TOXICITY OF PYRETHROIDS TO ORGANOPHOSHATE-CARBAMATE- AND DDT-RESISTANT MOSQUITOES

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ABSTRACT. Larvae of *Culex quinquefasciatus* Say and *Cx. tarsalis* Coquillett resistant to organophosphates by means of esterases were found to be fully susceptible to 26 synthetic pyrethroid insecticides that were examined [resistance ratios (RR) = 0.24 to 1.7]. However, *Cx. quinquefasciatus* resistant to propoxur and DDT, and *Anopheles albimanus* Wied. resistant to organophosphates, carbamates and DDT, were found to possess a low level of cross-tolerance to some of the pyrethroids. The available evidence indicates that this tolerance is due largely to the DDT resistance component of the strains.

Resistance to organochlorine, organophosphorus and carbamate insecticides has been found to be a serious problem in the control of several important species of mosquitoes. In *Culex quinquefasciatus* Say, a broad spectrum of organophosphate resistance has been reported in field populations from California (Georghiou *et al.* 1975), and moderate levels of resistance to carbamates have been induced by selection in the laboratory (Georghiou *et al.* 1965). In *Cx. tarsalis* Coquillett, resistance to malathion appeared in the field in 1956 (Gjullin and Isaac 1957) and was later followed by extensive multiresistance involving all organophosphates that were licensed for mosquito control (Georghiou *et al.* 1969, Apperson and Georghiou 1975a).

The important malaria vector in Central America, *Anopheles albimanus* Wied. has developed resistance to several organophosphates as well as to carbamates (Breeland *et al.* 1970, Georghiou *et al.* 1972). An account of the status of resistance in anopheline and culicine mosquitoes is given in the 1975 Report of the WHO Expert Committee on Resistance (WHO 1976).

Because of the emergence of the pyrethroid group as a source of alternative chemicals against resistant populations, we investigated the toxicity of 26 experimental pyrethroids of diverse chemical structure against several species and strains of mosquitoes representing most of the known mechanisms of resistance. In earlier papers we reported on the induction of high levels of pyrethroid resistance in *Culex quinquefasciatus* (Priester and Georghiou 1978) and indicated that permethrin-resistant strains are also variously cross-resistant to other pyrethroids (Priester and Georghiou 1980).

MATERIALS AND METHODS

The following species and strains were tested:

Cx. quinquefasciatus:

S-Lab	A susceptible reference strain of California origin.
Propoxur-R	Strain selected by propoxur to 25x larval and −15x adult resistance (Georghiou *et al.* 1965) based primarily on detoxication by mixed function oxidases (Shrivastava *et al.* 1970). This strain is also 67x resistant to DDT.
Temephos-R	Strain selected by temephos to 322x larval resistance based pri-

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	marily on detoxication by esterases (Ranasinghe and Georghiou 1979). This strain is also cross-resistant to other organophosphates and 19x resistant to DDT.
Cx. tarsalis:	
T-S	A susceptible reference strain of California origin.
Methyl parathion-R	Strain selected by methyl parathion to 94x larval resistance based primarily on esterase detoxication (Apperson and Georghiou 1975a;b). This strain is also cross-resistant to other organophosphates but not to DDT.
An. albimanus:	
S-Gorgas	A susceptible reference strain of Panamanian origin.
OP/Carb.-R	Strain selected by propoxur and subsequently by parathion to high levels of carbamate and organophosphate multi-resistance (Ariaratnam and Georghiou 1974, Ayad and Georghiou 1979) based primarily on reduced sensitivity of acetylcholinesterase (Ayad and Georghiou 1975). This strain is also 8x resistant to DDT and 293x resistant to dieldrin.

The compounds tested are listed below according to chemical structure. They are referred to in the tables in abbreviated form.

