Evaluation of organophosphorus and synthetic pyrethroid insecticides against six vector mosquitoe species

Domingo Montada Dorta*, V. Vasuki**, A. Rajavel**

DORTA, D.M. et al. Evaluation of organophosphorus and synthetic pyrethroid insecticides against six vector mosquitoe species. *Rev. Saúde Pública*, 27: 391-7, 1993. Three organophosphorus compounds- malathion, folithion and temephos- and two synthetic pyrethroids- alphamethrin and deltamethrin- were used fór monitoring the susceptibility status of larvae and adults of six vector mosquitoe species: *Culex quinquefasciatus* (Filariasis) and *Aedes albopictus* (Dengue) (both laboratory and field strains); laboratory strains of *Aedes aegypti* (Dengue), *Anopheles stephensi* and *Anopheles culicifacies* (Malaria), and *Culex tritaeniorhynchus* (Japanese encephalitis) in India. From the LC_{50} values obtained for these insecticides, it was found that all mosquito species including the field strains of *Cx. quinquefasciatus* and *Ae. albopictus* were highly susceptible Except for *Cx. quinquefasciatus* (field strain) against malathion, 100% mortality was observed at the discriminating dosages recommended by World Health Organization. The residual effect of alphamethrin, deltamethrin, malathion and folithion at 25 mg (ai)/m^2 on different surfaces against six species of vector mosquitoes showed that alphamethrin was the most effective on all four treated surfaces (mud, plywood, cement and thatch). Nevertheless, residual efficacy lasted longer on thatch than on the other surfaces. Therefore, synthetic pyrethroids such as alphamethrin can be effectively employed in integrated vector control operations.

Key words: Mosquito control, methods. Insecticides, toxicity. Insect vectors.

Introduction

The use of chemicals to control insects possibly dates back to classical Greece and Rome. In the twentieth century, after the insecticidal potential of DDT was discovered and insecticidal organophosphorous compounds were developed, a new era of insect and pest control began (Hassall[14], 1982). Unfortunately problems relating to the use of insecticides have arisen, some of them serious and causing considerable concern in scientific as well as in lay circles (Beroza[4], 1970). The development of resistance in mosquitoes to a wide variety of conventional insecticides has posed a serious problem for vector control program (Georghiou et al.[12,13], 1966; 1973; Das and Rajagopalan[8], 1980; Ariaratnan and Georghiou[3], 1975). To overcome these problems, the search for new compounds with insecticidal effect has been undertaken throughout the world. A new group of compounds known as synthetic pyrethroids, less toxic and comparatively safer, are promising tools for future vector control program (Elliot et al[11], 1978; Darwazeh et al.[6], 1978; Poister et al.[18], 1981; Kottkump et al.[16], 1981).

The present study compares the susceptibility status of larvae and adults of six vector mosquito species viz. *Culex quinquefasciatus* (Filariasis), *Anopheles stephensi* and *Anopheles culicifacies* (Malaria), *Aedes aegypti* and *Aeds albopictus* (Dengue) and *Culex tritaeniorhynchus* (Japanese encephalitis) in India (Manson-Bahr and Bell[17], 1982) to three organophosphorus compounds and two synthetic pyrethroids, using both laboratory and field strains of mosquito.

Material and Method

Malathion (50% EC), folithion (50% EC), temephos (50% EC), deltamethrin (Technical grade 99.9%) and alphamethrin (10% EC) were used for monitoring the susceptibility status of adults and larvae of *Cx. quinquefasciatus*, *An. stephensi*, *Ae. aegypti*, *Ae. albopictus*, *An. culicifacies* and *Cx. tritaeniorhynchus*, maintained at the insectories, Vector Control Research Centre, Pondicherry. In the cases of *Cx. quinquefasciatus* and *Ae. albopictus* field collected strains were also used. Insecticide impregnated papers for monitoring the adult

* Instituto de Medicina Tropical Pedro Kouri - Lisa Habana - Cuba

** Vector Control Research Centre (WHO Collaborating Centre for Research and Training in Integrated Methods of Vector Control Pondicherry - India)

Reprints: D.M. Dorta - Autopista Novia del Mediodia km 6 e/ Autopista Nacional y Carretera Central - Apartado 601 Lisa Habana - Cuba

susceptibility (Busvine[5], 1958) and standard solutions for assessing the larval susceptibility (WHO[23], 1981) were prepared in different concentrations at the VCRC. The procedures followed for determining the susceptibility status of larva and adult are the same as described by WHO[23,24], 1981). From the percentage mortalities resulting from different concentrations, LC_{50} and LC_{90} values were obtained by probit analysis (Sokal and Rohlf[21], 1981). Control mortality, if any, was corrected by using Abbott's formula (Abbott[1], 1925).

