INSECTICIDE TOLERANCE OF *CULEX NIGRIPALPUS* IN FLORIDA

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ABSTRACT. Larval susceptibility tests of *Culex nigripalpus* populations from various areas of Florida have shown resistance to several organophosphorus insecticides since 1984. Although the degree of resistance is low (2 to 7 times), it can be termed tolerance and appears to be the greatest for fenthion, followed by temephos, naled and malathion. It is suggested that pesticide runoff from lawns, golf courses and agricultural and urban areas may play a role in developing resistance in Florida mosquito populations.

INTRODUCTION

Culex nigripalpus Theobald is regarded as one of the main mosquito species in Florida against which control efforts are directed. It was incriminated as the vector of St. Louis encephalitis (SLE) during the 1959, 1961 and 1962 epidemics in the Tampa Bay area (Florida State Board of Health 1969). During these periods, 315 cases were reported with 55 fatalities (Florida State Board of Health 1963) The next SLE epidemic occurred in central Florida during 1977. *Culex nigripalpus* was also incriminated as the vector with 110 cases and 8 deaths recorded (Nelson et al. 1983).

Since 1964, the John A. Mulrennan, Sr., Research Laboratory (JAMSRL), formerly the West Florida Arthropod Research Laboratory (WFARL), has been monitoring the insecticide susceptibility of this species from various areas in the state. From 1965 to 1967, area populations were primarily tested against malathion and naled (Rogers and Rathburn 1964, Rathburn and Boike 1967, Boike and Rathburn 1968) During 1968–71, baseline data were established for the laboratory susceptible colonies with temephos, fenthion and chlorpyrifos (Boike and Rathburn 1969, 1972). From 1972 to 1978, *Cx. nigripalpus* larval populations were tested for malathion, naled and fenthion resistance (Boike and Rathburn. 1975, Boike et al. 1978, 1979) and beginning in 1979 for susceptibility to temephos (Boike et al. 1980). In anticipation of possible resistance and cross resistance to the other currently used insecticides, a program was initiated in 1980 to monitor the susceptibility of mosquito populations from selected areas of the state in which temephos was used (Boike et al. 1982). In 1984, results of the temephos (Abate) monitoring program indicated that some populations of *Cx. nigripalpus* were showing some tolerance to fenthion, temephos and naled (Boike et al. 1985).

In California a similar need to identify resistance trends over a period of several years was reported by Thompson (1986) who showed that, after testing *Cx. tarsalis* Coquillett larvae from throughout the state from 1983 to 1985, most populations were susceptible to malathion and fenthion but resistant to parathion and chlorpyrifos.

MATERIALS AND METHODS

Ideally, the variations of susceptibility of a mosquito population can best be shown when a population is sampled and tested from the same area or locality over a period of several consecutive years (Brown 1986). Many of the areas sampled during the earlier years of the susceptibility testing program (1965–70) were from several localities within a county and tested against several insecticides. Therefore, few mosquito populations from one locality were tested against the same insecticide for several consecutive years. Around 1980, when the Abate monitoring program was initiated, testing of populations from the same area against the same insecticide for consecutive years was realized. It was also around this time (1980–84) that an increase in tolerance to some insecticides was noted in some populations of *Cx. nigripalpus* around the state. All area mosquito populations were compared to the standard susceptible *Cx. nigripalpus* strain of the JAMSRL. This strain was colonized since 1964 from adults from Indian River County and has not been exposed to insecticides since then.

Most wild *Cx. nigripalpus* were collected for testing from various areas using CDC portable light traps baited with dry ice (Newhouse et al. 1966) In addition, chicken-baited lard can traps, (Bellamy and Reeves 1952) were used and on several occasions sweep nets were employed when adults were numerous. An average of 500 to 1,000 specimens were collected with the light trap method, while several hundred specimens were captured using lard cans and sweep nets. Specimens were shipped by bus or auto to the laboratory in cages placed inside styrofoam chests and chilled with plastic freezer containers. Adult mosquitoes were transferred to 46 cm^2 screened cages in the laboratory, blood fed

on anesthetized chicks, and offered a 10% sugar solution on cotton pads as a carbohydrate source. Egg rafts were collected on infusion water prepared from dried oak leaves and forest floor detritis, hatched, and the F_1 larvae tested.

Larvae were tested for susceptibility to fenthion, malathion, naled and temephos during 1966–86 using the following protocol: 1 ml of insecticide diluted in ACS acetone was pipetted into test beakers containing 200 ml of tap water. Then 25 3rd instar larvae in 49 ml of tap water were added to the beakers, giving a total of 250 ml of solution.

Initially, 600 ml Pyrex glass beakers were used; however, to eliminate breakage, 400 ml polypropylene beakers were used during most of the testing period. From 1986 to the present, 420 ml styrofoam cups were employed and discarded after usage. Since a considerable reduction in larval mortality occurred when plastic beakers were used for the temephos bioassay (Rathburn and Boike 1969) glass was employed throughout the testing period for this insecticide.

A replicate consisted of a control and 5 to 7 serial dilutions of the test insecticide. An average of 12 replications were performed on each insecticide and all tests were performed in water baths at 27 ± 1° C. Mortality counts were made at 24 h posttreatment. A *Cx. nigripalpus* larval bioassay of the susceptible colony from the JAMSRL was performed with each bioassay from the locality.

The resistance ratio is a comparison of the susceptibility of the field-collected mosquitoes to that of the susceptible strain and is defined as the LC_{50} or LC_{90} values of the field collected strain divided by the LC_{50} or LC_{90}, respectively, of the susceptible strain.

The LC_{50} and LC_{90} values were calculated by probit analysis using a Sharp programmable calculator during 1974–82. From 1983 to the present, the values were obtained with the SAS program through the facilities of the Northeast Regional Data Center (NERDC) located in Gainesville, FL and were expressed in μg AI/ml (ppm)

RESULTS

Results of the *Cx. nigripalpus* larval bioassays are presented for each insecticide in Tables 1 to 4. Similar localities sampled for 2 or more years and showing an increase in tolerance, were arranged chronologically. Some localities within the same county were sampled only once and are included for comparison either to localities with little or no tolerance or to localities showing significant tolerance (usually those sampled 1984–86). All resistant ratios (RR) were less than 10×, indicating tolerance as defined by Brown and Pal (1971): "For mosquito larvae, a 10-fold increase in LC_{50} is necessary to indicate resistance, whereas for adult mosquitoes a 4-fold increase is sufficient. In cases where the increase in LC_{50} is less than these indicated minima for the tests, but is nevertheless statistically significant, the word 'tolerance' has proved useful. This usually coincides with a degree of change in susceptibility level that has not resulted in a detectable loss of control by the insecticide." Tables 1 to 4 record the bioassays of *Cx. nigripalpus* with fenthion, temephos, naled and malathion, respectively.