I. (1*R*) - *cis* - permethrin; NRDC 167; 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 2 - dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

II. (1*R*) - *trans* - permethrin; NRDC 147; 3 - phenoxybenzyl (1*R*) - *trans* - 3 - (2, 2 - *dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;*

III. (1*R, S*) - *cis, trans* - permethrin; NRDC 143; 3 - phenoxybenzyl (1*R,S*) - *cis, trans* - 3 - (2, 2 - dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

IV. (1*R*(-*cis*-bromophenothrin; RU 23603; 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

V. RU 24701; 3 - phenoxybenzyl (1*R*) - *trans* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

VI. RU 24299; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 2 - dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

VII. RU 24298; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *trans* - 3 - (2, 2 - dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

VIII. NRDC 156; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

IX. RU 24633; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *trans* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

X. RU 25160; (*R, S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 3, 4, 5 - tetrahydro - 2 - oxothien - 3 - ylidenemethyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XI. RU24853; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *trans* - 3 - (2, 3, 4, 5 - tetrahydro - 2 - oxothien - 3 - ylidenemethyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XII. RU 24788; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*S*) - *cis* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XIII. RU 24787; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*S*) - *trans* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XIV. RU 25147; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *cis* - 3 - cyclopentylidenemethyl - 2, 2 - dimethylcyclopropanecarboxylate;

XV. RU 24673; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *trans* - 3 - cyclo - pentylidenemethyl - 2, 2 - dimethylcyclopropanecarboxylate;

XVI. cismethrin; NRDC 119; 5 - benzyl - 3 - furylmethyl (1*R*) - *cis* - 3 - (2, 2 - dimethylvinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XVII. bioresmethrin; NRDC 107; 5 - benzyl - 3 - furylmethyl (1*R*) - *trans* - 3 - (2, 2 - dimethylvinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XVIII. RU 12610; 5 - benzyl - 3 - furylmethyl (1*R*) - *cis* - 3 - cyclopentylidene - methyl - 2, 2 - dimethylcyclopropanecarboxylate;

XIX. RU 11679; 5 - benzyl - 3 - furylmethyl (1*R*) *trans* - 3 - cyclopentylidene-methyl - 2, 2 - dimethylcyclopropanecarboxylate;

XX. RU25136; (*S*) - allethronyl (1*R*) - *cis* - (2, 2 - difluorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XXI. RU25135; (*S*) - allethronyl (1*R*) - *trans* - 3 - (2, 2 - difluorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XXII. RU 24501; (*S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 2 - dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XXIII. RU 24674; (*R*) - α - cyano - 3 - phenoxybenzyl (*R*) - *cis* - 3 - (2, 2 - dichlorovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XXIV. (*S*) - α - (1*R*) - *cis* - decamethrin; NRDC 161; (*S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - *cis* - 3 - (2, 2 - dibromovinyl) - 2, 2 - dimethylcyclopropanecarboxylate;

XXV. RU 24957; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*R*) - 2 - (*p*-chlorophenyl) - 3 - methylbutyrate;

XXVI. RU 24956; (*R,S*) - α - cyano - 3 - phenoxybenzyl (1*S*) - 2 - (*p*-chlorophenyl) - 3 - methylbutyrate.

The test methods employed have been described earlier (Georghiou *et al.* 1965). The chemicals were applied dissolved in acetone. The toxicity of the pyrethroids is compared on the basis of their *trans*/*cis*, and 1*R*/1*S* configurations. The results are also discussed with respect to the known mechanisms of resistance of each strain.

