POTENTIAL USE OF BENDIOCARB (FICAM VC)® FOR MALARIA CONTROL IN AN AREA OF ZIMBABWE

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ABSTRACT. Ficam® (bendiocarb) was tested for its residual efficacy and irritation in malaria vector control by using a laboratory bred colony of *Anopheles arabiensis*. In the study area, the insecticide remained active for up to 8 wk (96% mortality) on thatch. In similar, especially constructed huts, 74% mortality was achieved up to 20 wk on mud compared with up to 100% on thatch. In the special huts, release/capture studies indicated that the lethal effect of Ficam on the insects was more pronounced than its irritant effect. This was shown by the low recapture numbers in exit traps as compared with the hut-floor mortalities. The implications of these findings in relation to studies elsewhere and the potential of Ficam use in malaria control are discussed.

INTRODUCTION

The use of insecticides for the control of vectors of malaria today offers the best prospects for control of the disease, given the widespread emergence of drug-resistant strains of *Plasmodium falciparum*. In only a few countries of Africa, including Zimbabwe, has sustained vector control been achieved through the indoor application of DDT in human habitations. In view of the success of DDT against the malaria vectors in the early 1960s, the World Health Organization (W.H.O.) still advocates its use (Pant and Fontaine 1983).

On the other hand, there has been mounting global criticism of the use of DDT (American Medical Association 1970). Its persistence and adverse effects of outdoor use of DDT on the environment, coupled with resistance to it by some malaria vectors (Brown 1986) and also its increasing failure to kill several household pests, are some of the reasons advanced by its critics. Financial constraints have often prevented a switch over to newer but more expensive insecticides, and these newer insecticides have often failed to match the residual effectiveness of DDT (Mpofu et al. 1988).

However, to forestall the problems associated with the possible emergence of vector resistance to DDT and also to win the cooperation and confidence of householders, it has become increasingly necessary for the Zimbabwe malaria control program to consider alternatives insecticides to DDT.

Since 1982, Ficam® (bendiocarb) has been included on the W.H.O. list of residual insecticides for malaria control (Pant et al. 1981). Village scale trials using Ficam VC have been conducted in several countries such as Iran (Eshghy et al. 1979, 1980), Indonesia (Fleming et al. 1983) and more recently in Mexico (Bown et al. 1987). Other countries, namely Nepal, Thailand, Sudan, Syria, India, Burma, Philippines and Turkey, have also conducted trials with satisfactory results [Cambridge Animal and Public Health Company (CAMCO) 1982].

In previous trials with Ficam VC, it was found to have a variable residual effectiveness at an application rate of 0.2 g AI/m^2 (Coosemans and Sales 1978, Hervy and Sales 1970, Rishkesh et al. 1978). In subsequent trials (Eshghy et al. 1980) a dose rate of 0.4 g AI/m^2 was found to give up to 3 months residual control of malaria vectors. The present study set out to establish the duration of malaria control using Ficam under Zimbabwe conditions.

MATERIALS AND METHODS

Study area: The Sangwe communal area (Fig. 1) is inhabited by the Shangani. It lies to the southeast of Zimbabwe in an area regarded as highly endemic for malaria (Taylor and Mutambu 1986, Crees and Mhlanga 1985). Malaria endemicity in the area is favored by the warm weather conditions prevailing and the poor drainage of the black basalt soils which allow for the proliferation of small transient water puddles during peak rainfall from November to March. These puddles support abundant vector mosquito breeding during the months January to March.

The study area is bounded to the east by the expansive and sandy Sabi River, to the south by the Gonarezhou Game Park, the Mkwasine sugar estates to the northwest and cattle ranches to the southwest and west (Fig. 1). The major road from Chiredzi (to the west) to Chisumbanje forms a natural north-south boundary. Until 1985 the southern part was very sparsely populated and resettlements were established (shown as circled numbers on Fig. 1). In the present study, the southern area was sprayed with Ficam while the north was sprayed with DDT as part of the normal malaria control program. Villages