Bioassays of *Cx. nigripalpus* from Gibsonton, FL, during 1981–86 indicated an increase in tolerance to fenthion with LC_{50} and LC_{90} resistance ratios from 0.9× during 1981 to 3.8× and 7.2×, respectively, in 1986 (Table 1). Since the LC_{50} and LC_{90} of the JAMSRL susceptible colony varied little during the time period, the increased resistance ratios were thought to be a result of true increases in the LC_{50} and LC_{90} values of the populations tested. Somewhat similar results were obtained for Marco Island. During 1982, the *Cx. nigripalpus* population and the JAMSRL colony were almost equally susceptible to fenthion. When tested in 1985, the wild population was 4.2× (LC_{50}) and 5.4× (LC_{90}) more tolerant than the JAMSRL strain. Larvae from wild populations from 3 localities (Chapman Road, Port Manatee and Tallevast) in Manatee County tested during 1985 and 1986 were 3.6 to 5.4× more tolerant at the LC_{50} level and 5.7 to 6.7× more tolerant at the LC_{90} level than the JAMSRL colony. Additional localities indicating an increase in tolerance to fenthion during 1985 and 1987 were: Temple Terrace in Hillsborough County, New Port Richey in Pasco County and Daytona Beach and Deltona in Volusia County.

Larval bioassays of *Cx. nigripalpus* from Gibsonton, Hillsborough County, indicated an increase in tolerance to temephos over a 6-year period (Table 2). During 1980, 1981 and 1982, the larvae were almost as susceptible as the JAMSRL strain. From 1984 to 1986, an increase in tolerance was noted with resistance ratios of 2.5× and 5.6× at the LC_{50} and LC_{90} levels, respectively. Larval bioassays conducted during 1984 and 1986 from the Treesweet processing plant in St. Lucie County indicated a 2-fold and 2.3-fold increase in the LC_{50} and LC_{90} resistance ratio, respectively compared to the JAMSRL strain. The 1979 larval bioassays from Ponce Inlet, Volusia County, were almost as susceptible as the JAMSRL strain. Larvae collected from Deltona and Daytona Beach (Volusia County) showed an increase in tolerance to temephos.

Table 1. Susceptibility of *Culex nigripalpus* larvae against fenthion from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier Bay	Marco Island	1982	0.00353	(0.00348–0.00359)	0.00530	(0.00510–0.00621)	1.1	1.3
	JAMSRL	1982	0.00317	(0.00310–0.00324)	0.00406	(0.00393–0.00418)	—	—
	Marco Island	1985	0.01304	(0.01272–0.01338)	0.02123	(0.02021–0.02248)	4.2	5.4
	JAMSRL	1985	0.00309	(0.00286–0.00331)	0.00395	(0.00363–0.00462)	—	—
	Naples	1986	0.00693	(0.00413–0.00939)	0.02297	(0.01475–0.10412)	2.4	6.4
	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
Hillsborough Bay	Gibsonton	1981	0.00302	(0.00295–0.00309)	0.00417	(0.00402–0.00434)	0.9	0.9
	JAMSRL	1981	0.00350	(0.00344–0.00356)	0.00452	(0.00437–0.00467)	—	—
	Gibsonton	1984	0.00732	(0.00646–0.00827)	0.01932	(0.01580–0.02582)	2.7	5.6
	JAMSRL	1984	0.00269	(0.00264–0.00273)	0.00343	(0.00336–0.00351)	—	—
	Gibsonton	1985	0.00964	(0.00797–0.01235)	0.02724	(0.01863–0.06346)	3.0	6.5
	JAMSRL	1985	0.00322	(0.00304–0.00340)	0.00416	(0.00385–0.00472)	—	—
	Gibsonton	1986	0.00996	(0.00824–0.01237)	0.02470	(0.01757–0.06017)	3.8	7.2
	JAMSRL	1986	0.00264	(0.00255–0.00273)	0.00345	(0.00332–0.00363)	—	—
	Temple Terrace	1985	0.01081	(0.00896–0.01321)	0.02339	(0.01765–0.04372)	3.4	5.6
	JAMSRL	1985	0.00322	(0.00304–0.00340)	0.00416	(0.00385–0.00472)	—	—
Indian River Bay	Vero Beach	1986	0.00999	(0.00899–0.01101)	0.01463	(0.01291–0.01832)	3.5	4.1
	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
Manatee Bay	Chapman Rd	1985	0.01134	(0.00944–0.01486)	0.02299	(0.01677–0.05176)	4.1	6.7
	JAMSRL	1985	0.00274	(0.00245–0.00298)	0.00343	(0.00313–0.00431)	—	—
	Chapman Rd	1986	0.01540	(0.01344–0.01668)	0.02057	(0.01816–0.03027)	5.4	5.7
	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
	Tallevast	1986	0.01295	(0.01140–0.01545)	0.02328	(0.01845–0.03898)	4.6	6.5
	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
	Port Manatee	1986	0.01054	(0.00352–0.01303)	0.01971	(0.01533–0.09521)	3.6	5.7
	JAMSRL	1986	0.00290	(0.00265–0.00313)	0.00347	(0.00320–0.00412)	—	—
Pasco Bay	N. Pt. Richey	1985	0.00854	(0.00623–0.01949)	0.02465	(0.01314–0.01780)	2.8	6.2
	JAMSRL	1985	0.00309	(0.00286–0.00331)	0.00395	(0.00363–0.00462)	—	—
Volusia Bay	Ponce Inlet	1979	0.00291	(0.00270–0.00507)	0.00457	(0.00412–0.00507)	0.9	1.0
	JAMSRL	1979	0.00331	(0.00326–0.00336)	0.00444	(0.00432–0.00455)	—	—
	Tomoka Marsh	1981	0.00288	(0.00279–0.00298)	0.00421	(0.00403–0.00440)	0.8	0.9
	JAMSRL	1981	0.00350	(0.00344–0.00356)	0.00452	(0.00437–0.00467)	—	—
	Daytona Beach	1987	0.00819	(0.00731–0.00921)	0.01603	(0.01324–0.02264	2.9	4.5
	JAMSRL	1987	0.00282	(0.00266–0.00297)	0.00353	(0.00332–0.00388)	—	—
	Deltona	1987	0.00859	(0.00767–0.00950)	0.01765	(0.01527–0.02178)	3.2	5.0
	JAMSRL	1987	0.00270	(0.00249–0.00287)	0.00355	(0.00330–0.00401)	—	—

$$\text{Resistance ratio} = \frac{LC_{50} \text{ or } LC_{90} \text{ of area strain}}{LC_{50} \text{ or } LC_{90} \text{ of susceptible strain}}.$$

Most *Cx. nigripalpus* naled bioassays prior to 1984 indicated that wild populations tested were similar in susceptibility as the JAMSRL strain (Table 3). Populations from Manatee County sampled in 1973 (Bradenton) and 1976 (Perico Island) showed similar susceptibility when compared with the JAMSRL colony; however, from 1985 to 1987 populations from Chapman Road, Port Manatee and Tallevast (located approximately 8 to 13 km from Bradenton and Perico Island) were 2.8 to 3.0× more tolerant to naled at the LC_{50} level and 3.8 to 4.9× more tolerant at the LC_{90} level. Populations from New Smyrna, Oak Hill, Ponce Inlet and Tomoka Marsh (Volusia County) tested during 1966–81 were almost as tolerant as the JAMSRL colony, while larval bioassays from Daytona Beach and Deltona conducted during 1987 indicated an increase in tolerance of 2.2× and 2.7× at the LC_{50} level and 3.7× and 4.3× at the LC_{90} level, respectively.

