INSECTICIDE RESISTANCE OF *ANOPHELES STEPHENSI MYSORENSIS* IN THE PROVINCE OF FARS, SOUTHERN IRAN, 1975[1]

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ABSTRACT. *Anopheles stephensi,* the main vector of malaria in the province of Fars, southern Iran, is resistant to DDT and dieldrin. Resistance to DDT was first recognized in 1957 and then to dieldrin in 1960.

Since 1968 this species has been under pressure of malathion house spraying, 50% w.d.p., 2g/m², 1–2 rounds per year. In recent years, agricultural pesticides such as malathion and carbamates are commonly used on a number of crops.

Tests carried out with malathion-impregnated papers during 1975 showed a change in the susceptibility level of *A. stephensi.*

The object of the present paper is to summarize and discuss briefly the field investigations concerning insecticide resistance in *A. stephensi.*

INTRODUCTION. *Anopheles stephensi mysorensis,* the main vector of malaria in south of Iran, is known to be largely endophilic. 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). Due to double resistance of *A. stephensi,* residual house spraying was discontinued from 1961 until 1967. Thereafter, several promising compounds for the control of mosquitoes have been evaluated, and malathion was found to be a readily available and convenient insecticide for use in the malaria eradication program (Manouchehri et al. 1972).

Malathion house spraying, 50% w.d.p. 2g/m², has been implemented 1 to 2 rounds per annum since 1968 and has resulted in the approximate control of *A. stephensi* on the littoral plain. In the foothill and mountainous area, where the activity of *A. stephensi* was reduced, other secondary vectors such as *A. dthali, A superpictus* and *A. fluviatilis* that normally are susceptible to DDT and dieldrin were still active.

The frequency of application of malathion may increase the possibility of development of tolerance or resistance of *A. stephensi.* It was noted that agricultural insecticides are commonly used on a number of crops. Malathion has been employed in the rice fields since 1972, while DDT, toxaphene and lindane have been employed in the sugar beet and cotton fields since 1971. In recent years, carbamates, notably carbaryl, have come into use against date palm pests.

Resistance to organophosphorous and carbamate compounds has been observed in *A. albimanus* in south America (Georghiou 1972; Georghiou et al. 1972). However, the frequent application of malathion may have a reverse effect on malaria control in this area. The susceptibility level of *A. stephensi* to DDT, dieldrin, and malathion has been checked regularly by the Kazeroun Medical Research Station.

MATERIALS AND METHODS. All tests were carried out using a field population of adult female *A. stephensi* collected from indoor resting places between 06.00 and 08.00 hours. The mosquitoes used were blood fed and caught by an aspirator tube.

The method used in testing is that developed by the World Health Organization (WHO 1963, 1970). Paper impregnated with DDT, dieldrin and malathion was used at a given concentration and was provided by WHO. For the controls, paper impregnated with Risella oil alone was used.