To evaluate residual activity, a bioassay was carried out in accordance with WHO methodology (WHO[25], 1981), modified at VCRC (Rajavel et al[19], 1987). Malathion (5% WP), alphamethrin (5% WP), deltamethrin (2.5% WP) and folithion (50% EC) were sprayed at the rate of 25 mg (ai)/m^2 on different surfaces viz. cement, mud, thatch and plywood. The mosquito were exposed to treated surfaces for 1 hour and after 24 hours mortality was recorded at weekly intervals until 50% mortality was observed. All the experiments were carried out at 27±2°C and 70-80% relative humidity.

Results and Discussion

Larvicidal efficacy of deltamethrin, alphamethrin, temephos and folithion against six species of mosquito is shown in tables 1-4. The LC_{50} values given in Table 1 showed that deltamethrin was more effective against *Cx. quinquefasciatus* (lab) than the other mosquito species tested. *An. stephensi* was found to be the least susceptible. The field strain of *Cx. quinquefasciatus* was found to be about 260 times less susceptible than the laboratory strain, when tested under similar condictions, using decamethrin against *Cx. quinquefasciatus* (lab.) and *Ae. aegypti*, it was found to be 24 and 12 times less susceptible respectively than the same strains tested on this occasion. On the other

Table 1. Larval susceptibility status of six vector mosquitoes to deltamethrin.

Species	LC_{50} (mg/1)	LC_{90} (mg/1)	Regression equation (Y = a+b 1nX)	X^2	95% Fiducial limits LCL - UCL
		Laboratory strain			
Cx. quinquefasciatus	2.95×10^{-6}	7.45×10^{-5}	Y = 10.04+0.39 lnX	2.39	4.12×10^{-5} - 1.40×10^{-4}
Cx. tritaeniorhynchus	1.32×10^{-5}	8.73×10^{-5}	Y = 12.62+0.68 lnX	0.19	6.36×10^{-5} - 1.20×10^{-4}
An. culicifacies	2.14×10^{-5}	2.62×10^{-4}	Y = 10.49+0.51 lnX	0.41	1.69×10^{-4} - 4.07×10^{-4}
An. stephensi	5.25×10^{-3}	1.08×10^{-2}	Y = 14.29+1.77 lnX	7.56*	9.54×10^{-3} - 1.23×10^{-2}
Ae. aegypti	8.20×10^{-6}	7.17×10^{-5}	Y = 11.92+0.59 lnX	10.77*	5.27×10^{-5} - 9.76×10^{-5}
Ae. albopictus	4.57×10^{-6}	6.49×10^{-5}	Y = 10.93+0.48 lnX	7.51*	4.20×10^{-5} - 1.00×10^{-4}
		Field strain			
Cx. quinquefasciatus	7.77×10^{-4}	1.07×10^{-3}	Y = 33.55+3.99 lnX	0.28	1.69×10^{-4} - 1.17×10^{-4}
Ae. albopictus	9.69×10^{-6}	6.41×10^{-5}	Y = 12.82+0.68 lnX	4.57	4.43×10^{-5} - 9.28×10^{-5}

* - Heterogeneity.

Table 2. Larval susceptibility status of six vector mosquitoes to alphamethrin.

Species	LC_{50} (mg/1)	LC_{90} (mg/1)	Regression equation (Y = a+b 1nX)	X^2	95% Fiducial limits LCL - UCL
		Laboratory strain			
Cx. quinquefasciatus	2.29×10^{-7}	6.58×10^{-7}	Y = 23.52+1.21 lnX	3.21	5.39×10^{-7} - 8.03×10^{-7}
Cx. tritaeniorhynchus	2.02×10^{-7}	5.86×10^{-7}	Y = 23.55+1.20 lnX	2.78	4.62×10^{-7} - 7.43×10^{-7}
An. culicifacies	1.07×10^{-6}	9.85×10^{-6}	Y = 12.94+0.58 lnX	10.02*	6.55×10^{-6} - 1.48×10^{-5}
An. stephensi	1.03×10^{-4}	8.89×10^{-4}	Y = 10.45+0.59 lnX	5.00	5.38×10^{-4} - 1.47×10^{-3}
Ae. aegypti	1.81×10^{-7}	3.72×10^{-6}	Y = 14.40+0.65 lnX	4.96	2.48×10^{-6} - 5.58×10^{-6}
Ae. albopictus	3.31×10^{-7}	1.08×10^{-6}	Y = 22.30+1.17 lnX	2.31	8.80×10^{-7} - 1.33×10^{-6}
		Field strain			
Cx. quinquefasciatus	1.34×10^{-4}	4.99×10^{-4}	Y = 13.60+0.97 lnX	0.90	3.80×10^{-4} - 6.57×10^{-4}
Ae. albopictus	3.69×10^{-7}	1.10×10^{-6}	Y = 22.35+1.17 lnX	1.85	8.52×10^{-7} - 1.42×10^{-6}

* - Heterogeneity.

hand, *Cx. quinquefasciatus* (field) and *An. stephensi* where found to be twice as susceptible as had been reported earlier for the same insecticide (Das and Kalyanasundaram [10], 1984).

