VILLAGE SCALE TRIAL OF BENDIOCARB (FICAM W) FOR THE CONTROL OF *ANOPHELES STEPHENSI* IN MAMASANI, SOUTHERN IRAN, 1978[1]

N. ESHGHY, M. MOTABAR AND B. JANBAKHSH

Department of Environmental Health, School of Public Health, University of Teheran, P. O. Box 1310, Teheran, Iran

ABSTRACT. A field trial of bendiocarb (Ficam W) at village scale was carried out in the Mamasani area in southern Iran, from May to October, 1978. *Anopheles stephensi* is resistant to DDT and dieldrin. Since 1968 this species has been under pressure of malathion house spraying, 50% w.d.p., 2g/m², 1–2 rounds per year. The village scale trial with bendiocarb was conducted with 1 round of spraying at dosage rate of 400 mg/m² of a.i. in July in a group of villages. It was concluded that bendiocarb is an effective insecticide against *An. stephensi.*

INTRODUCTION

The WHO programme for evaluation and testing of candidate insecticides provides 7 stages of evaluation, each succeeding stage having more exacting criteria for measuring effectiveness. The Stage V trial is concerned with the entomological evaluation of the insecticide against natural populations of mosquitoes in villages or groups of villages being sprayed with candidate pesticides, and consideration is given to the toxicological assessment (WHO 1967). In view of this, a WHO type expanded Stage V village scale trial of bendiocarb (2,2-dimethyl-1, 3-benzodioxol-4-yl n-methyl carbamate) formulated as an 80% w.d.p. (Ficam W) was evaluated during 1978 in the Mamasani area, southern Iran. The main objective of this trial was to assess the impact of insecticide treatment on the overall local anopheline population, special attention being given to *Anopheles stephensi,* the main vector of the area.

The technical difficulties encountered in the area related to malaria are resistance of *An. stephensi* to DDT and dieldrin, the exophilic and exophagic habits of *An. dthali, An. fluviatilis* and *An. superpictus* and the outdoor sleeping habits of inhabitants.

Resistance in *An. stephensi* to DDT was first recognized in 1957 and to dieldrin in 1960 (Janbakhsh et al. 1976). Since 1968 this species has been under pressure of malathion house spraying, 50% w.d.p., 2g/m², 1–2 rounds per year. The frequency of application of malathion has increased the possibility of development of tolerance or resistance of *An. stephensi* (Eshghy and Janbakhsh 1976). Therefore, having available other insecticides for the control of mosquitoes is always of vital importance.

One round of intradomiciliary residual spraying of bendiocarb was carried out at a selected group of villages with an 80% w.d.p. formulation at a target dosage of 400 mg/m² of a.i. (active ingredient). The insecticide was compared with a check village sprayed with malathion 50% w.d.p. applied as a residual treatment at the rate of 2g/m². The Stage V village-scale trial with bendiocarb was conducted from May to October 1978 with 1 round of spraying in July. The main larval breeding places are rice fields, canals and river banks. Due to seasonal rice cultivation in July, an increase in anopheline density occurs every year in this area.

MATERIALS AND METHODS

TRIAL AREA. The area is located on the

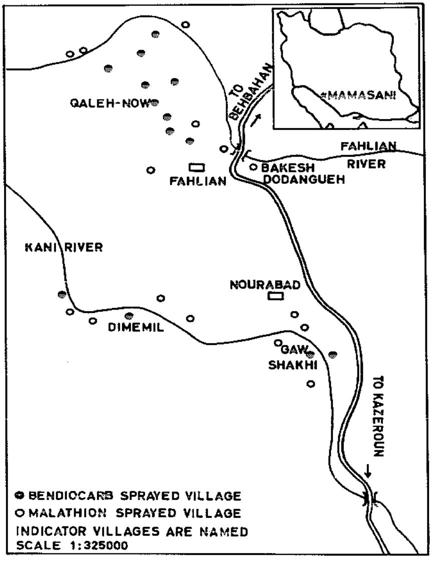
[1] This study was jointly carried out by the School of Public Health and Institute of Public Health Research of the University of Teheran and the Malaria Eradication Organization of the Ministry of Health. The study received material and financial support from Fisons Limited, England.

southern slopes of the Zagros Mountains and has a sub-tropical climate. The average maximum temperature is 40°C in July–August. The winters are mild, and the temperature rarely drops below zero. The relative humidity varies from 30–50% except on rainy days. The dwellings are built of sun-dried bricks covered with mud. The bendiocarb area (see map) comprised 13 villages with 4290 inhabitants. The bendiocarb treated villages were situated in an otherwise malathion sprayed area, and breeding places were therefore often shared by both malathion and bendiocarb treated villages. Three of the villages; Gawshakhi, Dime-mil and Qaleh-now were selected as indicator villages, and Bakesh-dodangueh served as a malathion check village for comparison.

