COMPARATIVE ORGANOPHOSPHORUS INSECTICIDE SUSCEPTIBILITY IN CARIBBEAN POPULATIONS OF *AEDES AEGYPTI* AND *TOXORHYNCHITES MOCTEZUMA*

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ABSTRACT. *Aedes aegypti* larvae from Antigua, Jamaica, Puerto Rico, St. Lucia, Trinidad and Union Island and predatory larvae, *Toxorhynchites moctezuma,* from Trinidad were tested for susceptibility to temephos, malathion, fenthion, fenitrothion and chlorpyrifos. There was some organophosphorus resistance in all strains of *Ae. aegypti,* in the approximate order: Antigua > Jamaica > Puerto Rico > St. Lucia > Trinidad > Union Island. *Toxorhynchites moctezuma* was much less susceptible to temephos than the *Ae. aegypti* strain, indicating its possible usefulness in an integrated management program.

Knipling (1966) suggested an integrated approach to managing insect populations by reducing pest numbers when they are the greatest through the application of insecticides and then reducing the remaining population using a biological control agent. Focks et al. (1986) operationally applied this concept by initially reducing a localized population of adult *Aedes aegypti* (Linn.) in a residential New Orleans, Louisiana, neighborhood by ULV-applied malathion. After this treatment, *Toxorhynchites amboinensis* (Doleshall) adults were released into the area and achieved an additional reduction of the remnant *Ae. aegypti* larval population.

On some Caribbean islands where peridomestic water storage is important, *Ae. aegypti* breeding is often a significant problem. In practice, the reduction of larval numbers through insecticidal use, followed by the introduction of *Toxorhynchites* larvae to control or eliminate the pest problem could be a practical approach. However, it must be demonstrated that *Toxorhynchites* larvae are able to survive any effects of previously used insecticides in the larval habitat. To provide such information, we evaluated the comparative susceptibility of a local predator, *Toxorhynchites moctezuma* (Dyar and Knab), and some Caribbean strains of *Ae. aegypti,* against a range of organophosphorus insecticides which could be used as larvicides. To date no such investigations have been reported in the literature.

Six field strains of *Ae. aegypti* used in this study were collected from November 1988 to April 1989 in St. John's, Antigua; Harbour View (Kingston), Jamaica; Puerto Neuva, Puerto Rico; Castries, St. Lucia; Curepe, Trinidad; and Union Island, St. Vincent and the Grenadines, and maintained in our laboratories for 2 to 3 generations. The Trinidad strain of *Tx. moctezuma,* maintained in our laboratories for ca. 4 years, was also tested. A known organophosphorus-susceptible Trinidad strain of *Ae. aegypti*—CAREC—(Georghiou et al. 1987) was used for the base line comparison of insecticidal susceptibility of the *Ae. aegypti* and *Tx. moctezuma* field strains.

The materials and methods for testing insecticide susceptibility in all mosquito strains were those of the World Health Organization (1980). Three replicates of 30 to 40 fourth instar larvae were exposed to 6 to 8 concentrations of temephos, malathion, fenthion, fenitrothion, and chlorpyrifos. Larval mortality was determined after 24 hours, and analyzed using the probit procedure of Finney (1971), to produce LC_{50} and LC_{90} values. Computer analysis was done using a probit analysis program adapted by the Caribbean Agricultural Research and Development Institute (CARDI) in Trinidad. Studies on each strain and insecticide were repeated at least twice.

The comparative susceptibility of the various strains of *Ae. aegypti* and *Tx. moctezuma* to the 5 organophosphorus insecticides are presented in Table 1. The degree of resistance of each *Ae. aegypti* strain and the relative toxicity of each chemical assayed against *Tx. moctezuma* were determined by comparison to our susceptible (CAREC) strain.

When compared to the CAREC (susceptible) strain, most populations demonstrated some organophosphorous insecticide resistance. At the LC_{50} level, using the minimum criterion of > 3-fold levels of resistance, the Antiguan and Jamaican strains were resistant to all 5 insecticides assayed, while the St. Lucian, Trinidadian and Puerto Rican strains were resistant to all except to fenitrothion. The Union Island strain was susceptible to all except to temephos and malathion. Generally, highest levels of resistance were recorded against temephos (St. Lucia 27.7-fold; Antigua 25.0-fold), and against fenthion (Antigua 24.8-fold).

At the LC_{90} level, the Antiguan population again showed quite high levels of resistance to fenthion (60.6-fold), to temephos (29.2-fold) and to chlorpyrifos (10.5-fold). The Jamaican strain also showed some resistance to fenthion (17.1-fold) and to chlorpyrifos (14.7-fold). The strains from St. Lucia and Trinidad also showed 19.3- and 14-fold resistance, respectively, to temephos. Generally, it was to this latter insecticide that the field-collected strains showed most resistance. This is understandable since this same insecticide has been used very extensively throughout the region for *Ae. aegypti* management for the past 10–15 years (Georghiou et al. 1987; Rawlins, personal observation, 1989). Resistance to temephos and fenithion in the Antigua strain has been reported previously by Georghiou et al. (1987). However, the LC_{50} levels of the same strain in our study were about 8 and 4 times greater.

