PROPOXUR SUSCEPTIBILITY TEST OF *ANOPHELES STEPHENSI* IN SOUTHERN ISLAMIC REPUBLIC OF IRAN (1976–86)

A. V. MANOUCHEHRI AND M. R. YAGHOOBI-ERSHADI

School of Public Health and Institute of Public Health Research, Teheran University, P.O. Box 6446, Teheran 14155, Islamic Republic of Iran

ABSTRACT. In southern Iran, adults of *Anopheles stephensi*, the main vector of malaria, are resistant to DDT, dieldrin and malathion. Susceptibility tests carried out with propoxur-impregnated papers during 1976–86 in 5 villages in Minab County, showed that, despite 10 years of propoxur application twice a year in dwellings, *An. stephensi* remained susceptible to this insecticide.

INTRODUCTION

Anopheles stephensi Liston, one of the important malaria vectors on the Indian subcontinent as well as in the Persian Gulf areas, is widespread through the Indian peninsula from the extreme northwest to the extreme south and east (Krishnan 1961, Bruce-Chwatt 1985). It has been recorded from India, China, Thailand, Burma, Pakistan, Afghanistan, Iraq, Iran, Bahrein, Oman and Saudi Arabia (Knight and Stone 1977, Zahar 1974).

In Iran, it occurs on the southern slopes of the Zagros chain up to 900 m altitude in Khuzistan, Fars, Kerman, Hormozgan, Baluchistan and southern Bakhtaran provinces (Manouchehri et al. 1976a). This species is known to be mainly endophilic in our country. Resistance to DDT in this species was first recognized in 1957 (Mofidi et al. 1958) and subsequently to dieldrin in 1960 (Mofidi and Samimi 1960) and to malathion in 1976 (Manouchehri et al. 1976). Propoxur house spraying, 50% WP 2 g/m^2, a regime of 2 rounds per year has been implemented since 1977 in Hormozgan Province (Manouchehri et al. 1976b) and up to April 1986, 18 rounds of spraying with this insecticide have been completed.

Globally, as of 1986, 14 species of anophelines have developed field populations resistant to carbamates, largely due to agricultural applications (World Health Organization 1986, Brown 1986). Because the frequent application of propoxur may have a reverse effect on malaria

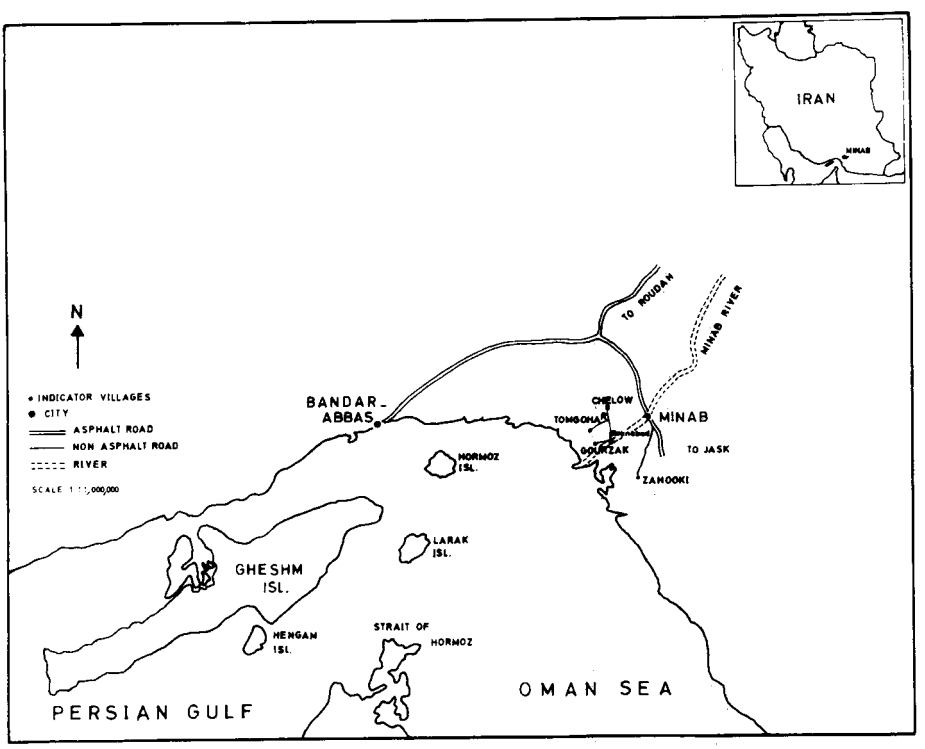

Fig. 1. Map of southern Iran showing location of susceptibility tests.

