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A VERANDAH-TRAP HUT FOR STUDYING THE HOUSE-FREQUENTING HABITS OF MOSQUITOS AND FOR ASSESSING INSECTICIDES. I.—A DESCRIPTION OF THE VERANDAH-TRAP HUT AND OF STUDIES ON THE EGRESS OF *ANOPHELES GAMBIAE* GILES AND *MANSONIA UNIFORMIS* (THEO.) FROM AN UNTREATED HUT

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(Plate IV)

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" Experimental huts of the window-trap type ", as they are generally called, have been used continually in East Africa for 15 years for studying the house-frequenting habits of *Anopheles gambiae* Giles and for assessing the excito-repellent and toxic effects of insecticides on them.

In recent years, the Tropical Pesticides Research Institute has used window-trap huts extensively in East Africa for screening candidate insecticides, as part of the World Health Organization programme for developing new insecticides for use against insects resistant to those in common use. Analysis of a vast amount of entomological data accumulated from 20 window-trap huts each year, with different insecticides, has more closely defined the value and disadvantages of these huts as a research tool for assessment of insecticides. These findings, taken together with supplementary observations using specially constructed huts, have shown that the window-trap hut is quite satisfactory for assessment of mortalities inflicted on *A. gambiae* by non-repellent insecticides because the trap is efficient, that is to say, only a few mosquitos leave through the eaves and escape assessment. The window trap is, however, less efficient with *A. gambiae* when the insecticide is repellent, because when this is so, a greater proportion of the total numbers leaving from the hut does so through the eaves and is unaccounted for. The explanation offered for the greater proportion leaving through the eaves is that mosquitos, repelled by insecticides, attempt to leave the hut earlier than they would otherwise have done, at night, and, since there is no directional source of light before dawn to guide them towards the window, they are less prone to leave by it. Another disadvantage of the window-trap hut is that it is unsuitable for assessing other domestic species with different habits; for example, *Mansonia uniformis* (Theo.) leaves even an untreated window-trap hut largely by the eaves. An account of the work just described is given, with references, in a recent general review of experimental hut techniques used in the study of insecticides in East Africa (Smith, 1964).

There are good reasons for reconsidering the design of the experimental hut used in assessing the toxic and excito-repellent effects of insecticides on domestic mosquitos. First, a more sophisticated trap hut is required to supplement, if not replace, the window-trap hut for assessing the effects of insecticides on *A. gambiae*. Secondly, a trap hut is required which can be used to assess the effects of insecticides on any species of mosquito that enters it, and its use may therefore have world-wide as well as local application.

When considering the design anew, it was borne in mind that (a) the unaccounted fraction was that which left by the eaves, (b) the technique of intermittently surrounding a window-trap hut with a cage of mosquito-netting as a means of assessing the numbers of mosquitos leaving through the eaves was found impracticable for long-term routine work as it required collections to be made at night, (c) eave traps fitted to experimental huts may be used, but they are liable to be contaminated easily by insecticides and they present problems in assessing mortalities due to fumigation *in situ* (by an eave trap is meant a trap fitted under the eave, not a trap fitted in a hole near the top of a wall), (d) the new trap hut should be designed so that a direct evaluation can be made of the numbers of mosquitos leaving through the eaves from the model of window-trap hut now in current use and their survival. In this way, the results would be of immediate value in testing insecticides. An experimental hut was therefore designed that consisted essentially of the existing type of window-trap hut fitted with additional verandah traps.

Description of the verandah-trap hut

The verandah-trap hut is basically the existing type of window-trap hut (Rapley, 1961) with verandahs constructed on all four sides. By addition of mosquito-wire screens to one of the verandahs, the latter could be converted into a verandah trap for mosquitos that had escaped from the hut by the eaves on that side.

