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COMPARATIVE SUSCEPTIBILITY OF LARVAE OF THREE *AEDES* SPECIES TO MALATHION AND PERMETHRIN

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ABSTRACT. Larvae of *Aedes hendersoni, Ae. atropalpus,* and 6 geographic strains of *Ae. triseriatus* were compared in terms of their susceptibility to malathion and permethrin. *Aedes atropalpus* was most tolerant to malathion, whereas *Ae. triseriatus* (Walton strain) was most tolerant to permethrin. Malathion LC_{50}s for 6 geographic strains of *Ae. triseriatus* ranked from high to low were: Alabama (ALA) > Michigan (UNDERC) > Indiana (WAL) > Kentucky (UKEN) > Texas (SAL) > Florida (VB); similar ranking of permethrin LC_{50}s resulted in: WAL > VB > SAL > UKEN > UNDERC > ALA. Differences in susceptibility were detected but were not considered large (i.e., over several orders of magnitude). As a result, no change in application rate of malathion or permethrin, from an operational viewpoint, would be warranted if used against these 3 mosquito species or the geographic strains of *Ae. triseriatus* investigated.

INTRODUCTION

Aedes triseriatus (Say) is a common eastern and midwestern mosquito in the United States and is considered to be a major vector of La Crosse encephalitis (DeFoliart 1983). This species develops prolifically in water-filled artificial containers as well as tree holes (Ballard et al. 1987). Many aspects of this mosquito's biology and vector potential have been studied (Sinsko and Craig 1979, Beier et al. 1982, DeFoliart 1983, Haramis and Foster 1983). Considering the wide distribution of *Ae. triseriatus,* interspecific differences may have important implications in vector control programs. Additionally, a sibling species of this mosquito, *Aedes hendersoni* Cockerell, also incriminated as a vector of La Crosse encephalitis, is occasionally collected in association with *Ae. triseriatus* (Truman and Craig 1968, Grimstead et al. 1985). Another mosquito species that sometimes can be found in association with tire-inhabiting *Ae. triseriatus* is *Aedes atropalpus* (Coq.). This latter species can become locally abundant and a biting nuisance in residential areas.

When control is aimed against one mosquito species (e.g., when applying larvicides to tires or other artificial containers) it is assumed that other mosquito species inhabiting those habitats also will be killed. It is further assumed that larvicide application will be equally effective regardless of geographic region (disregarding for the moment prior insecticide exposure of targeted populations). Therefore, we compared intraspecific susceptibility of 6 strains of *Ae. triseriatus* larvae as well as interspecific susceptibility of *Ae. atropalpus* and *Ae. hendersoni* to malathion and permethrin.

METHODS AND MATERIALS

Six strains of *Ae. triseriatus* designated as Walton [WAL] from South Bend, IN; Vero Beach [VB] from Vero Beach, FL; UNDERC from Gogebic Co., MI; Kentucky [UKEN] from Berea, KY; Salado [SAL] from Bexar Co., TX; Alabama [ALA] from Savannah, GA, as well as *Ae. hendersoni* [NHUV] from University of Notre Dame, IN; and *Ae. atropalpus* [COOKE] from Louisville, KY, were obtained as eggs from the Vector Biology Laboratory, University of Notre Dame on 5 × 8-cm wooden oviposition "paddles". Egg paddles were submerged in deoxygenated water until hatched (*ca.* 2 h) after which time paddles were removed. Subsequent larvae were then reared using the methods of Munstermann and Wasmuth (1985).

Each species and geographic strain was evaluated against malathion (91% AI, American Cyanamid, Princeton, NJ) and permethrin (95.7% AI, Burroughs Wellcome, Research Triangle Park, NC). Both insecticides were selected on the basis of proven effectiveness as larvicides in laboratory tests on another container-inhabiting species, *Aedes aegypti* (Linn.) (Pass and Knapp 1966, Herald et al. 1980). At least 5 concentrations each replicated 4 times were used. Concentrations were serially diluted in acetone from an initial 1% wt/vol solution for each insecticide. Two milliliters of each chemical were added to 200 ml of dechlorinated water in 250-ml glass beakers prior to the introduction of 25 late 3rd-instar larvae. Two hundred milliliters of dechlorinated water with 2 ml of acetone and another set of beakers with dechlorinated water only served as complementary controls. Mortality was recorded 24 h posttreatment. Larvae that

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Table 1. Intraspecific comparative toxicity of malathion to 3rd-instar larvae of 6 strains of *Aedes triseriatus*.

Strain	LC_{50}[1] (ppm)	(95% CL)	LC_{95}[1] (ppm)	(95% CL)	Slope ± SE
ALA	0.066a	(0.065–0.068)	0.088a	(0.085–0.093)	13.06 ± 0.88
UNDERC	0.065a	(0.061–0.069)	0.134bc	(0.123–0.151)	5.21 ± 0.41
WAL	0.062ab	(0.058–0.065)	0.097a	(0.092–0.103)	8.36 ± 0.12
UKEN	0.055b	(0.051–0.059)	0.109bc	(0.097–0.128)	5.49 ± 0.54
SAL	0.050c	(0.047–0.053)	0.153d	(0.137–0.174)	3.38 ± 0.17
VB	0.043d	(0.041–0.045)	0.093ac	(0.086–0.104)	4.86 ± 0.30

[1] LC_{50} or LC_{95} with different letters are significantly different from one another on the basis of failure of the 95% confidence intervals to overlap.

did not respond by a wiggling movement while the side of the beaker was tapped with a stirring rod were recorded as dead. Environmental conditions for the duration of the study were 20 ± 1°C with continuous light. No mortality was observed in controls during the tests.