METHOD OF ENTOMOLOGICAL EVALUATION. Entomological studies at 15-day intervals were conducted in both bendiocarb and malathion treated areas as follows:

1. Pyrethrum spray collections were made at 8 fixed capture stations in each indicator village. 2. Floor sheet collection—the number of dead mosquitoes found on sheets spread overnight on the floor of 2 rooms was counted in each indicator village. 3. Window trap collection—a total of 16 exit traps was installed in a number of houses in indicator villages, 4 window traps per village, and live specimens were observed for 24-hr mortality. 4. Shelter pit collection—16 artificial pits were established in both bendiocarb and malathion indicator villages; 4 shelter pits per village. 5. Night biting collections on human and animal bait were carried out at fortnightly intervals. 6. Vector age determination was assessed by the ovary dissection of females by the Detinova's method (1962). 7. Larval collections were made to obtain additional evidence of the continuing mosquito populations. 8. Biological evaluation—Bioassay tests on sorbent and non-sorbent surfaces of sprayed houses at 30-min exposure with

MAP SHOWING OPERATIONAL AREA TREATED WITH BENDIOCARB AND MALATHION, MAMASANI, SOUTHERN IRAN



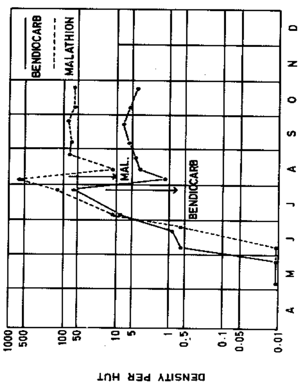


FIG. 1
INDOOR DENSITY OF ANOPHELES STEPHENSI IN BENDIOCARB AND MALATHION TREATED VILLAGES, MAMASANI, SOUTHERN IRAN, 1978

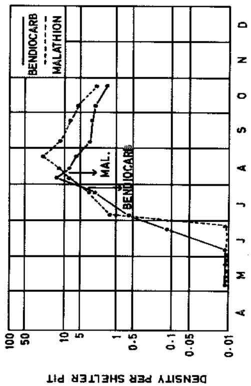


FIG. 2
SHELTER PIT COLLECTIONS OF ANOPHELES STEPHENSI IN BENDIOCARB AND MALATHION TREATED VILLAGES, MAMASANI, SOUTHERN IRAN, 1978

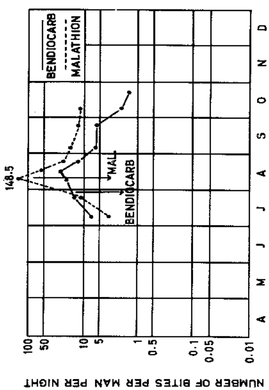


FIG. 3
NIGHT BITING CATCHES ON HUMAN BAIT IN BENDIOCARB AND MALATHION TREATED VILLAGES, MAMASANI, SOUTHERN IRAN, 1978

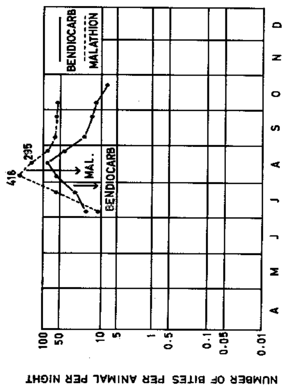


FIG. 4
NIGHT BITING CATCHES ON ANIMAL BAIT IN BENDIOCARB AND MALATHION TREATED VILLAGES, MAMASANI, SOUTHERN IRAN, 1978

laboratory reared *An. stephensi,* also bioassay of the airborne effect of bendiocarb sprayed on the interiors of houses. Bioassay tests were conducted according to the recommendation of WHO (1970). 9. Susceptibility tests, using the World Health Organization technique (WHO 1970) were conducted. Papers provided by WHO, impregnated with DDT, dieldrin, malathion and propoxur were used.