Malathion is the most widely used insecticide for mosquito control in the state. Susceptibility tests were performed from more locations at more time intervals than for the 3 previous insecticides (Table 4). Results from 1985–87 larval bioassays from Naples, Collier County; Gibsonton, Hillsborough County; Vero Beach, Indian River County; Chapman Road, Port Manatee, and Tallevast, Manatee County; New

Table 2. Susceptibility of *Culex nigripalpus* larvae against temephos from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier Bay	Naples	1980	0.000291	(0.000278–0.000304)	0.000547	(0.000513–0.000583)	0.9	0.9
	JAMSRL	1980	0.000327	(0.000313–0.000340)	0.000608	(0.000581–0.000635)	—	—
	Marco Island	1982	0.000478	(0.000469–0.000488)	0.000645	(0.000626–0.000665)	0.8	0.8
	JAMSRL	1982	0.000574	(0.000562–0.000585)	0.000824	(0.000792–0.000857)	—	—
	Marco Island	1984	0.000792	(0.000647–0.000948)	0.001252	(0.001016–0.002852)	1.2	1.4
	JAMSRL	1984	0.000637	(0.000626–0.000648)	0.000898	(0.000872–0.000929)	—	—
Hillsbor-ough Bay	Gibsonton	1980	0.000296	(0.000283–0.000309)	0.000609	(0.000564–0.000658)	0.6	0.8
	JAMSRL	1980	0.000470	(0.000354–0.000560)	0.000730	(0.000609–0.001160)	—	—
	Gibsonton	1981	0.000327	(0.000315–0.000340)	0.000700	(0.000651–0.000754)	0.5	0.5
	JAMSRL	1981	0.000600	(0.000588–0.000612)	0.000915	(0.000875–0.000957)	—	—
	Gibsonton	1982	0.000389	(0.000377–0.000402)	0.000626	(0.000605–0.000648)	0.7	0.7
	JAMSRL	1982	0.000524	(0.000511–0.000537)	0.000844	(0.000802–0.000888)	—	—
	Gibsonton	1984	0.001313	(0.001192–0.001464)	0.004031	(0.003244–0.005491)	2.1	4.5
	JAMSRL	1984	0.000637	(0.000626–0.000648)	0.000898	(0.000872–0.000929)	—	—
	Gibsonton	1984	0.001115	(0.000877–0.001348)	0.003402	(0.002490–0.006450)	1.7	3.9
	JAMSRL	1984	0.000651	(0.000636–0.000665)	0.000876	(0.000845–0.000915)	—	—
	Gibsonton	1985	0.001200	(0.001061–0.001344)	0.002640	(0.002219–0.003427)	2.4	3.4
	JAMSRL	1985	0.000506	(0.000384–0.000568)	0.000766	(0.000675–0.001055)	—	—
	Gibsonton	1986	0.001451	(0.000852–1.544009)	0.004469	(0.002146–1.677432)	2.5	5.6
	JAMSRL	1986	0.000583	(0.000502–0.000640)	0.000792	(0.000711–0.001016)	—	—
	Temple Terrace	1985	0.000797	(0.000745–0.000847)	0.002230	(0.001978–0.002622)	1.4	2.8
	JAMSRL	1985	0.000552	(0.000461–0.000611)	0.000796	(0.000706–0.001064)	—	—
Manatee Bay	Tallevast	1986	0.001654	(0.001092–0.002781)	0.003397	(0.002271–0.004195)	3.0	4.2
	JAMSRL	1986	0.000551	(0.000475–0.000604)	0.000810	(0.000724–0.001031)	—	—
	Chapman Rd.	1986	0.002033	(0.001534–0.003719)	0.005089	(0.003089–0.045879)	3.7	6.3
	JAMSRL	1986	0.000551	(0.000475–0.000604)	0.000810	(0.000724–0.001031)	—	—
St. Lucie Bay	Treesweet	1984	0.001072	(0.000947–0.001244)	0.002099	(0.001704–0.002954)	1.6	2.3
	JAMSRL	1984	0.000656	(0.000627–0.000689)	0.000905	(0.000835–0.001019)	—	—
	Treesweet	1986	0.001869	(0.001628–0.002288)	0.004276	(0.003190–0.007468)	3.2	5.4
	JAMSRL	1986	0.000583	(0.000502–0.000640)	0.000792	(0.000711–0.001016)	—	—
	Tropicana	1984	0.001115	(0.000914–0.000163)	0.001905	(0.001396–0.004851)	1.7	2.1
	JAMSRL	1984	0.000656	(0.000627–0.000689)	0.000904	(0.000835–0.001019)	—	—
Volusia Bay	Ponce Inlet	1979	0.000542	(0.000529–0.000555)	0.000859	(0.000815–0.000905)	1.2	1.1
	JAMSRL	1979	0.000468	(0.000458–0.000479)	0.000795	(0.000760–0.000832)	—	—
	Deltona	1987	0.001526	(0.001294–0.001818)	0.003272	(0.002477–0.006615)	2.3	3.4
	JAMSRL	1987	0.000669	(0.000646–0.000694)	0.000967	(0.000908–0.001051)	—	—
	Daytona Beach	1987	0.001622	(0.001318–0.002340)	0.004391	(0.002780–0.025535)	2.4	4.5
	JAMSRL	1987	0.000669	(0.000646–0.000694)	0.000967	(0.000908–0.001051)	—	—

Port Richey, Pasco County; Daytona Beach and Deltona, Volusia County, indicate a resistance ratio range of 1.7 to 2.5× to malathion at the LC_{50} level and a resistance ratio range of 1.9 to 2.9× at the LC_{90} level when compared to the JAMSRL strain. Only 3 locations, Tallevast, New Port Richey and Naples, had an LC_{90} resistance ratio approaching 3× that of the JAMSRL strain.

DISCUSSION

The increase in tolerance of *Cx. nigripalpus* larvae from different areas of the state to 4 commonly used insecticides can readily be documented for such localities as Gibsonton, Marco Island, Naples, Chapman Road and Tallevast, where populations were sampled from the same localities over a period of several years. Within the past 3 years, populations of *Cx. nigripalpus* from certain localities began showing tolerance. Some counties contained localities which showed tolerance while in other localities, tolerance could not be detrmined because no data was available to compare with the earlier data. *Culex nigripalpus* is considered a nonmigrating species with a dispersal range of 1.5 to 3 km (Nayar 1982). Those localities within a county showing tolerance should not be considered with the localities sampled earlier which showed very