At the same time, the *Tx. moctezuma* population was also less susceptible to all organophosphorus insecticides that were tested. In comparison with our susceptible *Ae. aegypti* strain, *Tx. moctezuma* was approximately 120- (LC_{50}) and 112- (LC_{90}) fold less susceptible to temephos. At the LC_{90} level, this was $>$ 3 times less susceptible to temephos as any of the 6 field-collected strains of *Ae. aegypti.* In theory, this larvicide could be used successfully in an integrated management program with *Tx. moctezyma* on the Caribbean islands mentioned in Table 1. Contamination of the *Ae. aegypti* larval habitat with temephos would not automatically result in the elimination of the *Tx. moctezuma* larvae; insecticide-susceptible prey larvae would be eliminated, while resistant ones may survive and be prey for the highly tolerant predator. Conversely, since *Tx. moctezuma* was approximately as susceptible as some of the *Ae. aegypti* populations to malathion, fenthion, fenitrothion and chlorpyrifos, these chemicals would not be useful for an integrated management program with this strain of *Tx. moctezuma.*

This use of temephos could meet the requirement of the Knipling (1966) hypothesis since *Tx. moctezuma* larvae could continue to control the relatively low numbers of *Ae. aegypti,* after the insecticide would have killed most of the population.

The value of the present data lies in the fact that if an integrated pest management program involving an insecticide and *Tx. moctezuma* were contemplated, it would be possible to determine which organophosphorus insecticide would not be compatible for use with this predator. For example, chlorpyrifos would not be very useful for management in the Jamaica strain of *Ae. aegypti* since this strain is $>$ 3 times more tolerant than the predator to this insecticide.

Table 1. Comparative insecticide susceptibility of some Caribbean strains of *Aedes aegypti* and relative toxicity of the predator *Toxorhynchites moctezuma.*

	Lethal concentrations (mg/liter) and (resistance ratio)[a] or (relative toxicity)[b]									
	Temephos		Malathion		Fenthion		Fenitrothion		Chlorpyrifos	
Species/strain	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
Aedes aegypti										
CAREC,	0.003	0.010	0.051	0.313	0.013	0.018	0.017	0.057	0.007	0.020
Trinidad	—	—	—	—	—	—	—	—	—	—
St. John's,	0.075	0.292	0.283	0.482	0.322	1.091	0.052	0.105	0.092	0.209
Antigua	(25.00)	(29.20)	(5.55)	(1.54)	(24.76)	(60.61)	(3.06)	(1.84)	(13.14)	(10.45)
Harbour View,	0.034	0.081	0.575	1.290	0.105	0.307	0.055	0.103	0.073	0.294
Jamaica	(11.33)	(8.10)	(11.27)	(4.12)	(8.08)	(17.06)	(3.24)	(1.81)	(10.42)	(14.70)
P. Nuevo,	0.032	0.089	0.329	0.603	0.049	0.096	0.029	0.094	0.041	0.073
Puerto Rico	(10.67)	(8.90)	(6.45)	(1.93)	(3.77)	(5.33)	(1.71)	(1.65)	(5.86)	(3.65)
Castries,	0.083	0.195	0.264	0.597	0.093	0.183	0.040	0.092	0.051	0.124
St. Lucia	(27.67)	(19.50)	(5.18)	(1.90)	(7.15)	(10.17)	(2.35)	(1.61)	(7.29)	(6.20)
Curepe,	0.058	0.140	0.647	0.919	0.062	0.231	0.045	0.150	0.064	0.121
Trinidad	(19.33)	(14.00)	(12.67)	(2.94)	(4.77)	(12.83)	(2.65)	(2.63)	(9.14)	(6.05)
Union Is.,	0.015	0.035	0.220	0.655	0.023	0.062	0.027	0.051	0.018	0.079
St. Vincent	(5.00)	(3.54)	(4.31)	(2.09)	(1.77)	(3.44)	(1.54)	(0.89)	(2.57)	(3.95)
Toxorhynchites moctezuma										
Chaguaramas,	0.359	1.120	0.412	1.057	0.090	0.143	0.088	0.156	0.020	0.074
Trinidad	(119.67)	(112.00)	(8.08)	(3.38)	(6.92)	(7.94)	(5.18)	(2.74)	(2.86)	(3.70)

[a] Resistance ratio = $\frac{LC_{50}}{LC_{50}}$ or $\frac{LC_{90}\ \textit{Ae. aegypti}\ \text{strain}}{LC_{90}\ \text{of susceptible (CAREC) strain}}$

[b] Relative toxicity = $\frac{LC_{50}}{LC_{50}}$ or $\frac{LC_{90}\ \text{of}\ \textit{Tx. moctezuma}}{LC_{90}\ \text{of susceptible (CAREC) strain}}$

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