RESULTS AND DISCUSSION

An 80% w.d.p. formulation of bendiocarb was used in the present expanded Stage V village scale trial to evaluate the effectiveness of this chemical against *An. stephensi,* the main malaria vector in the area. The insecticide showed a satisfactory impact on hut resting *An. stephensi* for at least 3 months after spraying. Overall mean reduction by 1 round of spraying was 93.2% for *An. stephensi,* based on the room density immediately before spraying (Figs. 1–4).

Morning resting densities were measured from 7.00 hr to 10.00 hr Pyrethrum spray collections of *An. stephensi* from houses in the 3 indicator villages just before bendiocarb house spraying totalled 1552 females and 106 males. Mean *An. stephensi* hut resting density in the 3 indicator villages was 64.7 in the 2nd half of July before the spraying operations. The number of half-gravid and gravid females was 476 (30.7%) and 402 (25.9%) respectively.

The indoor density for *An. dthali* was low; a total of 40 females and 3 males was collected prior to spraying. The density was 1.6 per hut. Mean *An. fluviatilis* and *An. superpictus* hut resting densities were nil or near zero in the evaluation villages. For 90 days after the bendiocarb application the density of *An. stephensi* was reduced to between 1.3–6.2 per hut. During August–October, from a total collection of 639 females and 415 males *An. stephensi,* the number of half-gravid and gravid was 20 (3.1%) and 6 (0.9%) respectively. In the 1st half of August, the mean *An. stephensi* density before malathion spraying in the check village of Bakesh-dodangueh, was 744.1 per indoor shelter. From a total collection of 5953 *An. stephensi,* the number of half-gravid and gravid were 1047 (17.6%) and 903 (15.1%) respectively. After malathion application the density ranged between 14–80.8 per shelter during August–October.

Adult anopheline collections were carried out in artificial pit shelters before and after bendiocarb application. The maximum density observed was 3.1 per pit shelter before the house spraying operation. The number of empty, blood fed, half-gravid and gravid females was 24 (63.1%), 8 (21.1%), 5 (13.1%) and 1 (2.7%) respectively. After the bendiocarb spraying the density of *An. stephensi* per pit shelter ranged between 17.4 and 3.1 from the 1st half of August to October.

In the malathion treated check village, the average density per shelter pit was 9.2 before malathion application and ranged from 23.7 to 5.7 after spraying. Due to extensive breeding areas and high larval density, appreciable numbers of *An. stephensi* were collected in shelter pits. This may also be associated with the outdoor sleeping habits of the people, and the practice of keeping animals outdoors during the hot season.

Exit trap observations were carried out 3 times during the pre-spray period of bendiocarb, and 132 *An. stephensi* females were collected, with an average mortality of 9.5, 12.2 and 5.7% after a 24 hr observation period. After house spraying, the mosquitoes captured in exit traps were kept for observation and the mortality decreased from 100 to 40%, 90 days after spraying. Among the collected mosquitoes, no later stages of blood digestion were seen. Before malathion spraying, 159 *An. stephensi* were collected in exit traps in the check village of Bakesh-dodangueh with an average mortality rate of 13.3–8.4%. After the malathion application, 195 *An. stephensi* were collected during 75 days and the mortality rate decreased from 47 to 13.6%.

During the 90 days after spraying with

bendiocarb, 2316 dead *An. stephensi* females plus 517 males were collected on 42 floor sheets spread overnight on the floor. The number dead per floor sheet per room decreased from 302.3 to 5.6 during this period. The finding of dead mosquitoes on floor sheets indicates that bendiocarb chemical contact was still lethal to these mosquitoes. A smaller mortality of mosquitoes was observed in the malathion treated check village. The number of dead per floor sheet per room decreased from 17 to zero during the 60 days after spraying.

The main larval breeding places of *An. stephensi* are rice fields, canals and river banks. Larval collections were made from various breeding habitats. Due to seasonal rice cultivation activity in July and the consequent increase in area of larval breeding places, a remarkable increase in number of larvae was observed.

Fortnightly *An. stephensi* outdoor man and animal biting catches were performed in both Dime-mil, the bendiocarb treated village and Bakesh-dodangueh, the malathion treated village. Four local people with exposed arms, faces and feet served as bait. Two catchers were on duty for 2 to 3 hr at a time, throughout the night. Catches on human and animal bait were carried out from 18.00–05.00 hr outdoors. During the pre-spraying period, the mean night biting collections ranged from 8.7 to 15.5 per night per bait on man, and 24 to 29.5 on animals in the bendiocarb treated village. During this period 4 to 148.5 per night per bait were caught on man and 10 to 418 on animals in the malathion treated village.