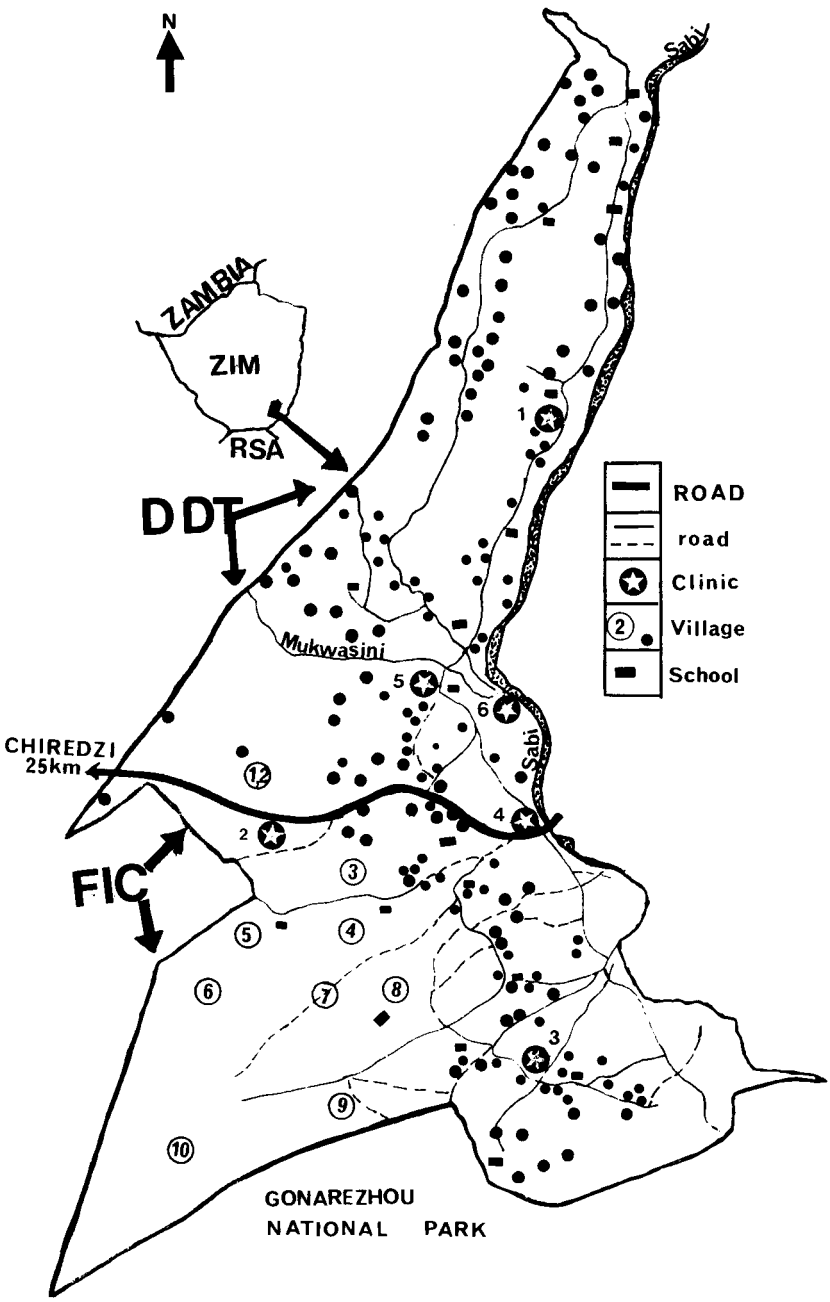

Fig. 1. Map of Sangwe communal area showing the two areas sprayed with DDT and Ficam (FIC).

in the south built prior to 1985 had been sprayed with DDT in the previous years, but those in the newly settled area had not been previously sprayed. Huts in the former category were excluded in follow-up activities.

Spraying program: The spraying was conducted in liaison and with the support of the Masvingo Provincial Medical Director's (P.M.D.) office, which is responsible for malaria control in Sangwe. Prior to the start of the spraying of Sangwe south, a vigorous publicity and education campaign was mounted. This was similar to that described by Laird et al. (1985) in Tuvalu, Polynesia, with emphasis on care of

domestic fowls following Ficam spraying. By the time the spraymen moved in, there was a high level of enthusiasm and cooperation from the population.

The spraying of the area commenced in the north (September 1986) where the huts were sprayed with DDT 75% wettable powder at a dose of 2 g AI/m^2 following standard W.H.O. recommendations (Bruce-Chwatt 1980). The south was sprayed with Ficam VC from November to December at a dose of 0.4 g AI/m^2 following the method described by Eshghy et al. (1979) and also Fleming et al. (1983). The spraymen were initially trained in the safe handling of Ficam. The spray coverage is shown in Table 1. In addition, one especially constructed experimental hut fitted with exit traps was sprayed with Ficam as above, and a second one served as a control (Fig. 2).

