Temephos			Chlorpyrifos			Control		
In Stream:	Food[b]	No	Comb.	Food	No	Comb.	Food	No	Comb.
Previously	309	120	429	57	69	126	93	87	180
Fed	+ +	+	+ +	–	0	–	+	0	+
Previously[a]	114	73	187	78	76	154	59	84	143
Starved	– –	–	– –	+	0	+	–	0	–

+ = migration enhanced
– = migration depressed
0 = migration unaffected
[a] = combined results of starvation for 48, 72, 96 hrs. breakdown in Table 2.
[b] = material fed and used for targets was *Elodea* and other unidentified live and dead vegetation collected with the organisms.

Table 2. Migration of *Gammarus* in response to insecticides: Effects of length of starvation.

Pesticide	Food in Stream	Fed	Hrs. Starved 48	72	96	Sum[a]	Fed[b]
Temephos	Yes	103	35	34	45	114	309
Temephos	No	40	26	20	27	73	120
Chlorpyrifos	Yes	19	47	29	2	78	57
Chlorpyrifos	No	23	47	22	7	76	69
Control	Yes	31	11	17	31	59	93
Control	No	29	35	39	10	84	87

[a] The three starvation periods combined.
[b] Fed times three to compare with sum of starved (a).

or not. With food in the stream their migration was low at 48 hr and increased at 72 and at 96 hr. Lacking food in the stream, they migrated at high rates for 48 and 72 hr, but rates dwindled considerably at 96 hr.

Lastly, if the animal is treated with pesticides in the presence of food will the LD_{10} be different than in the case where no food is present? In Ruber and Kocor (no food) the values were 2.0 ppm for temephos and 0.01 for chlorpyrifos, while in the present study (food present) we get 0.5 ppm for temephos and 0.0008 ppm for chlorpyrifos. The difference for chlorpyrifos is more than ten-fold, while that for temephos is four-fold. The temephos difference is not considered particularly significant since there is so much variability found in any attempt to designate LD_{10} levels. Unfortunately, since we were not thinking in this direction no LD_{50} levels were determined. The chlorpyrifos difference, however, is significant. Is this due to the ingestion of pesticide with the food? Perhaps. These results were obtained some time apart and the organisms in the two studies were collected from different locales. These additional variables cast sufficient doubt on the causes for these differences that this portion of the work will have to be repeated.

DISCUSSION. We find that generally temephos enhances migration at somewhere below LD_{10} levels while at slightly higher concentrations (Ruber and Kocor 1976) it begins to suppress them. This behavior correlates well with the observed hyperactivity of the treated organisms while still in the finger bowls. Such a hyperactive response to toxicants is not uncommon, but usually it is an uncoordinated response from which one would not expect increased, purposeful upstream migration, but rather, capture by the stream and downstream drift. Chlorpyrifos/starved at 48 hr also showed this enhancement of migration but at the longer deprivation times migration was unaffected or depressed. Does a little poison act as a stimulant? This is certainly not far-fetched.

The reversal of behavior between untreated/starved organisms when food was present or when it was absent is noteworthy. Apparently, if food is present, the longer they are starved (within our time limits), the more they migrate, while when there is no food present they reduce their rate of migration after 96 hr. This could be some kind of natural energy conservation mechanism of adaptive value in that when the scent of food is present, the animal searches for it, but when the scent is absent after a period of searching, it instead settles down, conserves energy, and waits. This particular question while of less practical importance in evaluating side-effects is of some interest in our understanding of the ecology of *G. fasciatus*.

SUMMARY AND CONCLUSIONS. This study examines whether previous feeding or starving affects migration in untreated, temephos and chlorpyrifos treated *Gammarus fasciatus* and whether the presence or absence of food in the stream modifies the response.

At doses used, 0.5 ppm temephos and

0.0008 ppm chlorpyrifos, and stream flow rates of 2 or 5 cm/sec temephos generally stimulated migration, especially when the treated organisms were fed, or when they were starved 48, 72, or 96 hr and there was a food source in the stream at the time of the test. Chlorpyrifos generally inhibited migration slightly in fed animals, enhanced it after 48 hr of starvation, and inhibited it greatly after 96 hr of starvation; these effects were not altered by the presence or absence of food-targets in the stream.

Untreated/starved animals responded inversely according to whether there was target food in the stream or not. If there was food, migration increased with starvation time, if there was no target food present, then migration decreased with starvation time.

LD_{10} values obtained in this study were lower than those obtained previously by Ruber and Kocor (1976): temephos, 0.5 vs. 2.0 ppm; chlorpyrifos 0.01 vs. 0.0008 ppm. These differences may have been due partially to experimental error, partially to different feeding states of the organisms and partially to the fact that the organisms came from different river systems.

References Cited

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