RESULTS AND DISCUSSION

The larval toxicity of several of the pyrethroids was comparable to that of other common insecticides. For example, the LC_{50} value of (1*R,S*)-*cis,trans*-permethrin (III) ranged from 0.0034 ppm for *Cx. quinquefasciatus* to 0.017 ppm for *Cx. tarsalis* to 0.036 ppm for *An. albimanus* (Tables 1–3). Such toxicity compares favorably with that of many organophosphates against the same species and strains (Georghiou *et al.* 1965, Apperson and Georghiou 1975a, Ayad and Georghiou 1979). In contrast, adulticidal activity tests with permethrin, using cellulose filter paper as a substrate (Georghiou and Metcalf 1961) produced LC_{50} values ranging from 4.5 μg/cm² for *An. albimanus* to 12.6 μg/cm² for *Cx. tarsalis* (Table 4). These values indicate 11- to 18-fold lower toxicity than is demonstrated by propoxur against the respective species. It must be pointed out, however, that the adulticidal toxicity of pyrethroids in laboratory tests can be enhanced by the use of di-(2-ethylhexyl) phthalate as a solvent (Barlow *et al.* 1977). Topical application tests against adult *Cx. quinquefasciatus* have revealed considerably higher toxicity of permethrin (LC_{50} *cis* isomer = 0.00044 μg/insect; LC_{50} *trans* isomer = 0.0011 μg/insect compared to 0.0069 for propoxur).

Compound XXIV ["(*S*) - α - (1*R*) - *cis* - decamethrin"] demonstrated the highest larvicidal activity, i.e., LC_{50} of 0.000046 against *Cx. quinquefasciatus* (Table 1). Of the 3 species examined, *An. albimanus* was almost always less sensitive to the pyrethroids than were the 2 *Culex* species (data in Table 3 vs Tables 1 and 2). Compound XXIV was also the most toxic to *An. albimanus* (Table 3).

ACTIVITY OF *cis* VS *trans* ISOMERS. In *Cx. tarsalis* the *cis* isomer was invariably more toxic than the *trans* isomer for all pyrethroids tested (Table 2). Likewise, against *Cx. quinquefasciatus*, the *cis* isomer was generally more toxic than the *trans* isomer, but not in all cases (Table 1). The exceptions were (*R,S*)-α-(−)-decamethrin (XII, XIII), (*R,S*)-α-(1*R*)-ethanocyphenothrin (XIV, XV) and (*S*)-α-(1*R*)-fluoroallethrin (XX, XXI). In *An. albimanus*, no consistent pattern was discernible (Table 3;. For example, against

the S-Gorgas strain, the *cis* isomer was more toxic in the case of (1*R*)-permethrin (I, II), (1*R*)-bromophenothrin (IV, V), (1*R*)-ethanoresmethrin (XVIII, XIX), while the *trans* isomer was more toxic in (*R,S*)-α-(1*R*)-cypermethrin (VI, VII), (*R,S*)-α-(1*R*)-decamethrin (VIII, IX), (*R,S*)-α-(1*R*)-ethanocyphenothrin (XIV, XV), (1*R*)-resmethrin (XVI, XVII), and (*S*)-α-(1*R*)-fluoroallethrin (XX, XXI). The OP/Carb.-R strain manifests the same relative pattern of response except

Table 1. Relative toxicity of *trans/cis*, (R)-α/(S)-α and (1*S*)/(1*R*) pyrethroids to larvae of susceptible, proporur-resistant and temephos-resistant strains of *Cx. quinquefasciatus*.