The exposure time to the impregnated

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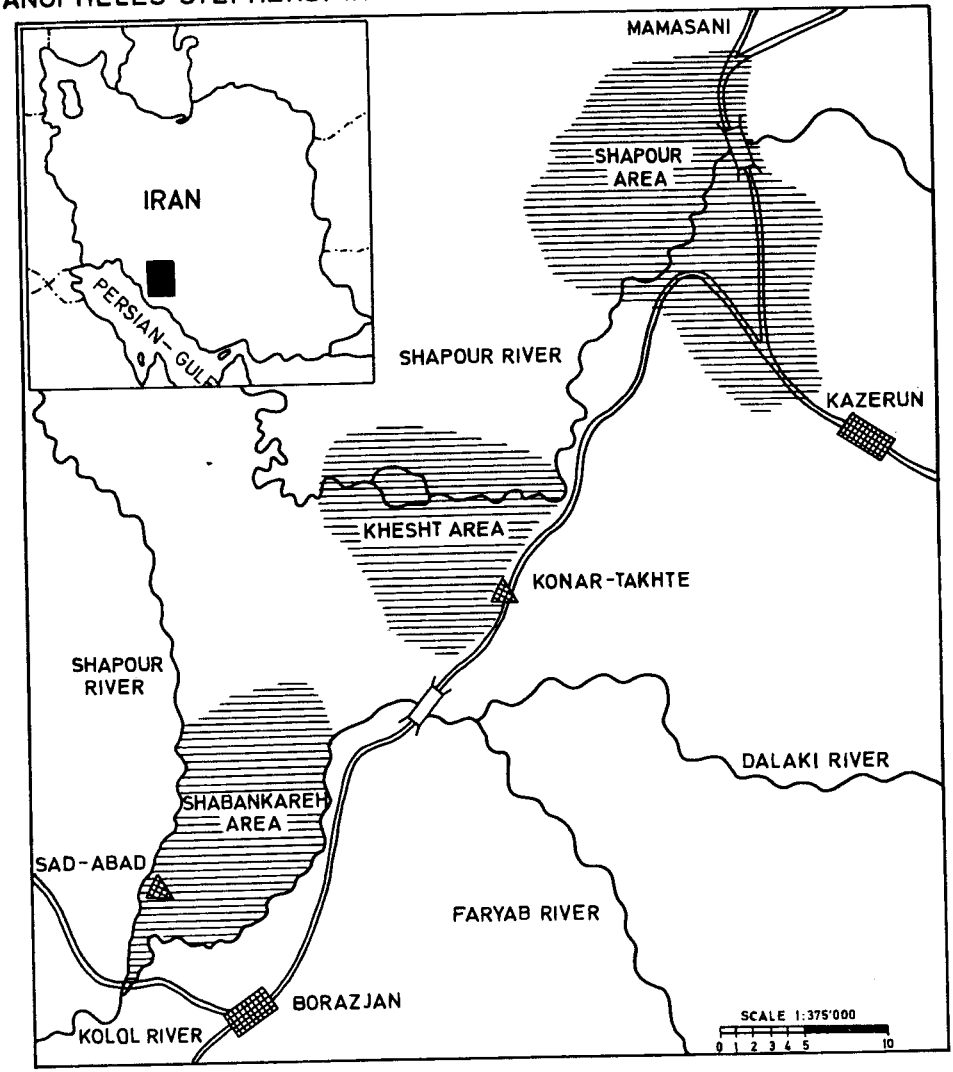
paper with malathion at concentrations of 0.5, 3.2 and 5.0% lasted 1 hr, and after a 24-hr recovery period, the mortality count was made. The exposure time to the impregnated paper with DDT and dieldrin at concentration of 4.0% was 1 hr and even prolonged for 4 hr.

OBSERVATION AREA. The susceptibility tests were carried out in different localities of the province of Fars, southern Iran. The villages of Tol-kharaki and Chamdarvahi in Shabankareh area, Borazjan shahrestan (county), 180 m above sea level are located 80 km north of the Persian Gulf. The village of Shah-davood in the Khesht area with 550 m altitude and the villages of Rashan-abad and Dashiabad with 850 m altitude in the Shapour

MAP SHOWING THE STUDY SITES OF INSECTICIDE RESISTANCE ON ANOPHELES STEPHENSI IN THE PROVINCE OF FARS, SOUTHERN IRAN



area, Kazeroun shahrestan (county) have a distance between 140 to 200 km from the Persian Gulf. The villages of Gaw-shakhi, Dimemeal and Kooshkak in the Mamasani area (north of Kazeroun), 900 m above sea-level are located 260 km north of the Persian Gulf, (see map of area).

RESULTS AND DISCUSSION. *A. stephensi* in Iran is resistant to DDT and dieldrin. Before the development of resistance, the LC_{50} of DDT was 0.9% to 1.1% and 0.08% to 0.32% for dieldrin. Tests carried out during 1973–75 confirmed a high level of resistance to DDT and dieldrin.

The average mortality obtained with exposure ot 4.0% DDT for 1 hr, followed by a 24-hr recovery period was zero percent and with a prolonged exposure to 4.0% DDT for 4 hr was between 11.7 to 20.8% in the villages of Tol-kharaki and Cham-darvahi in Borazjan County in 1975.

In tests carried out in the villages of Shah-davood, Rashan-abad and Dashi-abad in Kazeroun county with 4.0% DDT and 1 hr exposure, followed by 24 hr recovery, the mortality rate was observed to be between 1.2 and 10.8% and with 4 hours exposure between 6.1 to 16.8% during 1973–75.

Exposure to 4.0% DDT for 4 hr in the villages of Gawshakhi, Dimemeal and Kooshkak in Mamasani county showed the mortalities between 8.9 to 39.3% during 1972–75.

