National Communicable Disease Center (1969) *Annual Report of the Malaria Surveillance Unit*, Atlanta, US Public Health Service
Raghavan, K. (1966) *Bull. Wld Hlth Org.*, **34**, 788-791
Rogers, W. A., Jr., Fried, J. A. & Kagan, I. G. (1968) *Amer. J. trop. Med. Hyg.*, **17**, 804-809
Sulzer, A. J., Wilson, M. & Hall, E. C. (1969) *Amer. J. trop. Med. Hyg.*, **18**, 199-205
Todorovic, R., Ristic, M. & Ferris, D. (1968) *Trans. roy. Soc. trop. Med. Hyg.*, **62**, 58-68
Wilson M., Sulzer, A. J. & Runcik, K. (1970) *Amer. J. trop. Med. Hyg.*, **19**, 401-404

Studies on Infiltration of Marked *Culex pipiens fatigans* into Sprayed Areas in Rangoon, Burma*

by L. S. SELF,[1] M. M. TUN,[2] H. L. MATHIS,[3] M. H. M. ABDULCADER[4] & A. SEBASTIAN[2]

Studies made by the WHO Filariasis Research Unit (FRU), Rangoon, on the ecology of *Culex pipiens fatigans* and the control of larvae with fenthion emulsifiable concentrate have been described in various reports, both published and unpublished.[5] The study described in this note was carried out during the last phase of the research programme in order to determine whether adult mosquitos marked with fluorescent pigment,[6] and released at three fixed points along the outer barrier zone (BZ) boundary, could infiltrate into the original Kemmendine experimental field trial (KEFT) area. Flights, or transportation by other means, of at least 966 m were required to reach any of the six fixed FRU catching stations in the KEFT area, but the distance to the closest of nine fixed stations in an expanded sprayed area (EA) adjacent to the KEFT area was only 370 m. Also, in this particular study, one catching station was located within 61 m of each of three widely separated release points, and 7 other catching stations were located about 1 600 m south of the KEFT area in an unsprayed comparison area (UCA).

Mosquito releases were made from 11 October to 19 December 1969, about 3 ½ years after larval control measures had reduced adult densities in the KEFT area by 98%, i.e., to a level of about 1 mosquito bite per man hour per night. Although larval survey data indicated that only a very few adults emerged within the KEFT area from uncontrolled artificial containers, the possibility of significant infiltration from unsprayed areas was not ruled out.

Rearing and marking procedure

Late-instar larvae and pupae from natural breeding sites were placed in a 76 by 61 by 13 cm sheet-iron vat in the laboratory and reared in polluted field water with powdered dog biscuit added. The rearing vat was normally emptied every Saturday, and new field collections were made on Monday and Tuesday to ensure the emergence of about 8 000 adults a day. Cotton wool moistened with glucose syrup was always available to the newly emerged mosquitos.

A tight-fitting rectangular net on a 76 by 61 by 61 cm wooden frame was placed over the rearing vat. During the morning hours, the 1–2-day-old adults were removed by means of an aspirator tube (20 mosquitos per tube) through two sleeves in the net. The work was done by four or five mosquito scouts; one scout recorded the total numbers removed, and male and female mosquitos were individually counted in about every 20th aspirator tube. The mosquitos from the aspirator tubes were then transferred to 500-ml flasks (250 specimens per flask).

* From the WHO Filariasis Research Unit, Rangoon, Burma.

[1] WHO Entomologist. Present address: World Health Organization, Central Post Office Box 540, Seoul, Republic of Korea.

[2] Entomologist seconded from the Directorate of Health, Burma.

[3] WHO Entomologist.

[4] Project Leader.

[5] A list of published material and documents can be obtained from Vector Biology and Control, World Health Organization, 1211 Geneva, Switzerland.

[6] Redglo, supplied by H. Haeffner and Co. Ltd., Holmethorpe Trading Estate, Redhill, Surrey, England.