Compound	Susceptible		Propoxur-R		Temephos-R	
	LC_{50} (ppm)	Slope	LC_{50} (ppm)	RR[a]	LC_{50} (ppm)	RR[a]
I. (1*R*)-*c*-permethrin	0.00095	6.2	0.0032	3.4	0.001	1.1
II. (1*R*)-*t*-permethrin	0.0021	5.3	0.0056	2.7	0.0019	0.9
III. (1*R*)-*c,t*-permethrin	0.0034	4.2	0.011	3.2	0.0033	0.97
IV. (1*R*)-*c*-bromophenothrin	0.0010	4.5	0.0034	3.4	0.0017	1.7
V. (1*R*)-*t*-bromophenothrin	0.0030	6.0	0.016	5.3	0.0035	1.2
VI. (*R,S*)-α-(1*R*)-*c*-cypermethrin	0.00016	5.9	0.00031	1.9	0.00014	0.88
VII. (*R,S*)-α-(1*R*)-*t*-cypermethrin	0.00037	4.8	0.00079	2.1	0.00024	0.65
VIII. (*R,S*)-α-(1*R*)-*c*-decamethrin	0.00030	6.0	0.00053	1.8	0.00029	0.97
IX. (*R,S*)-α-(1*R*)-*t*-decamethrin	0.00049	7.6	0.0011	2.2	0.00055	1.1
X. (*R,S*)-α-(1*R*)-*c*-thiolactonylcyphenothrin	0.0045	3.4	0.0065	1.4	0.0021	0.47
XI. (*R,S*)-α-(1*R*)-*t*-thiolactonylcyphenothrin	0.049	5.6	0.30	6.1	0.043	0.88
XII. (*R,S*)-α-(1*S*)-*c*-decamethrin	0.039	4.2	0.082	2.1	0.043	1.1
XIII. (*R,S*)-α-(1*S*)-*t*-decamethrin	0.016	5.0	0.037	2.3	0.018	1.1
XIV. (*R,S*)-α-(1*R*)-*c*-ethanocyphenothrin	0.048	5.1	0.32	6.7	0.034	0.71
XV. (*R,S*)-α-(1*R*)-*t*-ethanocyphenothrin	0.012	4.8	0.042	3.5	0.011	0.92
XVI. (1*R*)-*c*-resmethrin	0.0034	5.8	0.0089	2.6	0.0028	0.82
XVII. (1*R*)-*t*-resmethrin	0.01	2.8	0.022	2.2	0.0049	0.49
XVIII. (1*R*)-*c*-ethanoresmethrin	0.01	2.7	0.050	5.0	0.0046	0.46
XIX. (1*R*)-*t*-ethanoresmethrin	0.019	5.0	0.079	4.1	0.013	0.68
XX. (*S*)-α-(1*R*)-*c*-fluoroallethrin	0.029	6.9	0.39	13.4	0.038	0.97
XXI. (*S*)-α-(1*R*)-*t*-fluoroallethrin	0.030	6.2	0.17	4.9	0.026	0.87
XXII. (*S*)-α-(1*R*)-*c*-cypermethrin	0.000081	6.7	0.00017	2.1	0.000076	0.94
XXIII. (*R*)-α-(1*R*)-*c*-cypermethrin	0.00032	2.0	0.0011	3.4	0.00018	0.56
XXIV. (*S*)-α-(1*R*)-*c*-decamethrin	0.000046	7.0	0.00012	2.6	0.000033	0.72
XXV. (*R,S*)-α-(1*R*)-fenvalerate	0.0032	5.5	0.02	6.3	0.0047	1.5
XXVI. (*R,S*)-α-(1*S*)-fenvalerate	0.42	1.5	>1	ND[b]	0.71	1.7

[a] Resistance ratio = LC_{50} resistant ÷ LC_{50} susceptible.
[b] Not detectable.

Table 2. Relative toxicity of selected pyrethroids to larvae of susceptible and organophosphate-resistant strains of *Cx. tarsalis*.

Compound	Susceptible		Methyl Parathion-R		
	LC_{50} (ppm)	Slope	LC_{50} (ppm)	Slope	RR[a]
I. (1*R*)-*c*-permethrin	0.0063	4.2	0.0024	2.1	0.38
II. (1*R*)-*t*-permethrin	0.0091	3.4	0.0045	2.0	0.49
III. (1*R*)-*c,t*-permethrin	0.017	2.8	0.0040	5.8	0.24
XVI. (1*R*)-*c*-resmethrin	0.0078	2.8	0.0053	4.4	0.68
XVII. (1*R*)-*t*-resmethrin	0.065	2.6	0.024	3.5	0.37

[a] As in Table 1.

in the case of (*S*)-α-(1*R*)-fluoroallethrin (XX, XXI) where the *cis* isomer is the most toxic (Table 3).