Table 3. Susceptibility of *Culex nigripalpus* larvae against naled from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier Bay	Naples	1981	0.0416	(0.0404–0.0429)	0.0583	(0.0554–0.0614)	1.1	1.1
	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
	Naples	1985	0.1402	(0.1239–0.1649)	0.2816	(0.2201–0.4560)	3.0	4.8
	JAMSRL	1985	0.0467	(0.0460–0.0474)	0.0583	(0.0570–0.0598)	—	—
	Naples	1986	0.1135	(0.0991–0.1325)	0.1875	(0.1539–0.2919)	2.8	3.2
	JAMSRL	1986	0.0402	(0.0384–0.0418)	0.0584	(0.0553–0.0630)	—	—
Hillsborough Bay	Gibsonton	1981	0.0528	(0.0512–0.0544)	0.0895	(0.0810–0.0990)	1.4	1.7
	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
	Gibsonton	1984	0.0722	(0.0659–0.0851)	0.1820	(0.1336–0.3371)	2.0	4.2
	JAMSRL	1984	0.0355	(0.0342–0.0365)	0.0436	(0.0422–0.0455)	—	—
	Gibsonton	1985	0.0730	(0.0663–0.0793)	0.1420	(0.1263–0.1659)	1.7	2.1
	JAMSRL	1985	0.0422	(0.0367–0.0465)	0.0667	(0.0575–0.0980)	—	—
	Gibsonton	1986	0.0902	(0.0866–0.0937)	0.1744	(0.1643–0.1870)	2.4	3.0
	JAMSRL	1986	0.0382	(0.0361–0.0399)	0.0575	(0.0542–0.0623)	—	—
Indian River Bay	Vero Beach	1967	0.0670	(0.0655–0.0698)	0.0800	(0.0761–0.0848)	0.9	0.8
	JAMSRL	1967	0.0756	(0.0677–0.0841)	0.0967	(0.0861–0.1470)	—	—
	Vero Beach	1968	0.0775	(0.0730–0.0830)	0.0946	(0.0875–0.1102)	1.1	1.1
	JAMSRL	1968	0.0680	(0.0611–0.0712)	0.0870	(0.0815–0.1049)	—	—
	Vero Beach	1986	0.1141	(0.1096–0.1188)	0.2398	(0.2214–0.2637)	2.4	3.7
	JAMSRL	1986	0.0467	(0.0421–0.0512)	0.0645	(0.0571–0.0869)	—	—
Manatee Bay	Bradenton	1973	0.0463	(0.0128–0.0805)	0.0815	(0.0577–0.5248)	1.1	1.4
	JAMSRL	1973	0.0419	(0.0409–0.0428)	0.0586	(0.0564–0.0616)	—	—
	Perico Island	1976	0.0593	(0.0580–0.0606)	0.0750	(0.0723–0.0776)	1.1	1.1
	JAMSRL	1976	0.0521	(0.0514–0.0529)	0.0713	(0.0692–0.0736)	—	—
	Chapman Rd	1985	0.1249	(0.1006–0.1624)	0.2568	(0.1863–0.7495)	3.0	3.9
	JAMSRL	1985	0.0422	(0.0367–0.0465)	0.0667	(0.0575–0.0980)	—	—
	Chapman Rd	1986	0.1304	(0.1062–0.1840)	0.2675	(0.1879–0.7472)	3.0	4.8
	JAMSRL	1986	0.0434	(0.0422–0.0446)	0.0558	(0.0538–0.0585)	—	—
	Port Manatee	1986	0.1221	(0.0986–0.1496)	0.2756	(0.2036–0.6168)	2.8	4.9
	JAMSRL	1986	0.0434	(0.0422–0.0446)	0.0558	(0.0538–0.0585)	—	—
	Tallevast	1986	0.1225	(0.1022–0.1556)	0.2100	(0.1628–0.4002)	2.8	3.8
	JAMSRL	1986	0.0434	(0.0422–0.0446)	0.0558	(0.0538–0.0585)	—	—
	Tallevast	1987	0.0847	(0.0805–0.887)	0.1674	(0.1572–0.1801)	1.7	2.4
	JAMSRL	1987	0.0510	(0.0487–0.0536)	0.0685	(0.0631–0.0784)	—	—
Pasco Bay	N.P. Richey	1974	0.0684	(0.0672–0.0696)	0.0911	(0.0878–0.0944)	1.8	1.7
	JAMSRL	1974	0.0371	(0.0362–0.0381)	0.0537	(0.0515–0.0559)	—	—
	N.P. Richey	1985	0.0901	(0.0801–0.1049)	0.2091	(0.1620–0.3286)	2.1	3.1
	JAMSRL	1985	0.0422	(0.0367–0.0465)	0.0667	(0.0575–0.0980)	—	—
Polk Bay	Mulberry	1981	0.0420	(0.0412–0.0427)	0.0627	(0.0603–0.0653)	1.1	1.2
	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
	Bartow AB	1986	0.0828	(0.0781–0.0871)	0.1467	(0.1387–0.1568)	1.8	2.3
	JAMSRL	1986	0.0467	(0.0421–0.0152)	0.0645	(0.0571–0.0869)	—	—
Volusia Bay	New Smyrna	1966	0.0777	(0.0766–0.0790)	0.0968	(0.0938–0.1008)	1.5	1.4
	JAMSRL	1966	0.0517	(0.0477–0.0548)	0.0690	(0.0649–0.0755)	—	—
	Oak Hill	1975	0.0612	(0.0593–0.0631)	0.0818	(0.0776–0.0863)	1.1	1.1
	JAMSRL	1975	0.0543	(0.0521–0.0567)	0.0726	(0.0663–0.0795)	—	—
	Ponce Inlet	1979	0.0525	(0.0510–0.0540)	0.0707	(0.0663–0.0753)	1.1	1.1
	JAMSRL	1979	0.0487	(0.0470–0.0505)	0.0621	(0.0582–0.0662)	—	—
	Tomoka Marsh	1981	0.0509	(0.0500–0.0519)	0.0740	(0.0711–0.0771)	1.3	1.4
	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
	Daytona Beach	1987	0.1192	(0.1016–0.1425)	0.2532	(0.1963–0.4127)	2.7	4.3
	JAMSRL	1987	0.0444	(0.0434–0.0453)	0.0595	(0.0576–0.0619)	—	—
	Deltona	1987	0.1005	(0.0964–0.1049)	0.2084	(0.1921–0.2296)	2.2	3.7
	JAMSRL	1987	0.0458	(0.0425–0.0488)	0.0562	(0.0520–0.0654)	—	—