Table 1. Results of propoxur susceptibility tests on *Anopheles stephensi* in Minab County, southern Iran (1976–86).

Village	Date	Spraying cycle	Temp. Min.–max. °C	% RH*	% mortality after following minutes, 24 hours recovery									
					Control	5	7	10	12	15	20	30	60	LT50
Roknabad	Apr. 1976	—	25.5–31	65	0.9 (103)	26.4 (106)	—	69.2 (104)	—	97 (103)	—	99 (103)	—	7.6
Zahooki	Apr. 1976	—	26–32	68	0 (106)	30 (113)	—	59.8 (102)	—	95.3 (107)	—	100 (104)	—	7.8
Chelow	Nov. 1976	—	24–35	65	0 (95)	7 (99)	—	27 (96)	—	55 (93)	—	100 (98)	—	14
Chelow	Mar. 1980	8 Propoxur	21–28.5	75	0 (160)	52.09 (22)	—	81.8 (44)	—	84.4 (45)	—	96.7 (104)	100 (191)	5.7
Chelow	Apr. 1982	10 Propoxur	22–34	65	1 (100)	0.9 (101)	—	47 (100)	—	74.3 (105)	97 (100)	100 (174)	100 (260)	11.01
Gourzank	Apr. 1983	12 Propoxur	23–36	75	0 (270)	2.7 (74)	—	40.8 (98)	—	90 (100)	—	100 (152)	100 (193)	11.1
Chelow	Apr. 1984	14 Propoxur	26–34	58	0.9 (105)	21.5 (93)	—	86.5 (89)	—	98.4 (128)	—	100 (94)	100 (100)	7.5
Roknabad	Apr. 1985	16 Propoxur	24–37	65	0 (52)	2.9 (68)	—	41.3 (92)	48.7 (76)	95 (60)	98.4 (62)	100 (93)	100 (91)	11.2
Roknabad	Apr. 1986	18 Propoxur	23–32	72	0 (260)	—	61.8 (136)	73.3 (131)	91.7 (144)	95.3 (129)	—	99.3 (152)	—	5.9
Tomgohar	Apr. 1986	18 Propoxur	25–32	75	0 (51)	22.9 (131)	—	—	—	—	—	100 (69)	100 (135)	—

* R.H. = Relative humidity.

Figures in parentheses are numbers of mosquitoes tested. Before 1976, the area was sprayed with DDT, dieldrin and malathion, 11, 4 and 20 rounds, respectively.

control, the susceptibility level of *An. stephensi* to propoxur has been checked regularly by the Bandar-Abbas Medical Research Station, School of Public Health.

MATERIALS AND METHODS

The susceptibility tests were carried out in 5 villages of Minab County, Hormozgan Province, southern Iran, where *An. stephensi* was first recorded to be resistant to DDT, dieldrin and malathion. These villages are located about 11–20 km from the coast of the Oman Sea and about 120 km from the city of Bandar-Abbas (Fig. 1).

In order to build up the population of *An. stephensi* for performing the susceptibility tests, it was requested that the malaria control unit delay the propoxur application in the tested villages and a surrounding 3 km radius for a month every year at the beginning of spraying which is coincident with the start of the seasonal activity of *An. stephensi* in the area. It should be mentioned that the probability for malaria transmission in March and April is very low. All tests were carried out using a field population of blood-fed female *An. stephensi* collected from indoor resting places between 0600 and 1000 hours. The mosquitoes to be tested were caught by aspirator tube and were kept in paper cups during the transport to the laboratory. Sufficient relative humidity was assured by placing small pieces of cotton wool impregnated with water on the top of the cups. The method used for the test was that recommended by the World Health Organization (1981). Papers impregnated with propoxur at the concentration of 0.1% were supplied by WHO. Papers treated with olive oil only were used for the controls. The multiple exposure times were 5, 7, 10, 12, 15, 20, 30 and 60 minutes. The mosquitoes were transferred to clean holding tubes after exposure to the toxicant and the percentage mortality was determined 24 hours later. All observed mortalities were corrected by Abbott's formula, when necessary (Abbott 1925).