Dose–mortality data were subjected to Probit analysis (SAS Institute 1985). The LC_{50}s and LC_{95}s of each mosquito strain and/or species were considered to be significantly different from one another when their 95% confidence intervals did not overlap.

RESULTS AND DISCUSSION

LC_{50}s (from high to low) of the 6 *Ae. triseriatus* strains to malathion were ALA > UNDERC > WAL > UKEN > SAL > VB (Table 1). The VB strain was significantly more susceptible to malathion than the other 5 strains, whereas the UKEN and SAL strains were significantly more susceptible than ALA and UNDERC strains. Toxicity ranking of LC_{95}s from high to low was SAL > UNDERC > UKEN > WAL > VB > ALA (Table 1). The LC_{95} of the ALA strain was significantly lower than the LC_{95}s of SAL, UNDERC, and UKEN strains but not lower than WAL and VB strains.

The LC_{50}s of the 6 *Ae. triseriatus* strains to permethrin (from high to low) were WAL > VB > SAL > UKEN > UNDERC > ALA (Table 2). The susceptibility of ALA to this insecticide was significantly greater compared with the other strains. The UKEN and UNDERC strains were significantly more susceptible to permethrin than WAL and VB. The WAL strain was significantly less susceptible to this insecticide, with the exception of the SAL strain, when compared with the other strains. Toxicity ranking of LC_{95}s from high to low was SAL > VB > WAL > UKEN > UNDERC > ALA. The ALA strain was significantly more susceptible at this level when compared with WAL, VB, and SAL strains.

The malathion LC_{50} and LC_{95} of *Ae. atropalpus* were both significantly greater when compared with those of *Ae. hendersoni* and the WAL *Ae. triseriatus* strains (Table 3). Although *Ae. atropalpus* had been collected from a tire pile in Louisville, KY, we do not know whether the 2 times difference in susceptibility indicated a true distinction between species or geographic variability.

The permethrin LC_{50} and LC_{95} of *Ae. hendersoni* were both significantly less than the other 2 *Aedes* species (Table 3). There were no significant differences in susceptibility at LC_{95} lev-

Table 2. Intraspecific comparative toxicity of permethrin to 3rd-instar larvae of 6 strains of *Aedes triseriatus*.

Strain	LC_{50}[1] (ppb)	(95% CL)	LC_{95}[1] (ppb)	(95% CL)	Slope ± SE
WAL	8.39a	(8.11–8.70)	13.99a	(12.97–15.41)	7.41 ± 0.50
VB	7.68b	(7.40–7.98)	14.68a	(13.47–16.38)	5.84 ± 0.38
SAL	7.38abc	(6.80–8.15)	15.66a	(12.92–21.46)	5.04 ± 0.53
UKEN	6.39c	(5.61–6.93)	12.06ab	(10.39–16.48)	5.96 ± 1.15
UNDERC	6.23c	(5.64–6.79)	10.44ab	(9.14–13.23)	7.34 ± 0.91
ALA	4.46d	(4.18–4.72)	10.16b	(9.09–11.81)	4.60 ± 0.39

[1] LC_{50} or LC_{95} with different letters are significantly different from one another on the basis of failure of the 95% confidence intervals to overlap.

Table 3. Comparison of malathion and permethrin toxicity to 3rd-instar larvae of *Aedes triseriatus, Aedes atropalpus,* and *Aedes hendersoni.*

Species	LC_{50}[1]	(95% CL)	LC_{95}[1]	(95% CL)	Slope ± SE
Malathion[2]					
Ae. triseriatus[3]	0.062a	(0.058–0.065)	0.097a	(0.092–0.103)	8.36 ± 0.12
Ae. hendersoni	0.066a	(0.056–0.076)	0.113a	(0.092–0.185)	7.08 ± 1.21
Ae. atropalpus	0.172b	(0.145–0.201)	0.482b	(0.373–0.745)	3.69 ± 0.47
Permethrin[4]					
Ae. triseriatus	8.389a	(8.107–8.703)	13.988a	(12.971–15.406)	7.41 ± 0.50
Ae. hendersoni	3.507b	(3.166–3.870)	8.463b	(7.285–10.320)	4.30 ± 0.36
Ae. atropalpus	6.168c	(5.688–6.671)	16.052a	(14.040–19.052)	3.96 ± 0.29

[1] LC_{50} or LC_{95} with different letters are significantly different from one another (within insecticide) on the basis of failure of the 95% confidence intervals to overlap.
[2] ppm.
[3] Walton (WAL) strain.
[4] ppb.

els between *Ae. atropalpus* and *Ae. triseriatus* (WAL strain).

In conclusion, susceptibility differences to malathion and permethrin occurred among some strains of *Ae. triseriatus* as well as between *Ae. hendersoni* and *Ae. atropalpus* larvae; however, these differences were not considered large (i.e., over several orders of magnitude). From an operational perspective, one would not expect an increase in mosquito control label rates with either insecticide.

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