Larval LC_{50} and LC_{90} values of alphamethrin are presented in Table 2 and the results indicate that *Ae. aegypti* was the most and *Cx. quinquefasciatus* (field) the least susceptible species. In an earlier study when alphamethrin was tested against *Cx. quinquefasciatus, Ae. aegypti* and *An. stephensi* (Amalraj et al.[2], 1987) it showed a potency 600, 83 and 40 times higher respectively than that here observed.

In comparison, *Cx. quinquefasciatus* (field), *Cx. tritaeniorhynchus, An. culicifacies, Cx. quinquefasciatus* (lab), *An. stephensi, Ae. albopictus* (lab.), *Ae. aegypti* and *Ae. albopictus* (field) were respectively 6, 66, 100, 13, 52, 13, 52, 13, 45 and 27 times less susceptible to deltamethrin than to alphamethrin.

Larval LC_{50} and LC_{90} values presented in Table 3 reveal that *Ae. albopictus* from laboratory was the most susceptible, and *An. stephensi* the least susceptible species to temephos. The susceptibility status of *Cx. quinquefasciatus, An. stephensi, Ae. aegypti* and *An. culicifacies* observed in the presented study was 88, 40, 30 and 550 times higher respectively than that reported earlier for the Pondicherry strains of the same species (Das and Rajagopalan[7], 1979; Das et al.[9], 1980).

The explanation might be that the strains used in the present study are from a laboratory colonies which have been maintained for about 14 years. It is therefore likely that even if the natural population were resistant, this phenomenon night have been reversed in the laboratory colony due to the removal of selection pressure.

Susceptibility status was determined for larvae of the same mosquito to folithion (fenitrothion). The values showed that *Cx. tritaeniorhynchu* and *Ae. albopictus* (field & lab.) were more susceptible than the other species tested. American strains of *Ae. albopictus* were also reported to be suscep-

Table 3. Larval susceptibility status of six vector mosquitoes to temephos.

Species	LC_{50} (mg/1)	LC_{90} (mg/1)	Regression equation (Y = a+b 1nX)	X^2	95% Fiducial limits LCL - UCL
			Laboratory strain		
Cx. quinquefasciatus	9.10×10^{-5}	1.03×10^{-4}	Y = 99.25+10.12 lnX	16.46*	1.00×10^{-4} - 1.05×10^{-4}
Cx. tritaeniorhynchus	1.20×10^{-6}	5.30×10^{-6}	Y = 14.76+0.86 lnX	3.66	3.79×10^{-6} - 7.40×10^{-6}
An. culicifacies	3.44×10^{-6}	9.17×10^{-6}	Y = 21.45+1.31 lnX	6.83*	7.48×10^{-6} - 1.12×10^{-5}
An. stephensi	1.37×10^{-3}	2.01×10^{-3}	Y = 26.82+3.31 lnX	13.00*	1.87×10^{-3} - 2.16×10^{-3}
Ae. aegypti	1.36×10^{-4}	2.96×10^{-4}	Y = 19.65+1.65 lnX	2.69	2.36×10^{-4} - 3.70×10^{-4}
Ae. albopictus	6.81×10^{-7}	5.66×10^{-6}	Y = 13.58+0.60 lnX	3.30	4.09×10^{-6} - 7.83×10^{-6}
			Field strain		
Cx. quinquefasciatus	4.73×10^{-5}	4.11×10^{-4}	Y = 28.05+2.40 lnX	0.27	1.02×10^{-4} - 1.29×10^{-4}
Ae. albopictus	1.57×10^{-6}	1.11×10^{-5}	Y = 13.74+0.65 lnX	0.95	7.22×10^{-6} - 1.71×10^{-5}

* - Heterogeneity.

Table 4. Larval susceptibility status of six vector mosquitoes to folithion.