Malaria prevalence surveys: Parasitological surveys were conducted in December (prior to the peak of malaria transmission) and in March [peak transmission (Mpofu 1985)]. Thick blood smears were collected from asymptomatic school children (age range 7–11 years) from 4 schools in each of the north and the south segments of Sangwe. These were stained with Giemsa and examined for parasites. Approximately 500 children from the 2 areas had blood slides taken twice. In addition, records were made of blood slide submissions from clinics serving each of the areas. These slides were sent to this laboratory, where clinical diagnosis was confirmed by microscopic examination.

Entomological measurements: Mosquito vector biting activity (predominantly *An. gambiae s. l.*) in each area was assessed using baited traps at 2 camps in each area (Mpofu and Masendu 1986). Indicator villages were chosen from each area on the basis of their potential to sustain a reasonable mosquito population, which could be used to make crude measurements of biting rates obtained in the 2 areas. The 2 villages used for this purpose were situated along the Mkwasine River in the north and the Sabi River in the south.

Bioassays were also conducted on mud and thatch surfaces in both DDT and Ficam sprayed huts as well as in experimental huts. A laboratory strain of *An. arabiensis* known to be susceptible at the diagnostic dose of 4% DDT was used. The bioassays were conducted monthly to measure the activity of the insecticides and assess their longevity on these surfaces. Apart from bioassays, the experimental huts were also utilized to assess vector behavior and mortality inside the Ficam sprayed huts. The dwellings were not best suited for this purpose, especially because of difficulty of retrieval of released insects.

The floors of the experimental huts were lined with white calico sheets to easily detect dead mosquitoes. Blood-fed, 3–5 day old *An. arabiensis* females were released into the experimental huts before dusk (1700 h). The traps were checked for escaping mosquitoes at 1900 h and the following morning at 0700 h. This routine was maintained throughout until all or no mosquitoes could be recovered. The recovered mosquitoes, if live, were held in the insectary on a diet of 4% sucrose solution and final 24 h mortalities scored. The calico-lined floors were checked every morning for dead or moribund mosquitoes.

Table 1. Breakdown of spray coverage for the Sangwe area, November to December, 1986.

Material (wt. in kg)	Total huts sprayed (% coverage)	Unsprayed huts (% of total)	Population covered
Ficam (266.4)	8,566 (99)	88 (1)	13,954
DDT (1,166)	10,458 (97.7)	252 (2.4)	13,963

RESULTS

Spray coverage: Table 1 gives a breakdown of the number of huts sprayed with both Ficam and DDT. The spray coverage using Ficam was high, showing cooperation by owners. In instances where huts had been omitted due to owner's absence, the spraymen were invited by the householder to return and spray these huts.

No side effects were reported by the spraymen. Ficam was observed to have a very broad spectrum of activity, killing household pests such as cockroaches and bed bugs. The householders were strictly warned not to allow their chickens or ducks to prey on dead insects. In one instance several ducks died when the owner ignored this instruction.

Parasitological surveys: The health centers serving the 2 sprayed areas are indicated on Fig. 1. Between January and July 1987, the 3 clinics in the DDT sprayed area submitted 174 slides for confirmation of clinical diagnoses. Only 19 cases were positive for malaria parasites. On the other hand, 2 clinics in the Ficam area submitted 53 slides of which 4% were found positive. Clinic 4 (see Fig. 1), which acts as a referral center for the area, had 60 cases of which 10% were malaria-positive.

The parasite surveys also reflected a very low level of malaria transmission. In December 1986, at the time of spraying, a total of 602 asymptomatic school children only yielded 1.5% positive

slides in the Ficam area, compared with 499 (0.8% positive) for the DDT area. At the presumed peak of transmission in March 1987, the figures were 500 (0%) and 501 (0.4%) for Ficam and DDT, respectively. The low levels of malaria in both areas made any comparisons difficult.

The results of the bioassays conducted are shown in Fig. 3 for both wall and thatch exposures. High percent mortalities were recorded for both Ficam and DDT up to 8 wk postspray. Although not indicated on Fig. 3, 1 h mortalities were high (about 85%) for Ficam compared with about 50% DDT for the thatch exposures. After 8 wk, the mortality figures for Ficam dropped drastically to about 30% for both mud and thatch exposures.

On the contrary, the figures for DDT remained fairly constant at about 70% on average for both types of surfaces. In the 20 wk bioassay for DDT, 100% mortality was still achieved on both surfaces. There were wide variations in the mortality figures obtained among the 5 huts assayed for Ficam during most follow ups. There was no corresponding variation observed with the data for DDT in most of the cases.