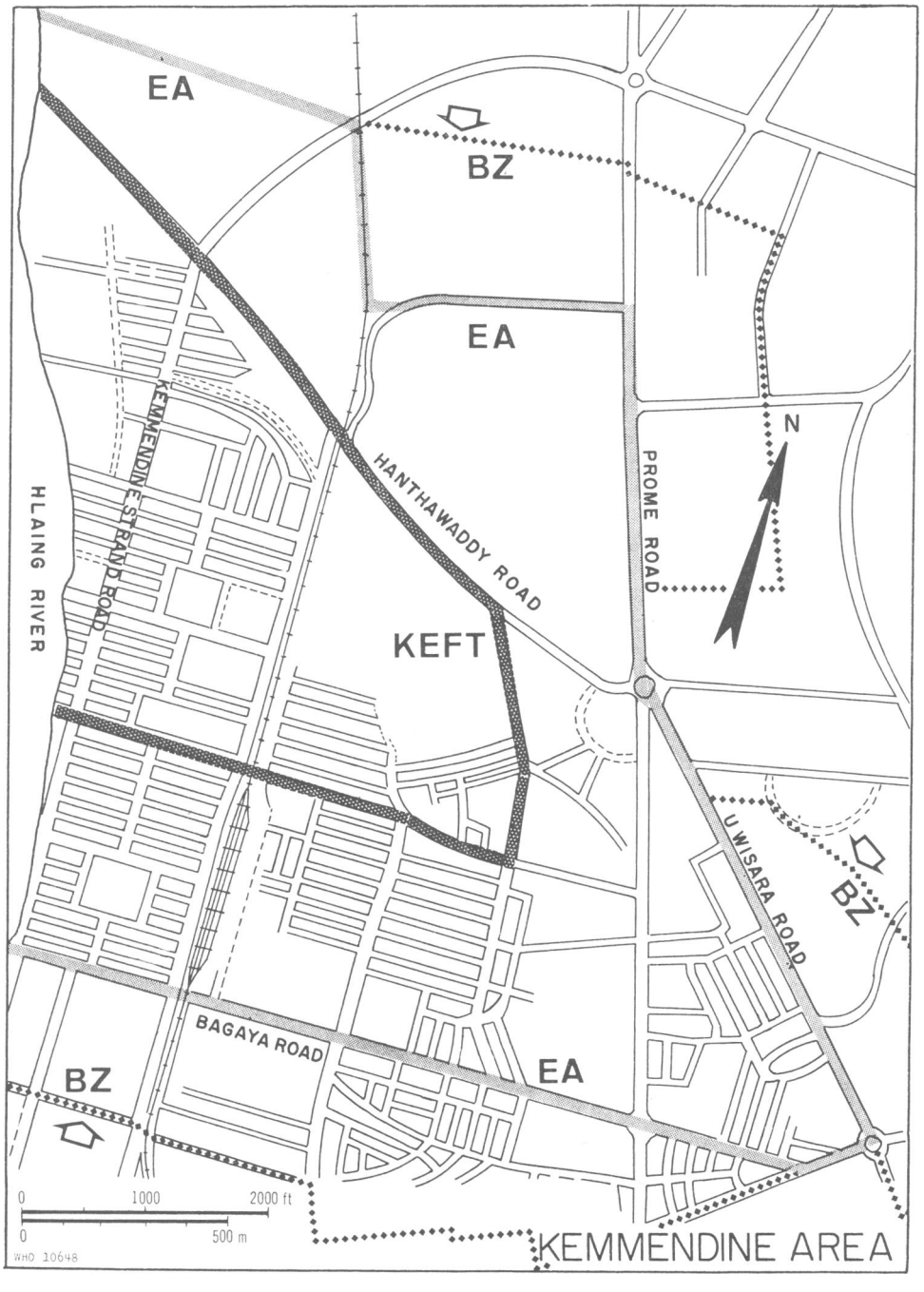

Fig. 1. The Kemmendine area of Rangoon showing the barrier zone (BZ), the expanded sprayed area (EA), and the Kemmendine experimental field trial area (KEFT). Points where marked mosquitos were released are indicated by arrows

To mark the mosquitos, fluorescent pigment was first introduced into an unused WHO larval test-kit bottle with three small holes in the cap. The pigment was then puffed into the flask containing mosquitos by squeezing the bottle two or three times. The flask was immediately plugged with cotton wool, and the pigment particles floated freely among the mosquitos for about 2 minutes. Afterwards, the cotton wool plug was removed and the flask was tilted and agitated inside a small (0.074 m^3) cage. When a cage held about 1 000 mosquitos, it was immediately taken into the field and the mosquitos were released.

Laboratory experiments with caged mosquitos indicated that the dye was detectable for at least 21 days and that it caused no rise in mortality of male or female mosquitos in comparisons with a control group of mosquitos. The dye faded considerably after 11 days, although it remained clearly visible on the thorax. For 2–3 days after marking, dye particles were noticed on relatively small structures such as the antennae. There was no evidence that the dye rubbed off marked mosquitos and contaminated unmarked ones when mixed batches were sorted in the laboratory.