Species	LC_{50} (mg/1)	LC_{90} (mg/1)	Regression equation (Y = a+b 1nX)	X^2	95% Fiducial limits LCL - UCL
			Laboratory strain		
Cx. quinquefasciatus	4.30×10^{-3}	6.93×10^{-3}	Y = 19.58+2.68 lnX	0.15	6.32×10^{-3} - 7.60×10^{-3}
Cx. tritaeniorhynchus	2.25×10^{-5}	9.09×10^{-5}	Y = 14.82+0.92 lnX	0.35	7.23×10^{-5} - 1.14×10^{-4}
An. culicifacies	1.42×10^{-3}	4.18×10^{-2}	Y = 7.48+0.38 lnX	0.11	2.39×10^{-2} - 7.28×10^{-2}
An. stephensi	7.08×10^{-2}	9.54×10^{-2}	Y = 16.35+4.28 lnX	0.15	6.32×10^{-2} - 7.60×10^{-1}
Ae. aegypti	2.57×10^{-3}	4.37×10^{-3}	Y = 19.41+2.42 lnX	0.56	4.03×10^{-3} - 4.75×10^{-3}
Ae. albopictus	2.38×10^{-5}	1.00×10^{-4}	Y = 14.46+0.89 lnX	0.80	7.90×10^{-5} - 1.28×10^{-4}
			Field strain		
Cx. quinquefasciatus	7.58×10^{-3}	1.07×10^{-2}	Y = 22.92+3.67 lnX	0.80	1.06×10^{-2} - 1.14×10^{-2}
Ae. albopictus	2.23×10^{-5}	1.77×10^{-4}	Y = 11.61+0.62 lnX	0.003	1.11×10^{-4} - 2.83×10^{-4}

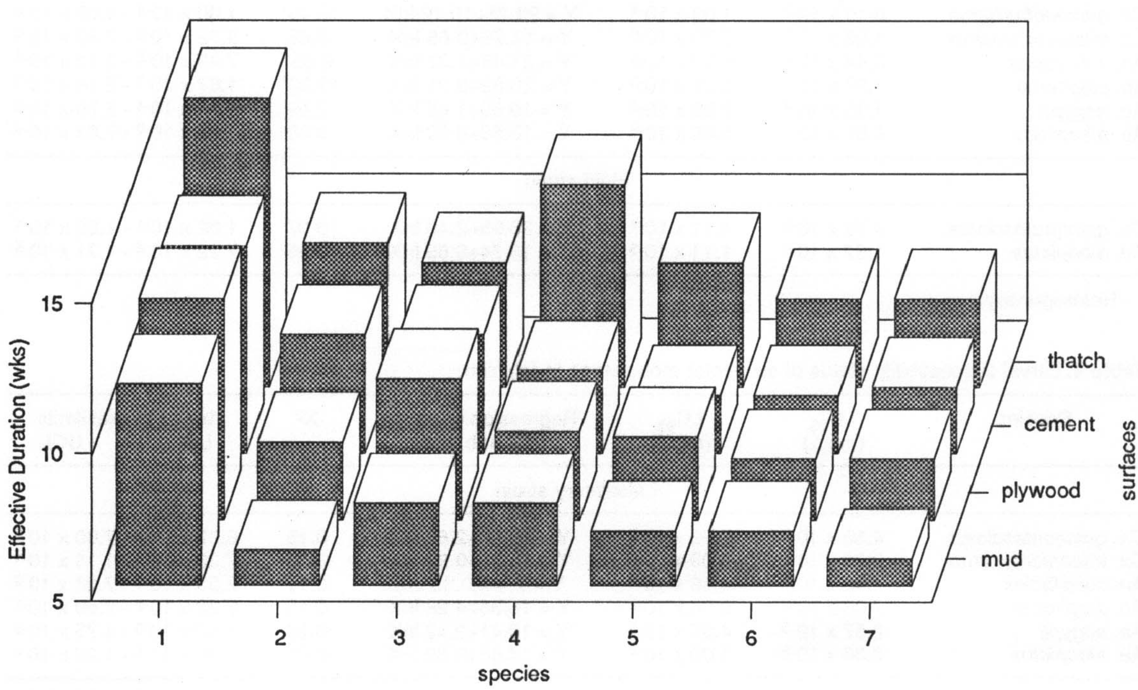
* - Heterogeneity.

tible to malathion. Conversely to this, *Ae. albopictus* resistant to folithion has been reported in Japan and the USA (Wesson[22], 1990). In the present study *An. stephensi* was found to be least susceptible to deltamethrin, temephos and folithion. Another interesting observation relates to the fact that LC_{50} values determined in the current study are considerable lower than the discriminating dosages recommended by WHO for the insecticides tested. This strongly suggests the need for determining the discriminating dose for different vector species from different areas, so that some base line data are made available for monitoring the resistance/susceptibility status of the vector mosquitoes in the field. Development of resistance cannot be detected early, if the high discriminating dosages recommended by the WHO are used.