During the 90 days after bendiocarb spray application, the number of bites per bait per night on man ranged from 27.5 to 3.2 on man and 99 to 13.3 on animals. In the malathion treated area, it was from 49 to 12 on man and from 295 to 51.5 on animals during 75 days after spraying. Observations were made outdoors as well as indoors on the prevailing human resting and sleeping habits.

Parous rate determinations were made on indoor resting samples. In the pre-bendiocarb spray period, 422 *An. stephensi* were dissected and the mean parous rate was 53.8%. Before malathion application the results of ovary dissections on 358 *An. stephensi* collected from indoor resting sites showed a parous rate of 57.8%. After spraying, the mean *An. stephensi* parous rates in the bendiocarb treated villages were consistently lower than the rates before spraying, and noticeably lower than the rates in the check malathion treated village during the post spray period. During the 75 days after bendiocarb application, of 622 dissected, the parous rate ranged between 3.8–13.6%. During 60 days after the malathion spraying operations, 650 *An. stephensi* were dissected, and the parous rate ranged between 10.8 and 63.1%.

The results of bioassay tests on bendiocarb insecticidal residue on surfaces with a 30-min exposure period showed a mortality rate of over 69.9% on mud walls and 98.5% on wood up to 60 days after spraying. Wood bioassay gave 80.2% mortality 90 days after spraying. When the exposure time was extended to 1 hr the mortality rate on mud wall was increased to 100% after 75 days and 85% after 90 days. Bioassay mortality on mud surfaces sprayed with malathion was 57% after 30 days. On wood, however, mortality was 72% at 45 days after spraying.

The air borne killing effect of bendiocarb was assayed in the interiors of houses. A total of 6 cages of 50 blood fed *An. stephensi* each were used in each test, of which 4 were installed in 4 sprayed rooms and 2 kept as controls. The time of exposure was 6 hr, from 7.00–13.00, and the holding time was 24 hr. The type of cage used in these tests was a cylindrical screen cage, 10 × 16 cm. in size, which was hung at 50 cm. distance from the wall and ceiling in treated houses. Over 96.5% kill occurred up to 30 days after spraying, and at 60 and 90 days after spraying the mortality rate was 53.2% and 16.2%, respectively.

Susceptibility tests using the WHO technique were carried out on *An. stephensi*. The tests were made on mosquitoes from the localities of Kooshkak, Jafar-abad and Dime-mil, Mamasani county, southern Iran, during August 1977 and July 1978. Susceptibility tests with 4.0% DDT paper and 1 hr exposure followed by a 24-hr recovery period showed 2.8% mortality in the village of Kooshkak. When the time of exposure was increased to 4 hr, the mortality rate was 16.4%. Mortality rate for 4.0% dieldrin after 1 hr exposure and 24 hr recovery was 17.1%. When the time of exposure was increased to 4 hr, the mortality was observed 38.8%. In susceptibility tests carried out with 3.2% malathion paper and 120 min exposure in the village of Kooshkak, the mortality rate was 98.9%. In tests made in 1978 in the villages of Kooshkak, Dime-mil and Jafar-abad with 5.0% malathion and 1 hr exposure the mortality rate was between 80.9 and 89.8%. When the time of exposure was increased to 2 hr, mortality rate was 100%.

With regard to the 0.1% propoxur paper, the range of mortality after 30 min exposure followed by a 24 hr recovery period was observed between 90.6 and 98.9% in July 1978. There is no doubt, therefore, that bendiocarb is an effective insecticide against *An. stephensi*, and the control of *An. stephensi* under conditions of this experiment lasted for at least 3 months after spraying.

References Cited

Detinova, T. S. 1962. Age grouping method in Diptera of medical importance. Wld. Hlth. Org. Monogr. Ser. 47:1–216.

Eshghy, N. and Janbakhsh, B. 1976. Insecticide resistance of *Anopheles stephensi mysorensis* in the province of Fars, southern Iran, 1975. Mosquito News 36: 336–339.

Janbakhsh, B., Eshghy, N. and Manouchehri, A. V. 1976. The present status of insecticide resistance in vector anopheline mosquitoes in Iran, 1974. Mosquito News 36:30–36.

W.H.O. 1967. Safe use of pesticides in public health. 16th Report of the WHO Expert Committee on Insecticides. Tech. Rep. Ser. 356:6–9.

W.H.O. 1970. Insecticide resistance and vector control. 17th Report of the W.H.O. Expert Committee on Insecticides. Tech. Rep. Ser. 443: 47–157.