Release of marked mosquitos

The three release points were in unsprayed territory within 61 m of the outer BZ boundary. The immediate areas north and south of this boundary had large human populations rather similar to those in the KEFT area, and there were also numerous mosquito breeding sites. To the east was a better developed residential area with considerably fewer breeding sites and better sanitation facilities. Mosquitos were not released at the east point after October. To the west of the KEFT area is the Hlaing River.

During release, the cages were placed on the ground in a shady location and then opened. It was observed that many marked mosquitos immediately flew to nearby vegetation, the sides or undersides of houses, and to other objects near human dwellings. It appeared that the first flight out of the release cage was extremely short since vertical flight patterns were not apparent. Dead or immobilized specimens found in the cages were removed and counted.

Collection of marked mosquitos

Each Monday, 1 hour (20.00–21.00 hours) was spent at each station collecting indoor-resting mosquitos and 3 hours (21.00–24.00 hours) were spent collecting mosquitos from human bait outdoors. All mosquitos captured from 13 October to 29 December 1969 were examined for dye markings before routine parous and infection determinations were made. Except in the unsprayed comparison area, special indoor morning collections also were made twice during November and five times in December.

Results

Table 1 is a summary of data on the numbers of mosquitos marked and released. Altogether, 397 593 mosquitos were released in 51 days (an average of 7 795 per day). Mortality due to handling was about 1%, and females represented about 58% of the total numbers marked. The approximate numbers released at the north, south, and east points were 178 619, 174 827, and 47 514, respectively.

Table 2 summarizes the total numbers of marked and unmarked mosquitos collected. A total of 181 marked females were collected in the barrier zone, 4 in the expanded sprayed area, and 1 in the comparison area, while 59 marked males were recovered in the barrier zone and 2 in the expanded sprayed area. In the KEFT area, no marked mosquitos were collected. About 98% of all recovered marked specimens were found within 61 m of the release points but no attempts were made to collect any mosquitos within 61–366 m of any release point. The total number of man hours expended for the collections in the barrier zone, the expanded sprayed area, and the KEFT area were 162, 498, and 348, respectively.

The 6 marked specimens caught in the expanded sprayed area were all recovered south of the KEFT area, indicating that mosquitos flew northwards. The EA station (No. 15) closest to the south release point had 2 marked females and 1 male, which indicated flights of at least 457 m. The other marked mosquitos in the expanded sprayed area had travelled at least 762–1 067 m. The one marked female mosquito captured in the unsprayed comparison area travelled at least 1 335 m, apparently from north to south. Further information obtained during February 1970 suggested that some infiltration might also occur from the north of the barrier zone.

None of the marked mosquitos were infected with *Wuchereria bancrofti*. Altogether, 143 of the females recaptured in the barrier zone were nulliparous, 8 were parous, and 30 were fully fed or gravid; no advanced age grading was attempted. In the expanded sprayed area, 1 female was nulliparous

Table 1. Number of *C.p. fatigans* marked and released during 1969

Period of release	No. of release day	No. of mosquitos marked	Mortality due to handling (%)	No. of mosquitos released	No. of mosquitos sexed before release	Proportion of females	Estimated no. of females released	Average no. of females released per day
11–29 October	18	149 340	1.3	147 399	7 704	0.60	88 439	4 913
1–29 November	21	170 244	0.58	169 257	4 448	0.54	91 399	4 352
1–18 December	12	81 376	0.54	80 937	867	0.55	44 515	3 710
total	51	400 960	0.99	397 593	13 019	0.58	224 353	4 399

and 3 were parous. The single female mosquito captured in the comparison area was gravid.

Discussion

The results presented here indicate that no appreciable infiltration of mosquitos from unsprayed areas into the KEFT area was occurring. However, the recovery of 2 marked females at distances of 1 067 m and 1 335 m shows that *C. p. fatigans* is capable of reaching the KEFT area from outside the protective 1969 boundary, although at this time (April 1971) larval control is being extended to other areas of the city.

Before larval control began, Lindquist et al. (1967) released 863 000 mosquitos in the KEFT area and found only 7 females that had travelled as far as 915 m. About 80% of the specimens labelled with radioactive phosphorus (^{32}P) that were recovered

Table 2. Numbers of *C.p. fatigans* captured at standard catching stations from 13 October to 29 december 1969. The number of marked mosquitos is shown in parentheses