Susceptibility tests with 4.0% dieldrin paper and 1 hr exposure showed 11.5, 31.6, 19.3 and 19.5% mortality in the villages of Tol-kharaki, Cham-darvahi, Rashan-abad and Kooshkak in 1975. When the time of exposure was increased to 4 hr, the mortalities were observed to be between 26.6 to 45.7% in 1975.

The base-line data collected just prior to starting malathion spraying for control of *A. stephensi* in Chelow village, Minab county, southern Iran (October 1964) showed that the discriminating dosage that kills 100% of this species was 3.2% malathion, 1 hr exposure, 24 hr recovery (Shahgudian et al. 1965).

Tests carried out in April–May 1975 in the villages of Tol-Kharaki and Cham-darvahi in Borazjan county showed a tolerance to malathion. The percentage mortality with 3.2% malathion paper and 1 hr exposure was observed to be between 35.1 to 78.6% and with 5.0% malathion the mortality was 98.9%.

The mosquitoes tested during 1973–74 in the same villages of Tol-kharaki and Cham-darvahi, were found susceptible to malathion.

In susceptibility tests carried out with 3.2% and 5.0% malathion papers and 1 hr exposure the mortalities were observed to be between 91.6–100% and 100% respectively.

In tests made in 1975 in the villages of Rashan-abad and Kooshkak with 3.2% malathion and 1 hr exposure the mortalities were observed to be between 91.5–90.7% and with 5.0% malathion between 97.9–100%.

In susceptibility tests carried out during 1973–74 in those villages located in Kazeroun and Mamasani Counties, the mortality with 3.2–5.0% malathion and 1 hr exposure followed by a 24 hr recovery was observed to be between 96.4–100% and 100% respectively.

With regard to the 0.1% and 1.0% fenitrothion (OMS–43) papers, a study was made as base-line data in the villages of Bakesh-dodangeh and Shir-spary in the Mamasani county in August 1972. The range of mortality after 0.5 hr exposure followed by a 24-hr recovery period was observed to be between 0.0% to 2.0% and 99.2% to 100% respectively, and with 1 hr exposure between 0.7% to 5.8% and 100%, respectively.

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EXPERIMENTAL RELEASE OF A MERMITHID NEMATODE TO CONTROL FLOODWATER MOSQUITOES IN LOUISIANA [1]

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ABSTRACT. Cultures containing the mermithid nematode *Reesimermis nielseni* were introduced into habitats of floodwater mosquitoes in Louisiana as a pre-hatch treatment. Significant levels of parasitism were achieved when cultures were placed in damp habitats that possessed adequate amounts of vegetation or organic debris and were subjected to minimum flushing action when flooded.

Fifty-two percent of *Aedes atlanticus*, 59% of *A. tormentor*, 38% of *Psorophora columbiae*, and 51% of *P. howardii* were parasitized in 39 larval collections from 13 habitats. *Reesimermis nielseni* was observed to penetrate but failed to develop in larvae of *Psorophora ferox*.

Reesimermis nielseni Tsai and Grundmann, a nematode parasite of larval mosquitoes, has been experimentally released in semipermanent and permanent water breeding sites. High levels of parasitism were achieved, and the nematode exhibited a strong propensity for establishment and recycling (Petersen et al. 1972, Petersen and Willis 1972a, 1974, and 1975). Also, *Reesimermis nielseni* was found naturally parasitizing large numbers of *Psorophora columbiae* Dyar and Knab (=*confinnis*), *Aedes atlanticus* Dyar and Knab, and *Aedes tormentor* Dyar and Knab in semipermanent breeding sites when water levels fluctuated sufficiently to produce these species (Petersen et al. 1968, Petersen and Willis 1971). When *R. nielseni* was introduced into breeding sites of *Anopheles crucians* Wiedemann, 50–100% of the *A. atlanticus*, *A. vexans* (Meigen), *A. tormentor*, and *P. columbiae* in the site were parasitized (Petersen and Willis 1972a).

Since floodwater mosquitoes generally develop rapidly and are most susceptible to *R. nielseni* in the 1st and 2nd instars, *R. nielseni* must be applied to breeding sites within 24 hr after hatching of the host. Thus, the use of this parasite as a posthatch treatment is often impractical. A study was therefore made to determine the potential of *R. nielseni* in the control of floodwater mosquitoes when the parasite was introduced into temporary breeding sites as a pre-hatch treatment.

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