Figure 4 shows the results obtained with bioassays conducted in experimental huts for 20 and 24 wk postspray. These results are compared on the same diagram with corresponding

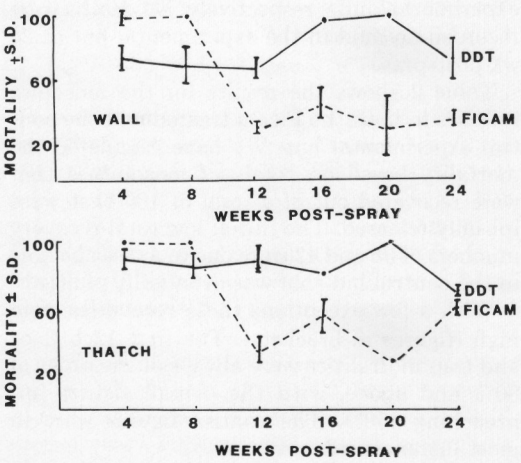

Fig. 3. Results of wall and thatch bioassays (1 h exposure).

results for dwellings from Fig. 2. It is evident that the mortality figures in the experimental huts are much higher than those obtained for dwellings, i.e., 100% (20 wk) and 95% (24 wk) for thatch as compared with 55% and 60% for dwelling huts. The wall mortalities for the 20 wk assays were 45% and 67% for dwelling and

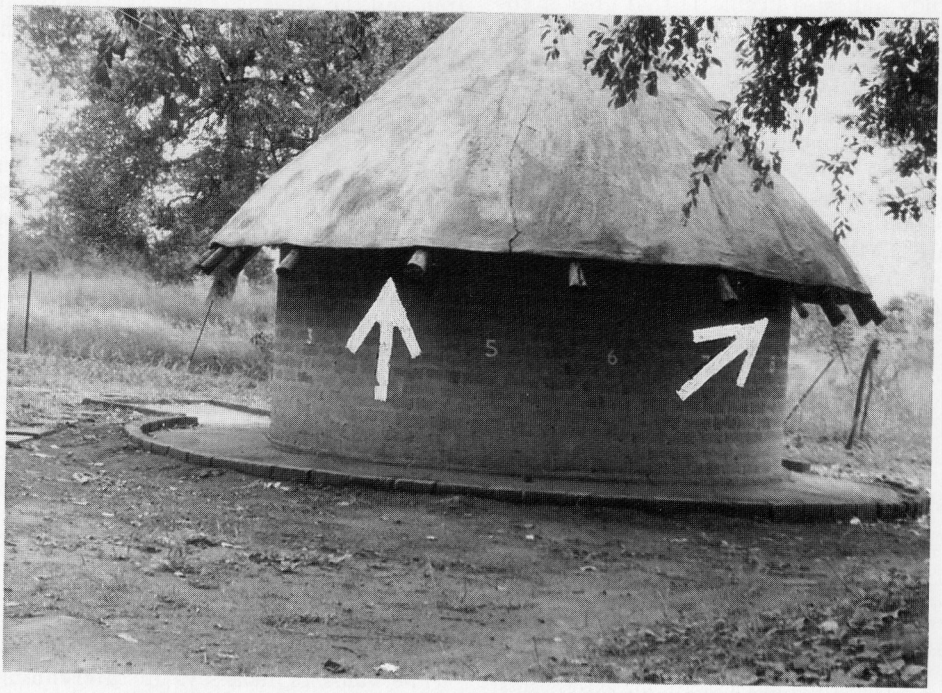

Fig. 2. An experimental hut (light arrows point to the exit traps); door and traps are not visible.

experimental huts, respectively. No deaths were recorded on mud in the experimental hut at 24 wk postspray.

Table 2 shows the results for the mosquito releases in both the Ficam treated and the control experimental hut. We have calculated the mortality based on totals of mosquitoes that were recovered out of a total of 100 that were initially released. The initial low total recovery numbers of 35 and 42 were due to an escape hole in the control hut that was eventually plugged.

With a few exceptions these recoveries were high (figures in brackets). The first 12 h floor and trap mortalities were always of the order of 80% and above, with the overall figures approaching 100%. The control figures were in most instances nil.

Table 3 shows the number of escapees through the door and window exit traps of the experimental huts. The majority of the escapees were recorded in the control hut and very few from the Ficam sprayed hut. However, a few live trap collections were made in the treated hut after 8 wk postspray, and these numbers increased with increasing postspray duration.

Table 2. *Anopheles arabiensis* mortality following releases in sprayed experimental hut (includes floor and exit traps). Mortality calculations based on total numbers recovered (not released).