Table 4. Susceptibility of *Culex nigripalpus* larvae against malathion from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier Bay	Naples	1980	0.0242	(0.0231–0.0253)	0.0452	(0.0422–0.0484)	0.8	1.2
	JAMSRL	1980	0.0312	(0.0306–0.0318)	0.0393	(0.0382–0.0405)	—	—
	Naples	1985	0.0626	(0.0596–0.0658)	0.1188	(0.1090–0.1318)	2.4	3.0
	JAMSRL	1985	0.0258	(0.0183–0.0296)	0.0397	(0.0337–0.0722)	—	—
	Naples	1986	0.0470	(0.0402–0.0546)	0.0737	(0.0617–0.1067)	1.9	1.9
	JAMSRL	1986	0.0242	(0.0191–0.0282)	0.0387	(0.0318–0.0805)	—	—
	Marco Island	1982	0.0330	(0.0322–0.0337)	0.0470	(0.0450–0.0490)	1.1	1.2
	JAMSRL	1982	0.0300	(0.0292–0.0307)	0.0392	(0.0372–0.0410)	—	—
Hillsborough Bay	Gibsonton	1980	0.0242	(0.0237–0.0247)	0.0357	(0.0343–0.0372)	0.8	0.9
	JAMSRL	1980	0.0312	(0.0306–0.0318)	0.0393	(0.0382–0.0405)	—	—
	Gibsonton	1985	0.0461	(0.0414–0.0504)	0.0804	(0.0715–0.0948)	1.7	2.2
	JAMSRL	1985	0.0276	(0.0271–0.0280)	0.0371	(0.0362–0.0381)	—	—
	Gibsonton	1986	0.0375	(0.0284–0.0448)	0.0764	(0.0621–0.0112)	1.5	2.0
	JAMSRL	1986	0.0242	(0.0191–0.0282)	0.0387	(0.0318–0.0805)	—	—
Indian River Bay	Vero Beach	1967	0.0376	(0.0339–0.0424)	0.0508	(0.0445–0.0675)	1.3	1.1
	JAMSRL	1967	0.0300	(0.0269–0.0337)	0.0450	(0.0389–0.0572)	—	—
	Vero Beach	1968	0.0380	(0.0318–0.0442)	0.0540	(0.0436–0.0822)	1.4	1.5
	JAMSRL	1968	0.0267	(0.0263–0.0271)	0.0353	(0.0345–0.0362)	—	—
	Vero Beach	1987	0.0580	(0.0536–0.0636)	0.0921	(0.0807–0.1124)	2.4	2.7
	JAMSRL	1987	0.0243	(0.0203–0.0280)	0.0337	(0.0290–0.0554)	—	—
Manatee Bay	Bradenton	1973	0.0413	(0.0369–0.0456)	0.0739	(0.0638–0.0927)	1.3	1.7
	JAMSRL	1973	0.0315	(0.0301–0.0329)	0.0447	(0.0418–0.0491)	—	—
	Perico Island	1976	0.0451	(0.0436–0.0466)	0.0670	(0.0631–0.0712)	1.3	1.4
	JAMSRL	1976	0.0340	(0.0333–0.0346)	0.0485	(0.0466–0.0504)	—	—
	Chapman Road	1985	0.0459	(0.0442–0.0476)	0.0856	(0.0815–0.0905)	1.7	2.3
	JAMSRL	1985	0.0276	(0.0271–0.0280)	0.0371	(0.0362–0.0381)	—	—
	Port Manatee	1986	0.0511	(0.0477–0.0551)	0.0841	(0.0752–0.0981)	2.0	2.5
	JAMSRL	1986	0.0260	(0.0230–0.0282)	0.0342	(0.0310–0.0434)	—	—
	Tallevast	1986	0.0462	(0.0401–0.0523)	0.0715	(0.0619–0.0918)	1.8	2.1
	JAMSRL	1986	0.0260	(0.0230–0.0282)	0.0342	(0.0310–0.0434)	—	—
	Tallevast	1987	0.0545	(0.0529–0.0563)	0.0822	(0.0799–0.0875)	2.5	2.9
	JAMSRL	1987	0.0217	(0.0196–0.0230)	0.0285	(0.0209–0.0333)	—	—
Pasco Bay	N. Pt. Richey	1974	0.0330	(0.0320–0.0340)	0.0550	(0.0530–0.0570)	1.4	1.2
	JAMSRL	1974	0.0230	(0.0220–0.0240)	0.0470	(0.0450–0.0490)	—	—
	N. Pt. Richey	1985	0.0608	(0.0526–0.0693)	0.1035	(0.0876–0.0138)	2.2	2.8
	JAMSRL	1985	0.0276	(0.0271–0.0280)	0.0371	(0.0362–0.0381)	—	—
Volusia Bay	Daytona Beach	1967	0.0349	(0.0322–0.0368)	0.0445	(0.0414–0.0498)	1.1	1.0
	JAMSRL	1967	0.0304	(0.0269–0.0337)	0.0443	(0.0389–0.0572)	—	—
	Oak Hill	1975	0.0482	(0.0470–0.0494)	0.0719	(0.0684–0.0758)	1.7	1.5
	JAMSRL	1975	0.0288	(0.0280–0.0297)	0.0471	(0.0436–0.0509)	—	—
	Ponce Inlet	1979	0.0282	(0.0273–0.0292)	0.0481	(0.0458–0.0506)	1.1	1.3
	JAMSRL	1979	0.0264	(0.0253–0.0275)	0.0381	(0.0359–0.0404)	—	—
	Deltona	1987	0.0389	(0.0376–0.0402)	0.0619	(0.0591–0.0656)	1.7	2.1
	JAMSRL	1987	0.0228	(0.0216–0.0239)	0.0290	(0.0273–0.0316)	—	—
	Daytona Beach	1987	0.0532	(0.0481–0.0583)	0.0864	(0.0763–0.1053)	1.7	1.7
	JAMSRL	1987	0.0321	(0.0284–0.0414)	0.0506	(0.0399–0.1152)	—	—

little tolerance, because, in most cases, collections were made more than 3 km from the tolerant population. The increase in tolerance of all 4 insecticides appears to have started prior to 1984 with fenthion exhibiting the highest degree, followed by temephos, naled and malathion. Although fewer areas were sampled for fenthion before 1984 than after 1984, those sampled before 1984 were almost as susceptible as the JAMSRL strain. Although used since 1979, there was no tolerance to fenthion until after the widespread use of temephos in 1984 (W. R. Opp, personal communication).

Since cross resistance between fenthion and temephos has been shown with *Aedes nigromaculis* (Ludlow) in California (Gillies et al 1968),

it is possible that the use of temephos could have contributed to fenthion tolerance in *Cx. nigripalpus*. In view of the data presented here and the fact that malathion has been the most widely used adulticide in Florida, it appears that its continued use for the control of *Cx. nigripalpus* should be continued since the compound exhibited the least tolerance of all insecticides tested, while the use of fenthion and temephos should be curtailed. The future monitoring of certain localities should be accomplished to ascertain whether tolerances are increasing.

The increased use of agricultural insecticides has been associated with the development of resistance in mosquito populations worldwide (Georghiou 1982). We concur with this and also suggest that exposure to pesticide runoff from lawns, golf courses, agricultural areas and other urban sites may play a role in developing resistance in mosquito populations in Florida.

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Tables 1–4 on pages 524–527 should be replaced by the following tables.