When adults were exposed to the diagnostic doses of malathion, folithion, alphamethrin and deltamethrin recommended by WHO (1981[24]), a 100% mortality was observed in all species except *Cx. quinquefasciatus* from field to malathion (52.5%). However, adults of *Ae. albopictus* were highly susceptible to malathion with LT_{50} value of 6.65 min (Chi sq. 0.594). Earlier studies had showed that *Cx. quinquefasciatus* adults collected in the field from Pondicherry were highly susceptible to malathion (Das et al.[9], 1980). The present study has shown that *Cx. quinquefasciatus* has a potentiality to develop resistance to this O.P. compound. Malathion resistance in the adults of *Ae. albopictus* adults has been observed in Sri Lanka and Texas (Robert and Olson[20], 1990; WHO[26], 1986).

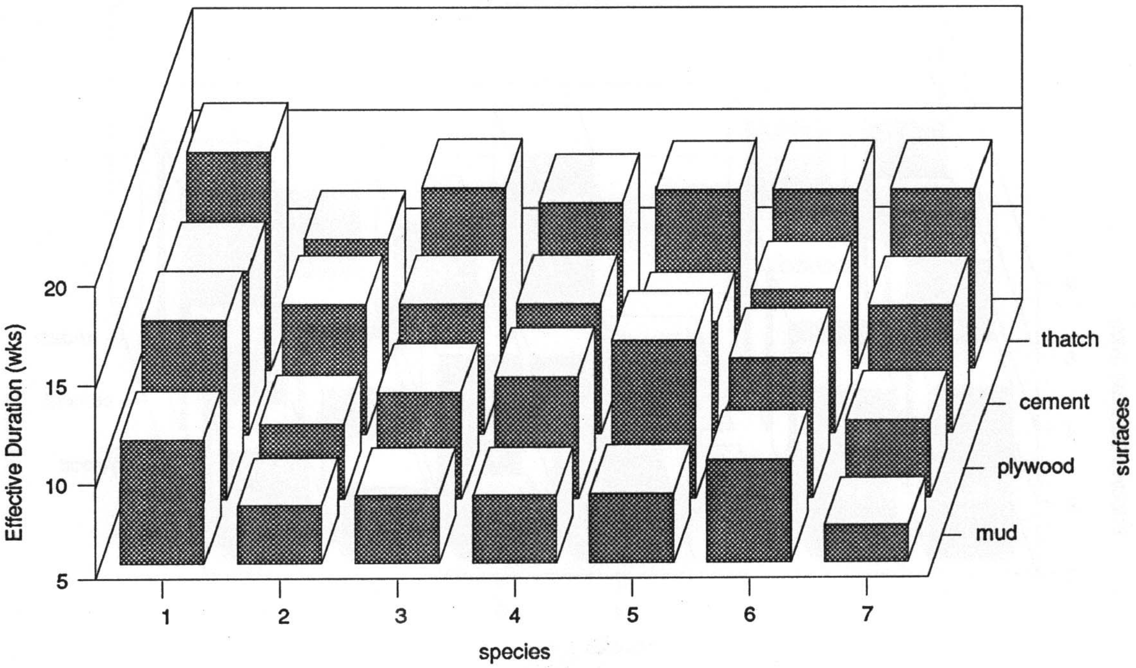
The residual effect of deltamethrin, alphamethrin, malathion and folithion at 25 mg(ai)/m² on different surfaces against six species of vector mosquitoes is presented in Fig. 1-4. In general both pyrethroid compounds, deltamethrin and alphamethrin were more effective than malathion and folithion.

As between the two synthetic pyrethroids tested, alphamethrin show the highest residual activity on all surfaces against all the mosquito species tested, in accordance with the results reported earlier (Amalraj et al[2], 1987). However, the bioassay conducted on mud, cement, thatch and plywood showed that the residual efficacy of deltamethrin and alphamethrin lasted longer (8-17 wks) on the thatched surface than on the other three surfaces. Earlier reports showed that the residual efficacy of alphamethrin tested on the same surfaces at 100 mg(ai)/m² lasted for 20 wks against *Cx. quinquefasciatus* and *An. stephensi*, but it was more effective on the cement surface (Almaraj et al.[2], 1987).