	Weeks postspray (% mortality)						
	5	6	7	8	12	17	26
1st 12 h	97	96	88	79	79	90	10
Total	100	99	100	95	96	95	85
	(58)*	(75)	(81)	(85)	(42)	(81)	(63)
Control	0	0	0	0	0	5	13
	(35)	(42)	(80)	(65)	(45)	(54)	(54)

* Total number recovered.
Dose was 0.4 g Ficam.

Table 3. Mosquitoes exiting (live) through window traps as a percent of total mosquitoes recovered (not released).

	Weeks postspray						
	5	6	7	8	12	17	26
0.4 g Ficam	0	0	0	15	15	18	30
	(58)	(75)	(81)	(85)	(42)	(81)	(63)
Control	91	100	93	92	90	92	60
	(35)	(42)	(80)	(65)	(45)	(54)	(57)

DISCUSSION AND CONCLUSIONS

The current malaria control program in Zimbabwe is faced with opposition to DDT spraying by house owners in the malaria affected areas. Our study indicates (Table 1) that greater cooperation can be obtained with massive health education campaigns and the use of a broad spectrum insecticide such as Ficam.

While it is widely accepted that newer insecticides will not match the residual efficacy of DDT (Goose 1983), the problem of vector resistance has necessitated a change from DDT. In the present study, no attempt is made to compare DDT to Ficam but rather to assess the residual effectiveness of Ficam. The results of the bioassays (Fig. 3) are very similar to the results obtained in Iran by Eshghy et al. (1979, 1980), who used a 30 min exposure period as compared with ours of 1 hour. A drastic drop in mortality was observed after 8 wk in both the Iran and the present trial. From the results of the present study and that in Iran, it appears that the duration of insecticide activity is somewhat more prolonged on thatch than on mud walls.

The present study has assessed Ficam activity up to 24 wk postspray. While the mosquito mortalities show a consistent decrease after 8 wk, there was much variability in the data obtained in each of the 5 huts tested (Fig. 3). This suggests that some huts were replastered subsequent to the spraying. In the absence of a noticeable spray deposit of Ficam as compared with DDT, it was not possible to ascertain whether a hut had been replastered. However, the data of experimental huts (Fig. 4 and Table 2) show that Ficam has good residual activity up to 20 wk on both thatch and mud. But at 24 wk, activity on mud disappears while thatch continues to show good activity. Again, this could be explained as in the preceding paragraph. It was only realized much later that during construction the experimental huts had been plastered with mud mixed with a small amount of cement. This may have inactivated the Ficam.

The value of bioassays in determining the residual effectiveness of insecticides is debatable

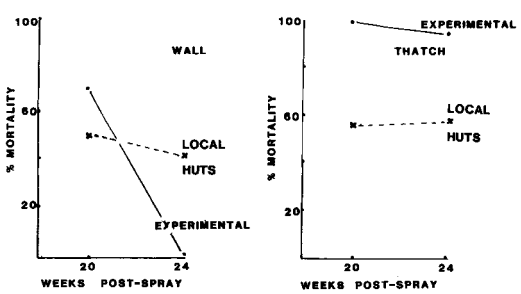

Fig. 4. Comparison of bioassays for experimental and local huts at 20 and 24 wk postspray.

(Mpofu et al. 1988). The study in Mexico by Bown et al. (1987) showed that there were significant reductions in man-mosquito contact following application of Ficam and that this was due to irritability. As the spray deposits become progressively older, this irritability became less marked and led to mosquito mortalities up to 80%. In the present study we would have been unable to demonstrate such a phenomenon due to the low mosquito population following a drought. This is also reflected in the very few malaria cases reported in the area. Our data with laboratory bred *An. arabiensis* (Table 3) released into the sprayed experimental hut are meant to provide some indication of the irritant effect of Ficam. Very few insects managed to escape through the exit traps, as most were collected dead on the floor. This shows that any irritant effect of Ficam may not be a drawback, as the mosquitoes pick up a lethal dose before they manage to escape. This same observation was made by Bown et al. (1987).

The experiments with hut releases were the closest to the natural situation. The results demonstrate that under these conditions, Ficam remains active even at 26 wk with 85% mosquito mortality 24 h after release (Table 2). Moreover, a large proportion of these mosquitoes die within the first 12 h of release into the treated huts. Eshghy et al. (1979) showed a mortality rate of 79.9% with overnight exposure of blood fed *An. stephensi* Liston in huts sprayed 8 wk previously. This may be compared to our figure of 78% with *An. arabiensis*, and this suggests an excellent level of vector control at that stage after spraying.

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