Table 1. Susceptibility of *Culex nigripalpus* larvae against fenthion from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier	Marco Island	1982	0.00353	(0.00348–0.00359)	0.00530	(0.00510–0.00621)	1.1	1.3
Bay	JAMSRL	1982	0.00317	(0.00310–0.00324)	0.00406	(0.00393–0.00418)	—	—
Collier	Marco Island	1985	0.01304	(0.01272–0.01338)	0.02123	(0.02021–0.02248)	4.2	5.4
Bay	JAMSRL	1985	0.00309	(0.00286–0.00331)	0.00395	(0.00363–0.00462)	—	—
Collier	Naples	1986	0.00693	(0.00413–0.00939)	0.02297	(0.01475–0.10412)	2.4	6.4
Bay	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
Hillsborough	Gibsonton	1981	0.00302	(0.00295–0.00309)	0.00417	(0.00402–0.00434)	0.9	0.9
Bay	JAMSRL	1981	0.00350	(0.00344–0.00356)	0.00452	(0.00437–0.00467)	—	—
Hillsborough	Gibsonton	1984	0.00732	(0.00646–0.00827)	0.01932	(0.01580–0.02582)	2.7	5.6
Bay	JAMSRL	1984	0.00269	(0.00264–0.00273)	0.00343	(0.00336–0.00351)	—	—
Hillsborough	Gibsonton	1985	0.00964	(0.00797–0.01235)	0.02724	(0.01863–0.06346)	3.0	6.5
Bay	JAMSRL	1985	0.00322	(0.00304–0.00340)	0.00416	(0.00385–0.00472)	—	—
Hillsborough	Gibsonton	1986	0.00996	(0.00824–0.01237)	0.02470	(0.01757–0.06017)	3.8	7.2
Bay	JAMSRL	1986	0.00264	(0.00255–0.00273)	0.00345	(0.00332–0.00363)	—	—
Hillsborough	Temple Terrace	1985	0.01081	(0.00896–0.01321)	0.02339	(0.01765–0.04372)	3.4	5.6
Bay	JAMSRL	1985	0.00322	(0.00304–0.00340)	0.00416	(0.00385–0.00472)	—	—
Indian River	Vero Beach	1986	0.00999	(0.00899–0.01101)	0.01463	(0.01291–0.01832)	3.5	4.1
Bay	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
Manatee	Chapman Rd	1985	0.01134	(0.00944–0.01486)	0.02299	(0.01677–0.05176)	4.1	6.7
Bay	JAMSRL	1985	0.00274	(0.00245–0.00298)	0.00343	(0.00313–0.00431)	—	—
Manatee	Chapman Rd	1986	0.01540	(0.01344–0.01668)	0.02057	(0.01816–0.03027)	5.4	5.7
Bay	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
Manatee	Tallevast	1986	0.01295	(0.01140–0.01545)	0.02328	(0.01845–0.03898)	4.6	6.5
Bay	JAMSRL	1986	0.00284	(0.00278–0.00291)	0.00360	(0.00350–0.00373)	—	—
Manatee	Port Manatee	1986	0.01054	(0.00352–0.01303)	0.01971	(0.01533–0.09521)	3.6	5.7
Bay	JAMSRL	1986	0.00290	(0.00265–0.00313)	0.00347	(0.00320–0.00412)	—	—
Pasco	N. Pt. Richey	1985	0.00854	(0.00623–0.01949)	0.02465	(0.01314–0.01780)	2.8	6.2
Bay	JAMSRL	1985	0.00309	(0.00286–0.00331)	0.00395	(0.00363–0.00462)	—	—
Volusia	Ponce Inlet	1979	0.00291	(0.00270–0.00507)	0.00457	(0.00412–0.00507)	0.9	1.0
Bay	JAMSRL	1979	0.00331	(0.00326–0.00336)	0.00444	(0.00432–0.00455)	—	—
Volusia	Tomoka Marsh	1981	0.00288	(0.00279–0.00298)	0.00421	(0.00403–0.00440)	0.8	0.9
Bay	JAMSRL	1981	0.00350	(0.00344–0.00356)	0.00452	(0.00437–0.00467)	—	—
Volusia	Daytona Beach	1987	0.00819	(0.00731–0.00921)	0.01603	(0.01324–0.02264)	2.9	4.5
Bay	JAMSRL	1987	0.00282	(0.00266–0.00297)	0.00353	(0.00332–0.00388)	—	—
Volusia	Deltona	1987	0.00859	(0.00767–0.00950)	0.01765	(0.01527–0.02178)	3.2	5.0
Bay	JAMSRL	1987	0.00270	(0.00249–0.00287)	0.00355	(0.00330–0.00401)	—	—

$$\text{Resistance ratio} = \frac{LC_{50} \text{ or } LC_{90} \text{ of area strain}}{LC_{50} \text{ or } LC_{90} \text{ of susceptible strain}}$$

Table 2. Susceptibility of *Culex nigripalpus* larvae against temephos from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.I.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier	Naples	1980	0.000291	(0.000278–0.000304)	0.000547	(0.000513–0.000583)	0.9	0.9
Bay	JAMSRL	1980	0.000327	(0.000313–0.000340)	0.000608	(0.000581–0.000635)	—	—

Table 2—*Continued*

County	Locality	Year	Lethal concentration in μg AI/ml (ppm) LC_{50}	95% C.I.	LC_{90}	95% C.L.	Resistance ratio LC_{50}	Resistance ratio LC_{90}
Collier	Marco Island	1982	0.000478	(0.000469–0.000488)	0.000645	(0.000626–0.000665)	0.8	0.8
Bay	JAMSRL	1982	0.000574	(0.000562–0.000585)	0.000824	(0.000792–0.000857)	—	—
Collier	Marco Island	1984	0.000792	(0.000647–0.000948)	0.001252	(0.001016–0.002852)	1.2	1.4
Bay	JAMSRL	1984	0.000637	(0.000626–0.000648)	0.000898	(0.000872–0.000929)	—	—
Hillsborough	Gibsonton	1980	0.000296	(0.000283–0.000309)	0.000609	(0.000564–0.000658)	0.6	0.8
Bay	JAMSRL	1980	0.000470	(0.000354–0.000560)	0.000730	(0.000609–0.001160)	—	—
Hillsborough	Gibsonton	1981	0.000327	(0.000315–0.000340)	0.000700	(0.000651–0.000754)	0.5	0.5
Bay	JAMSRL	1981	0.000600	(0.000588–0.000612)	0.000915	(0.000875–0.000957)	—	—
Hillsborough	Gibsonton	1982	0.000389	(0.000377–0.000402)	0.000626	(0.000605–0.000648)	0.7	0.7
Bay	JAMSRL	1982	0.000524	(0.000511–0.000537)	0.000844	(0.000802–0.000888)	—	—
Hillsborough	Gibsonton	1984	0.001313	(0.001192–0.001464)	0.004031	(0.003244–0.005491)	2.1	4.5
Bay	JAMSRL	1984	0.000637	(0.000626–0.000648)	0.000898	(0.000872–0.000929)	—	—
Hillsborough	Gibsonton	1984	0.001115	(0.000877–0.001348)	0.003402	(0.002490–0.006450)	1.7	3.9
Bay	JAMSRL	1984	0.000651	(0.000636–0.000665)	0.000876	(0.000845–0.000915)	—	—
Hillsborough	Gibsonton	1985	0.001200	(0.001061–0.001344)	0.002640	(0.002219–0.003427)	2.4	3.4
Bay	JAMSRL	1985	0.000506	(0.000384–0.000568)	0.000766	(0.000675–0.001055)	—	—
Hillsborough	Gibsonton	1986	0.001451	(0.000852–1.544009)	0.004469	(0.002145–1.677432)	2.5	5.6
Bay	JAMSRL	1986	0.000583	(0.000502–0.000640)	0.000792	(0.000711–0.001016)	—	—
Hillsborough	Temple Terrace	1985	0.000797	(0.000745–0.000847)	0.002230	(0.001978–0.002622)	1.4	2.8
Bay	JAMSRL	1985	0.000552	(0.000461–0.000611)	0.000796	(0.000706–0.001064)	—	—
Manatee	Tallevast	1986	0.001654	(0.001092–0.002781)	0.003397	(0.002271–0.004195)	3.0	4.2
Bay	JAMSRL	1986	0.000551	(0.000475–0.000604)	0.000810	(0.000724–0.001031)	—	—
Manatee	Chapman Rd	1986	0.002033	(0.001534–0.003719)	0.005089	(0.003089–0.045879)	3.7	6.3
Bay	JAMSRL	1986	0.000551	(0.000475–0.000604)	0.000810	(0.000724–0.001031)	—	—
St. Lucie	Treesweet	1984	0.001072	(0.000947–0.001244)	0.002099	(0.001704–0.002954)	1.6	2.3
Bay	JAMSRL	1984	0.000656	(0.000627–0.000689)	0.000905	(0.000835–0.001019)	—	—
St. Lucie	Treesweet	1986	0.001869	(0.001628–0.002288)	0.004276	(0.003190–0.007468)	3.2	5.4
Bay	JAMSRL	1986	0.000583	(0.000502–0.000640)	0.000792	(0.000711–0.001016)	—	—
St. Lucie	Tropicana	1984	0.001115	(0.000914–0.000163)	0.001905	(0.001396–0.004851)	1.7	2.1
Bay	JAMSRL	1984	0.000656	(0.000627–0.000689)	0.000904	(0.000835–0.001019)	—	—
Volusia	Ponce Inlet	1979	0.000542	(0.000529–0.000555)	0.000859	(0.000815–0.000905)	1.2	1.1
Bay	JAMSRL	1979	0.000468	(0.000458–0.000479)	0.000795	(0.000760–0.000832)	—	—
Volusia	Deltona	1987	0.001526	(0.001294–0.001818)	0.003272	(0.002477–0.006615)	2.3	3.4
Bay	JAMSRL	1987	0.000669	(0.000646–0.000694)	0.000967	(0.000908–0.001051)	—	—
Volusia	Daytona Beach	1987	0.001622	(0.001318–0.002340)	0.004391	(0.002780–0.025535)	2.4	4.5
Bay	JAMSRL	1987	0.000669	(0.000646–0.000694)	0.000967	(0.000908–0.001051)	—	—