RESULTS AND DISCUSSION

As Table 1 shows, 0.1% propoxur killed 100% of mosquitoes tested after the one hour exposure and the 24 hour recovery period. When mosquitoes were exposed to 0.1% propoxur for 30 minutes, the percentage mortalities were between 96.7 and 100%. The observed percentage mortalities of this species to this test exposure in 1976 (before application of propoxur) and in 1986 (after 10 years of propoxur application) were 99.3 and 99%, respectively, in the village of Roknabad. The estimated LT_{50} in Minab County was between 7.6 and 14 minutes in 1976. The same figures after 10 years of propoxur application were observed to be between 5.7 and 11.2 minutes. Our conclusion is that after 10 years of propoxur trials in the southern parts of Islamic Republic of Iran, *An. stephensi* is still susceptible to this insecticide. In order to forecast the possibility of resistance to propoxur in *An. stephensi* much as has been done for malathion resistance in this species (Manouchehri et al. 1976b), a study is under way to place *An. stephensi* under selection pressure with propoxur in our laboratory at Teheran University, which is out of the distribution range of this vector species.

In the recent tabulations on the resistance of mosquitoes to insecticides (Brown 1986, World Health Organization 1986), the Islamic Republic of Iran has been included among the countries in which *An. stephensi* has shown resistance to propoxur. The only organization that follows the susceptibility level of mosquitoes to insecticides in this country is the Department of Medical Entomology and Vector Control, School of Public Health, University of Teheran and it found no evidence for propoxur resistance in the field. Our observations reported here show that in spite of 10 years of propoxur application at the rate of 2 g/m^2, twice a year in the Minab area, where this insecticide is used only for controlling adult anophelines and where there is no record of the use of carbamate insecticides for agricultural pest control, *An. stephensi* is still susceptible to propoxur.

ACKNOWLEDGMENTS

We wish to express our thanks to the staff of the Bandar-Abbas Medical Research Station for their help during these studies. We are indebted to the local authorities of the Malaria Eradication Unit of Hormozgan province for their sincere cooperation in this program.

REFERENCES CITED

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18:265–267.

Bruce-Chwatt, L. J. 1985. Essential malariology. Second ed. William Heinemann, London. 452 pp.

Brown, A. W. A. 1986. Insecticide resistance in mosquitoes: A pragmatic review. J. Am. Mosq. Control Assoc. 2:123–140.

Krishnan, K. S. 1961. Vectors of malaria in India, Second ed. National Society of India for Malaria and Other Mosquito-borne Disease, Delhi.

Knight, K. L. and A. Stone, 1977. A catalog of the mosquitoes of the world. Thomas Say Foundation. Vol. 6, 611 pp.

Mofidi, Ch., B. Samimi, N. Eshghi and M. Ghiassedin. 1958. Further studies of anopheline susceptibility to

insecticide in Iran, result of Busvine and Nash Method, Inst. Parasit. and Malariology. Teheran, Iran. Publ. no. 585/7.

Mofidi, Ch. and B. Samimi. 1960. Resistance of *An. stephensi* to dieldrin, Inst. Parasit. and Malariology, Teheran, Iran, Publ. no. 650, 3-4.

Manouchehri, A. V., E. Javadian, N. Eshghi and M. Motabar. 1976a. Ecology of *Anopheles stephensi* Liston in southern Iran. Trop. Geogr. Med. 28:41–44.

Manouchehri, A. V., B. Djanbakhsh and F. Rouhani. 1976b. Studies on the resistance of *Anopheles stephensi* to malathion in Bandar-Abbas, Iran. Mosq. News 36:320–322.

Manouchehri, A. V. and M. R. Yaghoobi-Ershadi. 1985. A large scale propoxur trial against *Anopheles stephensi* Liston in Hormozgan province, southern Iran. J. Entomol. Soc. Iran (in press).

World Health Organization. 1970. Insecticide resistance and vector control. 17th Report of the W.H.O. Expert Committee on Insecticides. Tech. Rep. Ser. 443:47–65.

World Health Organization. 1981. Instructions for determining the susceptibility of resistance of adult mosquitoes to organochlorine, organophosphate and carbamate insecticides established of the base-line. WHO/VBC/81/805.

World Health Organization. 1986. Resistance of vectors and reservoirs of disease to pesticides. Tenth report of the W.H.O. Expert Committee on Vector Biology and Control. W.H.O. Tech. Rep. Ser. 737:75–78.

Zahar, A. R. 1974. Review of the ecology of malaria vectors in the WHO Eastern Mediterranean Region. Bull. W.H.O. 50:427–440.