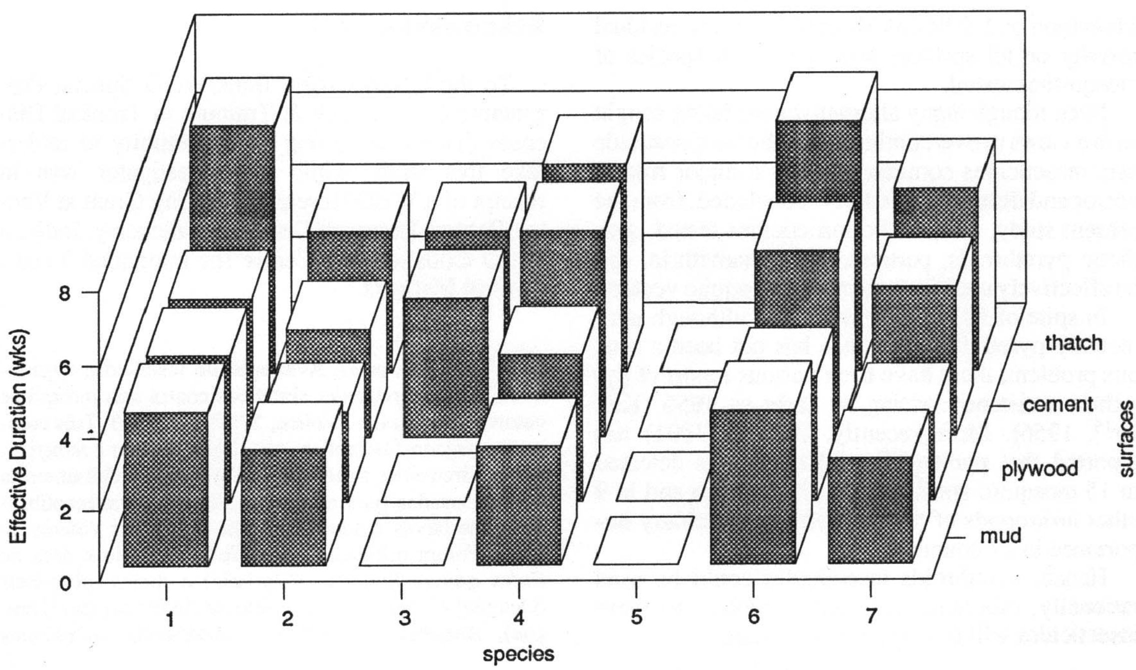
1. *Cx. quinquefasciatus* (Lab.)
2. *Cx. quinquefasciatus* (Field)
3. *An. stephensi*
4. *An. culicifacies*
5. *Ae. aegypti*
6. *Ae. albopictus*
7. *Cx. tritaeniorhynchus*

Figure 1. Residual efficacy of Deltamethrin.



1. *Cx. quinquefasciatus* (Lab.)
2. *Cx. quinquefasciatus* (Field)
3. *An. stephensi*
4. *An. culicifacies*
5. *Ae. aegypti*
6. *Ae. albopictus*
7. *Cx. tritaeniorhynchus*

Figure 2. Residual efficacy of Alphametrin.



1. *Cx. quinquefasciatus* (Lab.)
2. *Cx. quinquefasciatus* (Field)
3. *An. stephensi*
4. *An. culicifacies*
5. *Ae. aegypti*
6. *Ae. albopictus*
7. *Cx. tritaeniorhynchus*

Figure 3. Residual efficacy of Malathion.