Table 3. Susceptibility of *Culex nigripalpus* larvae against naled from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm) LC_{50}	95% C.L.	LC_{90}	95% C.L.	Resistance ratio LC_{50}	Resistance ratio LC_{90}
Collier	Naples	1981	0.0416	(0.0404–0.0429)	0.0583	(0.0554–0.0614)	1.1	1.1
Bay	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
Collier	Naples	1985	0.1402	(0.1239–0.1649)	0.2816	(0.2201–0.4560)	3.0	4.8
Bay	JAMSRL	1985	0.0467	(0.0460–0.0474)	0.0583	(0.0570–0.0598)	—	—
Collier	Naples	1986	0.1135	(0.0991–0.1325)	0.1875	(0.1539–0.2919)	2.8	3.2
Bay	JAMSRL	1986	0.0402	(0.0384–0.0418)	0.0584	(0.0553–0.0630)	—	—
Hillsborough	Gibsonton	1981	0.0528	(0.0512–0.0544)	0.0895	(0.0810–0.0990)	1.4	1.7
Bay	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
Hillsborough	Gibsonton	1984	0.0722	(0.0659–0.0851)	0.1820	(0.1336–0.3371)	2.0	4.2
Bay	JAMSRL	1984	0.0355	(0.0342–0.0365)	0.0436	(0.0422–0.0455)	—	—
Hillsborough	Gibsonton	1985	0.0730	(0.0663–0.0793)	0.1420	(0.1263–0.1659)	1.7	2.1
Bay	JAMSRL	1985	0.0422	(0.0367–0.465)	0.0667	(0.0575–0.0980)	—	—
Hillsborough	Gibsonton	1986	0.0902	(0.0866–0.0937)	0.1744	(0.1643–0.1870)	2.4	3.0
Bay	JAMSRL	1986	0.0382	(0.0361–0.0399)	0.0575	(0.0542–0.0623)	—	—

Table 3—*Continued*

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Indian River	Vero Beach	1967	0.0670	(0.0655–0.0698)	0.0800	(0.0761–0.0848)	0.9	0.8
Bay	JAMSRL	1967	0.0756	(0.0677–0.0841)	0.0967	(0.0861–0.1470)	—	—
Indian River	Vero Beach	1968	0.0775	(0.0730–0.0830)	0.0946	(0.0875–0.1102)	1.1	1.1
Bay	JAMSRL	1968	0.0680	(0.0611–0.0712)	0.0870	(0.0815–0.1049)	—	—
Indian River	Vero Beach	1986	0.1141	(0.1096–0.1188)	0.2398	(0.2214–0.2637)	2.4	3.7
Bay	JAMSRL	1986	0.0467	(0.0421–0.0512)	0.0645	(0.0571–0.0869)	—	—
Manatee	Bradenton	1973	0.0463	(0.0128–0.0805)	0.0815	(0.0577–0.5248)	1.1	1.4
Bay	JAMSRL	1973	0.0419	(0.0409–0.0428)	0.0586	(0.0564–0.0616)	—	—
Manatee	Perico Island	1976	0.0593	(0.0580–0.0606)	0.0750	(0.0723–0.0776)	1.1	1.1
Bay	JAMSRL	1976	0.0521	(0.0514–0.0529)	0.0713	(0.0692–0.0736)	—	—
Manatee	Chapman Rd	1985	0.1249	(0.1006–0.1624)	0.2568	(0.1863–0.7495)	3.0	3.9
Bay	JAMSRL	1985	0.0422	(0.0367–0.0465)	0.0667	(0.0575–0.0980)	—	—
Manatee	Chapman Rd	1986	0.1304	(0.1062–0.1840)	0.2675	(0.1879–0.7472)	3.0	4.8
Bay	JAMSRL	1986	0.0434	(0.0422–0.0446)	0.0558	(0.0538–0.0585)	—	—
Manatee	Port Manatee	1986	0.1221	(0.0986–0.1496)	0.2756	(0.2036–0.6168)	2.8	4.9
Bay	JAMSRL	1986	0.0434	(0.0422–0.0446)	0.0558	(0.0538–0.0585)	—	—
Manatee	Tallevast	1986	0.1225	(0.1022–0.1556)	0.2100	(0.1628–0.4002)	2.8	3.8
Bay	JAMSRL	1986	0.0434	(0.0422–0.0446)	0.0558	(0.0538–0.0585)	—	—
Manatee	Tallevast	1987	0.0847	(0.0805–0.887)	0.1674	(0.1572–0.1801)	1.7	2.4
Bay	JAMSRL	1987	0.0510	(0.0487–0.0536)	0.0685	(0.0631–0.0784)	—	—
Pasco	N.P. Richey	1974	0.0684	(0.0672–0.0696)	0.0911	(0.0878–0.0944)	1.8	1.7
Bay	JAMSRL	1974	0.0371	(0.0362–0.0381)	0.0537	(0.0515–0.0559)	—	—
Pasco	N.P. Richey	1985	0.0901	(0.0801–0.1049)	0.2091	(0.1620–0.3286)	2.1	3.1
Bay	JAMSRL	1985	0.0422	(0.0367–0.0465)	0.0667	(0.0575–0.0980)	—	—
Polk	Mulberry	1981	0.0420	(0.0412–0.0427)	0.0627	(0.0603–0.0653)	1.1	1.2
Bay	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
Polk	Bartow AB	1986	0.0828	(0.0781–0.0871)	0.1467	(0.1387–0.1568)	1.8	2.3
Bay	JAMSRL	1986	0.0467	(0.0421–0.0152)	0.0645	(0.0571–0.0869)	—	—
Volusia	New Smyrna	1966	0.0777	(0.0766–0.0790)	0.0968	(0.0938–0.1008)	1.5	1.4
Bay	JAMSRL	1966	0.0517	(0.0477–0.0548)	0.0690	(0.0649–0.0755)	—	—
Volusia	Oak Hill	1975	0.0612	(0.0593–0.0631)	0.0818	(0.0776–0.0863)	1.1	1.1
Bay	JAMSRL	1975	0.0543	(0.0521–0.0567)	0.0726	(0.0663–0.0795)	—	—
Volusia	Ponce Inlet	1979	0.0525	(0.0510–0.0540)	0.0707	(0.0663–0.0753)	1.1	1.1
Bay	JAMSRL	1979	0.0487	(0.0470–0.0505)	0.0621	(0.0582–0.0662)	—	—
Volusia	Tomoka Marsh	1981	0.0509	(0.0500–0.0519)	0.0740	(0.0711–0.0771)	1.3	1.4
Bay	JAMSRL	1981	0.0385	(0.0376–0.0395)	0.0512	(0.0496–0.0528)	—	—
Volusia	Daytona Beach	1987	0.1192	(0.1016–0.1425)	0.2532	(0.1963–0.4127)	2.7	4.3
Bay	JAMSRL	1987	0.0444	(0.0434–0.0453)	0.0595	(0.0576–0.0619)	—	—
Volusia	Deltona	1987	0.1005	(0.0964–0.1049)	0.2084	(0.1921–0.2296)	2.2	3.7
Bay	JAMSRL	1987	0.0458	(0.0425–0.0488)	0.0562	(0.0520–0.654)	—	—