ACTIVITY OF (1*S*) VS (1*R*) ISOMERS. In the three (1*R*/1*S*) pairs examined, the (1*R*) isomer (VIII, IX, XXV) was considerably more toxic than the respective (1*S*) isomer (XII, XIII, XXVI). This relationship held true in all species and strains tested. This is in accordance with Elliott and Janes (1973) and Elliott *et al.* (1978) who have shown that the dextrorotatory isomer is always more toxic than the levorotatory isomer in mustard beetles and the house fly.

CROSS RESISTANCE TO PYRETHROIDS. Although the permethrin-resistant strains of *Cx. quinquefasciatus* are cross-resistant to all pyrethroids that were tested (Priester and Georghiou 1980), the organophosphate-resistant strains of *Culex* spp. were found to be of equal or greater susceptibility than the respective susceptible reference strains (resistance ratio ≤1). Negative cross resistance has been reported with various chemicals in the past (see reviews by Brown 1971, Georghiou 1965), but this phenomenon has not found application as a countermeasure for resistance to date.

At variance with these results are the data obtained on Propoxur-R *Cx. quinquefasciatus* and OP/Carb-R *An. albimanus* which show a low level of positive cross resistance to pyrethroids. It must be pointed out that propoxur resistance in *Cx. quinquefasciatus* is partially due to a piperonyl butoxide-suppressible oxidative mechanism (Shrivastava et al. 1970) and that this synergist also provides partial suppression of pyrethroid resistance in permethrin-resistant strains of this species (Priester and Georghiou 1980). In this regard, it is also noteworthy that Propoxur-R *Cx. quinquefasciatus* resists most pyrethroids at about the same degree as Permethrin-R *Cx. quinquefasciatus* resists propoxur (resistance ratio = ≲4.0). Previously, Collins (1976) reported propoxur-resistant German cockroach to be cross-resistant to DDT and pyrethrins at greater than 12-fold. This has been attributed to a "single pleio-tropic mechanism" providing a protective effect against both DDT, pyrethrins and propoxur (Collins 1976).

The cross resistance to pyrethroids in *An. albimanus* was somewhat unexpected in view of the fact that this strain resists organophosphates and carbamates through a single gene involving insensitivity of acetylcholinesterase (Ayad and Georghiou 1975). From the evidence presently available, it would appear that the DDT resistance component of these strains (i.e. 8× in OP/Carb-R *An. albimanus* and 67× in Propoxur-R *Cx. quinquefasciatus*) is responsible for at least part of the low level cross resistance of these strains toward pyrethroid insecticides. Such correlation of DDT resistance with cross resistance to pyrethroids has also been observed earlier in *Cx. tarsalis* (Plapp and Hoyer 1968) and more recently in *Aedes aegypti* (Chadwick et al. 1977, Prasittisuk and Busvine 1977), and *Anopheles stephensi* (Omer and Georghiou 1980).

Table 3. Relative toxicity of *trans/cis*, (R)-*α*/(*S*)-*α*, and (1*S*)/(1*R*) pyrethroids to larvae of susceptible and organophosphate/carbamate-resistant strains of *An. albimanus*.