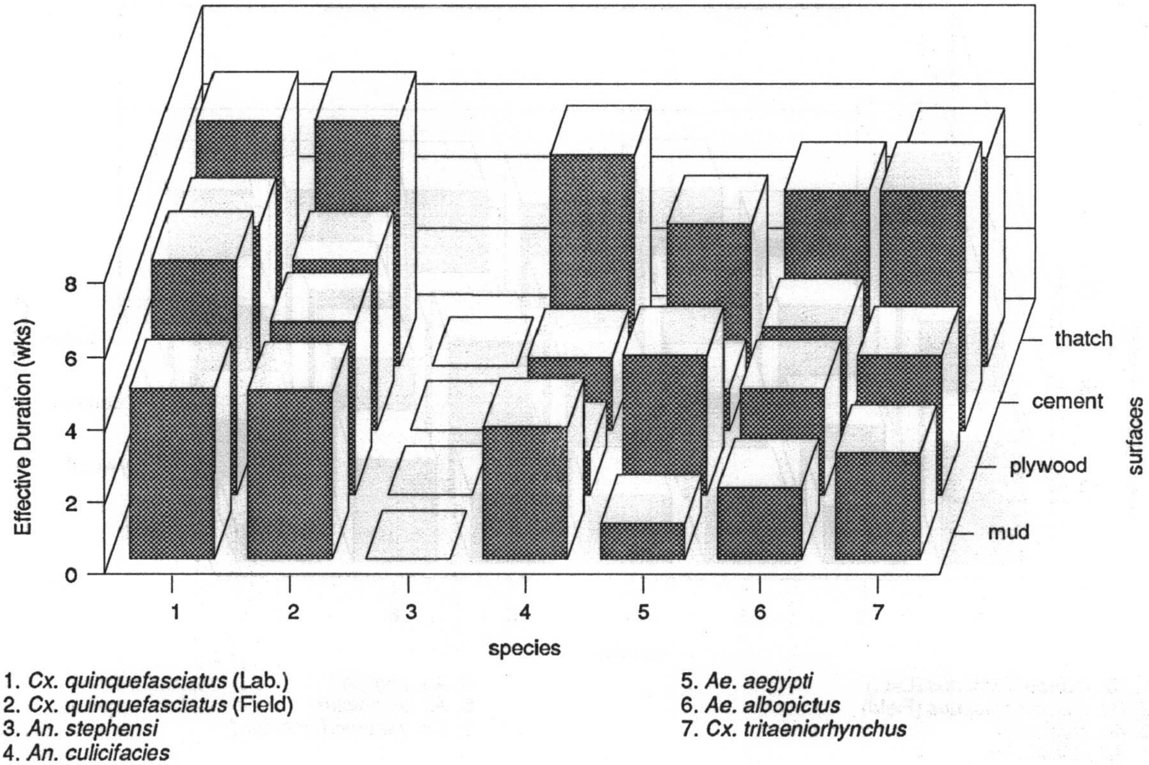


Figure 4. Residual efficacy of Folithion.

Malathion and folithion showed very low residual activity on all surfaces and against all species of mosquitoes tested.

Even though many alternatives are being sought with a views to overcoming the problem of pesticide use, insecticides continue playing a major role in vector and disease control. It is concluded, from the present study, that, of the insecticides tested, synthetic pyrethroids, particularly, alphamethrin, can be effectively used for controlling mosquito vectors.

In spite of above mentioned and although until recently pyrethroid resistance has not been a serious problem, there have been various report of pyrethrin resistance arising as early as 1956 (Keller[15], 1956). More recently, WHO[27] (1991) has reported that pyrethroids resistance was detected in 15 mosquito species from 32 countries and in 9 other arthropods of public health or veterinary importance in 27 countries.

Hence, pyrethroids insecticides could be used rationally, otherwise resistance problem to these insecticides will be appear in the future.

Acknowledgement

To the UNDP/World Bank/WHO Special Programme for Research & Training in Tropical Diseases (TDR) for giving an opportunity to undertake this study while the investigator was in receipt of a WHO Research Training Grant at Vector Control Research Centre, Pondicherry, India, a WHO Collaborating Centre for Integrated Vector Control Methods.

DORTA, D.M. et al. Avaliação de inseticidas organo-fosforados e piretroides sintéticos contra seis mosquitos vetores. *Rev. Saúde Pública*, **27**: 391-7, 1993. Três compostos organo-fosforados - *malation, folition* e *temefos* - e dois piretroides sintéticos - alfametrina e deltametrina - foram usados para controlar o estado da susceptibilidade das larvas e adultos de seis mosquitos vetores na Índia. Foram utilizadas cepas de laboratório e área de *Culex quinquefasciatus* (filariasis) e *Aedes albopictus* (Dengue) e cepas de laboratório de *Aedes aegypti* (Dengue), *Anopheles stephensi* e *Anopheles culicifacies*

(Malária) e *Culex tritaenorhynchus* (encefalite japonesa). Os valores de Cl_{50} obtidos para esses inseticidas mostram que todas as espécies incluindo as cepas de área foram muito susceptíveis. Nos mosquitos adultos das referidas espécies salvo na cepa da área de *Culex quinquefasciatus* com o *malathion*, observou-se 100% da mortalidade às doses discriminatórias recomendadas pela Organização Mundial de Saúde. O efeito residual da alfametrina, deltametrina, malation e folition a 25 mg (ai)/m^2 em diversas superfícies contra seis espécies de mosquitos vetores evidenciou que a alfametrina foi a mais efetiva em todas as superfícies tratadas (argila, "plywood", cimento e palha).

Descritores: Controle de mosquitos, métodos. Inseticidas, toxicidade. Insetos vetores.