Table 4. Susceptibility of *Culex nigripalpus* larvae against malathion from various localities in Florida for indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Collier	Naples	1980	0.0242	(0.0231–0.0253)	0.0452	(0.0422–0.0484)	0.8	1.2
Bay	JAMSRL	1980	0.0312	(0.0306–0.0318)	0.0393	(0.0382–0.0405)	—	—
Collier	Naples	1985	0.0626	(0.0596–0.0658)	0.1188	(0.1090–0.1318)	2.4	3.0
Bay	JAMSRL	1985	0.0258	(0.0183–0.0296)	0.0397	(0.0337–0.0722)	—	—
Collier	Naples	1986	0.0470	(0.0402–0.546)	0.0737	(0.0617–0.1067)	1.9	1.9
Bay	JAMSRL	1986	0.0242	(0.0191–0.0282)	0.0387	(0.0318–0.0805)	—	—
Collier	Marco Island	1982	0.0330	(0.0322–0.0337)	0.0470	(0.0450–0.0490)	1.1	1.2
Bay	JAMSRL	1982	0.0300	(0.0292–0.0307)	0.0392	(0.0372–0.0410)	—	—

Table 4—*Continued* indicated years.

County	Locality	Year	Lethal concentration in μg AI/ml (ppm)				Resistance ratio	
			LC_{50}	95% C.L.	LC_{90}	95% C.L.	LC_{50}	LC_{90}
Hillsborough	Gibsonton	1980	0.0242	(0.0237–0.0247)	0.0357	(0.0343–0.0372)	0.8	0.9
Bay	JAMSRL	1980	0.0312	(0.0306–0.0318)	0.0393	(0.0382–0.0405)	—	—
Hillsborough	Gibsonton	1985	0.0461	(0.0414–0.0504)	0.0804	(0.0715–0.0948)	1.7	2.2
Bay	JAMSRL	1985	0.0276	(0.0271–0.0280)	0.0371	(0.0362–0.0381)	—	—
Hillsborough	Gibsonton	1986	0.0375	(0.0284–0.0448)	0.0764	(0.0621–0.0112)	1.5	2.0
Bay	JAMSRL	1986	0.0242	(0.0191–0.0282)	0.0387	(0.0318–0.0805)	—	—
Indian River	Vero Beach	1967	0.0376	(0.0339–0.0424)	0.0508	(0.0445–0.0675)	1.3	1.1
Bay	JAMSRL	1967	0.0300	(0.0269–0.0337)	0.0450	(0.0389–0.0572)	—	—
Indian River	Vero Beach	1968	0.0380	(0.0318–0.0442)	0.0540	(0.0436–0.0822)	1.4	1.5
Bay	JAMSRL	1968	0.0267	(0.0263–0.0271)	0.0353	(0.0345–0.0362)	—	—
Indian River	Vero Beach	1987	0.0580	(0.0536–0.0636)	0.0921	(0.0807–0.1124)	2.4	2.7
Bay	JAMSRL	1987	0.0243	(0.0203–0.0280)	0.0337	(0.0290–0.0554)	—	—
Manatee	Bradenton	1973	0.0413	(0.0369–0.0456)	0.0739	(0.0638–0.0927)	1.3	1.7
Bay	JAMSRL	1973	0.0315	(0.0301–0.0329)	0.0447	(0.0418–0.0491)	—	—
Manatee	Perico Island	1976	0.0451	(0.0436–0.0466)	0.0670	(0.0631–0.0712)	1.3	1.4
Bay	JAMSRL	1976	0.0340	(0.0333–0.0346)	0.0485	(0.0466–0.0504)	—	—
Manatee	Chapman Road	1985	0.0459	(0.0442–0.0476)	0.0856	(0.0815–0.0905)	1.7	2.3
Bay	JAMSRL	1985	0.0276	(0.0271–0.0280)	0.0371	(0.0362–0.0381)	—	—
Manatee	Port Manatee	1986	0.0511	(0.0477–0.0551)	0.0841	(0.0752–0.0981)	2.0	2.5
Bay	JAMSRL	1986	0.0260	(0.0320–0.0282)	0.0342	(0.0310–0.0434)	—	—
Manatee	Tallevast	1986	0.0462	(0.0401–0.0523)	0.0715	(0.0619–0.0918)	1.8	2.1
Bay	JAMSRL	1986	0.0260	(0.0230–0.0282)	0.0342	(0.0310–0.0434)	—	—
Manatee	Tallevast	1987	0.0545	(0.0529–0.0563)	0.0822	(0.0799–0.0875)	2.5	2.9
Bay	JAMSRL	1987	0.0217	(0.0196–0.0230)	0.0285	(0.0209–0.0333)	—	—
Pasco	N. Pt. Richey	1974	0.0330	(0.0320–0.0340)	0.0550	(0.0530–0.0570)	1.4	1.2
Bay	JAMSRL	1974	0.0230	(0.0220–0.0240)	0.0470	(0.0450–0.0490)	—	—
Pasco	N. Pt. Richey	1985	0.0608	(0.0526–0.0693)	0.1035	(0.0876–0.0138)	2.2	2.8
Bay	JAMSRL	1985	0.0276	(0.0271–0.0280)	0.0371	(0.0362–0.0381)	—	—
Volusia	Daytona Beach	1967	0.0349	(0.0322–0.0368)	0.0445	(0.0414–0.0498)	1.1	1.0
Bay	JAMSRL	1967	0.0304	(0.0269–0.0337)	0.0443	(0.0389–0.0572)	—	—
Volusia	Oak Hill	1975	0.0482	(0.0470–0.0494)	0.0719	(0.0684–0.0758)	1.7	1.5
Bay	JAMSRL	1975	0.0288	(0.0280–0.0297)	0.0471	(0.0436–0.0509)	—	—
Volusia	Ponce Inlet	1979	0.0282	(0.0273–0.0292)	0.0481	(0.0458–0.0506)	1.1	1.3
Bay	JAMSRL	1979	0.0264	(0.0253–0.0275)	0.0381	(0.0359–0.0404)	—	—
Volusia	Deltona	1987	0.0389	(0.0376–0.0402)	0.0619	(0.0591–0.0656)	1.7	2.1
Bay	JAMSRL	1987	0.0228	(0.0216–0.0239)	0.0290	(0.0273–0.0316)	—	—
Volusia	Daytona Beach	1987	0.0532	(0.0481–0.0583)	0.0864	(0.0763–0.1053)	1.7	1.7
Bay	JAMSRL	1987	0.0321	(0.0284–0.0414)	0.0506	(0.0399–0.1152)	—	—