Area[a]	Indoor resting (10.00–12.00 hours)			Indoor resting (20.00–21.00 hours)			Outdoor biting (21.00–24.00 hours)		
	Man hours of collection	No. of females	No. of males	Man hours of collection	No. of females	No. of males	Man hours of collection	No. of females	No. of males
				October					
BZ				6	189 (47)	36 (14)	18	535 (46)	23 (5)
EA				18	41 (0)	16 (0)	54	79 (0)	7 (0)
KEFT				12	17 (0)	10 (0)	36	29 (0)	0 (0)
				November					
BZ	24	162 (14)	110 (10)	12	160 (2)	41 (6)	36	432 (25)	22 (2)
EA	72	114 (1)	67 (0)	35	60 (0)	40 (0)	105	189 (1)	1 (1)
KEFT	48	52 (0)	33 (0)	24	36 (0)	6 (0)	72	46 (0)	0 (0)
				December					
BZ	30	360 (21)	208 (16)	9	163 (7)	60 (3)	27	351 (19)	23 (3)
EA	54	147 (1)	75 (1)	40	95 (0)	31 (0)	120	448 (2)	6 (0)
KEFT	36	132 (0)	57 (0)	30	59 (0)	22 (0)	90	198 (0)	5 (0)

[a] All marked mosquitos captured in the barrier zone (BZ) travelled less than 61 m; all marked mosquitos captured in the expanded sprayed area (EA) travelled 457–1 067 m; one female captured in the comparison area (UCA) travelled at least 1 335 m.

had travelled less than 549 m. In New Delhi, Afridi & Abdul Majid (1938) released 138 000 mosquitos marked with a silver powder in a non-inhabited area and recovered 7 females in populated districts at distances of 1 006–5 032 m from the release point.

It is noteworthy that most (98%) of the marked mosquitos recovered in the present study were collected within 61 m of the release points (BZ) even though the total collecting time was only about one-fifth of that in the expanded sprayed and the KEFT areas. The results on the parous and abdominal condition of all recovered females indicated that many young mosquitos fly relatively short distances for their first blood meal when emergence is in a densly populated area.

In the precontrol study made by Lindquist et al. (1967), 65 tagged males and 119 tagged females, were recovered; that is, 0.002% of the total numbers released. In this study, 61 dyed males and 186 dyed females were recovered (about 0.006%). Many of the dyed mosquitos undoubtedly flew in directions away from the sprayed areas and the fixed catching stations, whereas the radioactively labelled mosquitos were released at a central point and, subsequently, collections were made in all directions. Although conditions were not the same for the two experiments, the higher recovery rate obtained in the study with the dye may be partly attributed to the release of much smaller numbers per day over a longer period. Both studies indicate that only a very small percentage of the *C. p. fatigans* adults in and near the Kemmendine area of Rangoon fly as far as 915 m, and the majority travel much less than 549 m from the site of emergence.

These results also support previous studies and indicate that very low adult vector densities can be achieved by larval control alone in certain sections of large cities having a high prevalence of human microfilaraemia.

ACKNOWLEDGEMENTS

We thank Dr G. Davidson of the Ross Institute, London, for forwarding a generous supply of the fluorescent dye.

REFERENCES

Afridi, M. K. & Abdul Majid, J. S. (1938) *J. Malar. Inst. India*, **1**, 155-167

Lindquist, A. W., Ikeshoji, T., Grab, B., de Meillon, B. & Khan, Z. H. (1967) *Bull. Wld Hlth Org.*, **36**, 21-37

Prospection sur *Aedes aegypti* et les vecteurs potentiels de fièvre jaune en République démocratique somalie et dans le Territoire français des Afars et des Issas*

par J. MOUCHET [1]

Cette mission s'est étalée du 1er au 29 mai 1969. Elle avait pour but de recueillir des informations sur la présence ou l'absence de vecteurs potentiels de fièvre jaune dans cette partie de l'Afrique. En effet, bien qu'aucun cas de cette affection ne soit signalé dans ces pays depuis de très nombreuses années, la proximité des foyers amarils éthiopiens laisse toujours planer une menace.

Les seules informations sur la Somalie furent fournies oralement par le Dr K. Hocking qui, en 1942, avait observé *Aedes aegypti* dans les villes côtières du sud ainsi qu'à Berbera dans le nord. A cette époque, une épidémie de dengue avait d'ailleurs éclaté à Mogadiscio, nécessitant la mise sur pied d'opérations de lutte contre le vecteur.

* Cette étude a bénéficié de subventions du Service de Santé publique des Etats-Unis d'Amérique (N° CC 00174 du National Communicable Disease Center, Atlanta, Ga.) et de l'Organisation mondiale de la Santé.

[1] Entomologiste médical, Services scientifiques centraux de l'Office de la Recherche scientifique et technique Outremer (ORSTOM), 93 Bondy, France.