Compound		Susceptible		OP/Carb.-R		
		LC_{50} (ppm)	Slope	LC_{50} (ppm)	Slope	RR[a]
I.	(1*R*)-*c*-permethrin	0.017	3.9	0.014	3.0	0.82
II.	(1*R*)-*t*-permethrin	0.024	4.2	0.019	3.9	0.79
III.	(1*R*)-*c,t*-permethrin	0.036	2.0	0.054	2.8	1.5
IV.	(1*R*)-*c*-bromophenothrin	0.018	3.2	0.064	3.0	3.6
V.	(1*R*)-*t*-bromophenothrin	0.048	1.9	0.50	5.2	10.4
VI.	(*R,S*)-*α*-(1*R*)-*c*-cypermethrin	0.008	4.0	0.032	9.3	4.0
VII.	(*R,S*)-*α*-(1*R*)-*t*-cypermethrin	0.0029	3.8	0.0052	2.3	1.8
VIII.	(*R,S*)-*α*-(1*R*)-*c*-decamethrin	0.021	6.3	0.034	4.9	1.6
IX.	(*R,S*)-*α*-(1*R*)-*t*-decamethrin	0.0023	4.0	0.0061	2.2	2.7
X.	(*R,S*)-*α*-(1*R*)-*c*-thiolactonylcyphenothrin	>1	ND[a]	>1	ND	ND
XI.	(*R,S*)-*α*-(1*R*)-*t*-thiolactonylcyphenothrin	>1	ND[b]	>1	ND	ND
XII.	(*R,S*)-*α*-(1*S*)-*c*-decamethrin	>1	ND	>1	ND	ND
XIII.	(*R,S*)-*α*-(1*S*)-*t*-decamethrin	>1	ND	>1	ND	ND
XIV.	(*R,S*)-*α*-(1*R*)-*c*-ethanocyphenothrin	>1	ND	>1	ND	ND
XV.	(*R,S*)-*α*-(1*R*)-*t*-ethanocyphenothrin	0.12	2.5	0.24	3.2	2.0
XVI.	(1*R*)-*c*-resmethrin	0.015	3.7	0.025	2.8	1.7
XVII.	(1*R*)-*t*-resmethrin	0.012	4.2	0.016	2.4	1.3
XVIII.	(1*R*)-*c*-ethanoresmethrin	0.024	3.4	0.036	2.0	1.5
XIX.	(1*R*)-*t*-ethanoresmethrin	0.031	3.4	0.042	2.0	1.4
XX.	(*S*)-*α*-(1*R*)-*c*-fluoroallethrin	0.30	5.8	0.12	4.8	0.4
XXI.	(*S*)-*α*-(1*R*)-*t*-fluoroallethrin	0.25	3.7	0.23	5.6	0.92
XXII.	(*S*)-*α*-(1*R*)-*c*-cypermethrin	0.020	4.3	0.038	2.8	1.9
XXIII.	(*R*)-*α*-(1*R*)-*c*-cypermethrin	0.039	3.2	0.072	2.8	1.8
XXIV.	(*S*)-*α*-(1*R*)-*c*-decamethrin	0.00016	1.4	0.0028	3.8	17.5[c]
XXV.	(*R,S*)-*α*-(1*R*)-fenvalerate	0.082	2.2	0.20	2.5	2.4
XXVI.	(*R,S*)-*α*-(1*S*)-fenvalerate	>1	ND	>1	ND	ND

[a] As in Table 1.

[b] Not detectable.

[c] This relatively high RR value was apparently enhanced by the low slope of the susceptible line (b = 1.4). At the LC_{95}, RR is only 2.9.

Table 4. Comparative toxicity of (1*R*)-*cis*, *trans*-permethrin to larvae and adults of susceptible, organophosphate- and/or carbamate-resistant strains of *Cx. quinquefasciatus*, *Cx. tarsalis* and *An. albimanus*.

Species and Strain	Larval			Adult		
	LC_{50} (ppm)	Slope	RR[a]	LC_{50} ($\mu g/cm^2$)	Slope	RR[a]
Cx. quinquefasciatus						
S-Lab	0.0034	4.2		10.4	2.3	
Temephos-R	0.0033	5.7	0.97	12.7	1.7	1.2
Propoxur-R	0.011	2.0	3.2	44.6	1.4	4.5
Cx. tarsalis						
T-S	0.017	2.8		12.6	2.6	
methyl Parathion-R	0.004	5.8	0.24	14.0	3.3	1.1
An. albimanus						
S-Gorgas	0.036	2.0		4.5	2.4	
OP/Carb.-R	0.054	2.8	1.5	5.9	2.7	1.3

[a] Resistance ratio = LC_{50} resistant ÷ LC_{50} susceptible.

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