References

1. ABBOTT, W.S. A method of computing the effectiveness of insecticides. *J. Econ. Entomol.*, **18**: 265-7, 1925.
2. ALMARAJ, D. et al. Evaluation of Alphamethrin a synthetic pyrethroid insecticidal activity aga' ıst mosquitoes. *Indian J, Med. Res.*, **86**: 601-9, 1987.
3. ARIARATNAM, V. & GEORGHIOU G.P. Carbamate resistance in *Anopheles albimanus*. penetration and metabolism of carbaryl in propoxur selected larvae. *Bull. World Health Organ.*, **53**: 91, 1975.
4. BEROZA, M. *Chemical controlling insect behaviour*. London, Academic Press, 1970.
5. BUSVINE, J.R. Development of the WHO resistance test for mosquitoes. *Indian J. Malariol.*, **12**: 279, 1958.
6. DARWAZEH, D.A. et al. Synthetic pyrethroids for the control of resistant mosquitoes in irrigated pastures. *Proc. Pap. California Mosq. Cont. Assoc.*, **46**: 121, 1978.
7. DAS, P.K. & RAJAGOPALAN, P.K. Susceptibility of larvae of *Culex fatigans* (Wiedemann). *Anopheles stephensi* (Liston) and *Aedes aegypti* (Lin) to insecticides in Pondicherry. *Indian J. Med. Res.*, **70**: 412-6, 1979.
8. DAS, P.K. & RAJAGOPALAN, P.K.Insecticides resistance in *Culex pipiens fatigans* and its relevance to vector control. *Indian J. Med. Res.*, **72**: 50, 1980.
9. DAS, P.K. et al. Insecticides susceptibility status of some mosquitoes in Pondicherry. *Indian J. Med. Res.*, **72**: 214-7, 1980.
10. DAS, P.K. & KALYANASUNDARAM, M. Evaluation of K-otrine a synthetic pyrethroid for insecticidal efficacy against mosquito vectors. *Indian J. Med. Res.*, **80**: 74-7, 1984.
11. ELLIOT, M. et al. The future of pyrethroids in insect control. *Annu Rev. Entomol.*, **23**: 443, 1978.
12. GEORGHIOU, G.P. et al. Carbamate resistance in mosquitoes: selection of *Culex pippiens fatigans* (Wiedemann) (*Cx. quinquefasciatus* says) for resistance to Baygon. *Bull. World Health Organ.*, **35**: 691, 1966.
13. GEORGHIOU, G.P. Organophosphate multiresistance in *Culex quinquefasciatus* in California. *J. Econ. Entomol.*, **65**: 461, 1973.
14. HASSALL, K.A. *The chemistry of pesticides*, London, Mac. Millan Press, 1982.
15. KELLER, J.C. et al. Susceptibility of insecticide-resistant cockroaches to pyrethrin. *Pest Control*, **24**: 14-5, 1956.
16. KOTTKUMP, W.B. et al. Efficacy of three pyrethroids as larvicides against rice and mosquito larvae in field plots. *Mosq. News*, **41**: 382, 1981.
17. MANSON-BAHR, P.E.C. & BELL, D.R. *Manson's tropical disease*. 18.ed. London, Bailliere Tindall, 1982.
18. POIESTER, T.M. et al. Toxicity of pyrethroids to organophosphate-carbamate and DDT resistant mosquitoes. *Mosquito News*, **41**: 143, 1981.
19. RAJAVEL, A.R. et al. Evaluation of a synthetic pyrethroid (Cyfluthrin) for insecticidal activity against different mosquito species. *Indian J. Med. Res.*, **5**: 168-75, 1987.
20. ROBERT L.L. & OLSON, J.K. Susceptibility of female *Aedes albopictus* from Texas to conmonly used adulticides. *J. Amer. Mosq. Control Assoc.*, **5**: 251-3, 1990.
21. SOKAL, R.R. & ROHLF, J.P. *Biometry: the principles and practice of statistics in biological research.* 2nd ed. New York, W.H. Crreamn and Co. 1981. p. 180-445.
22. WESSON, D.M. Susceptibility to organophosphate insecticides in larval *Aedes albopictus*. *J. Amer. Mosq. Control Assoc.*, **6**: 258-64, 1990.
23. WORLD HEALTH ORGANIZATION. Instructions for determining the susceptibility or resistance of adult mosquitoes to organochlorine, organophosphate and carbamate insecticides: establishment of baseline. Geneva, 1981. (WHO mimeographed document VBC/ 81.805).
24. WORLD HEALTH ORGANIZATION. Instructions for determining the susceptibility or resistance of mosquito larvae to insecticides. Geneva, 1981. (WHO mimeographed document VBC/81.807).
25. WORLD HEALTH ORGANIZATION. Instructions for the bio-assay of insecticidal deposits on wall surfaces. Geneva, 1981. (WHO mimeographed document VBC/81.5).
26. WORLD HEALTH ORGANIZATION EXPERT COMMITTEE ON VECTOR BIOLOGY AND CONTROL, Geneva, 1985. *Resistance of vectors and reservois of disease to pesticides*. Geneva, 1986 (WHO-Technical Report Series, 737).
27. WORLD HEALTH ORGANIZATION EXPERT COMMITTEE ON VECTOR BIOLOGY AND CONTROL, Geneva, 1991. *Vector resistance to pesticides*; report (WHO-Technical Report Series, 818).

Recebido para publicação em 24.11.1992
Reapresentado em 28.6.1993
Aprovado para publicação em 15.9.1993