The Rapley type of window-trap hut is, briefly, a semi-permanent structure with walls of burnt brick 5 ft. 6 in. high, internally plastered with a layer of mud 2 in. thick, and there is a thatched hipped roof supported on a framework of sisal poles, and culminating in a short ridge 2 ft. long. The hut, which is 8 ft. square, is supported on short concrete pillars each with its

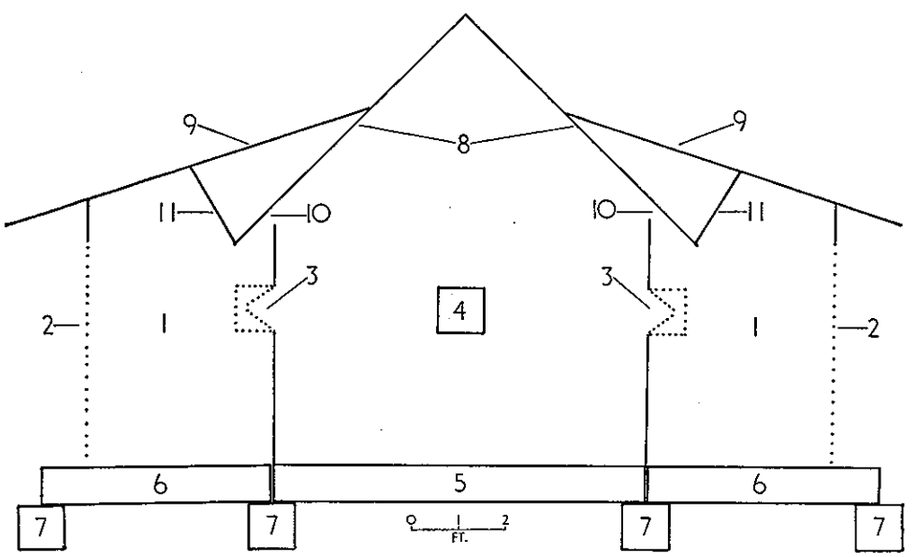

Fig. 1.—Diagram to show the basic design of the verandah-trap hut. 1, verandah trap; 2, removable screen of copper gauze; 3, window traps in walls to right and left; 4, window (closed) in wall facing the observer; 5, beam supporting wall of hut; 6, beam supporting verandah; 7, concrete pillar; 8, roof of hut; 9, roof of verandah; 10, eave; 11, partition of thatch cutting off upper part of verandah roof-space. It should be noted that not all the parts shown lie in the same vertical plane.

own water channel to prevent ants entering the hut (see Pl. IV, fig. 2). The roof and mud linings are renewed at the end of each insecticide trial. The verandah traps are added as indicated in the basic plan outlined in fig. 1. A hut is illustrated in Pl. IV, figs. 1 and 2. Each verandah is 4 ft. wide and is made by extending the wall-plates, at the top of each wall, and by additional beams at the bottom as shown in Pl. IV, fig. 2. Each beam for the verandah trap extends five feet from the wall. The separate roof of each verandah, which is supported by 4 in. × 4 in. uprights and a 4 in. × 2 in. cross-piece at the front, joins that of the hut half-way between the ridge and the eaves. A thatched partition is placed between the bottom edge of the roof of the hut and the underside of the roof of the verandah to cut off the upper part of the roof space of the verandah and so aid collection of mosquitos in the verandah trap. The screens of copper mosquito-wire can be fitted to the framework, by means of thumb-screws, to enclose all sides of the verandah. On the side of each verandah, near to the wall of the hut, is fitted a screen with split hinges that can be married to counterpart hinges on the side of the hut to form a doorway to the verandah trap. The door to the hut opens from the verandah facing north. Removable white-painted sheets of hardboard are placed on the floor of the hut and on the floors of the verandahs to aid detection of dead mosquitos. An indication of the quantities of materials used and their cost (in East African shillings) is listed below together with estimates of the cost of labour and transport involved in building a hut 90 miles away from the Institute headquarters.

	Shs.	
4½ cwt. cement	49	
15 cu. ft. of ¾-in. crushed stone	15	
4 pieces of softwood (9 × 4 in.) 8 ft. 4 in. long 8 pieces of softwood (9 × 4 in.) 5 ft. 4 in. long	200	
245 ft. of softwood (4 × 2 in.)	110	
376 ft. of softwood (2 × 1 in.)	45	
48 ft. of softwood (4 × 4 in.)	22	
48 ft. of softwood (2 × 2 in.)	11	
70 ft. of softwood (2 × ½ in.)	5	
350 ft. of 1-in. tongue and groove board	175	
6 sheets of hardboard (8 × 4 ft.)	72	
1000 bricks	135	
120 sisal poles	18	
300 bundles of grass	75	
42 pounds of sisal twine	48	
40 handles for screens	32	
80 ft. of copper mosquito-gauze 6 ft. wide	125	
48 yd. of sheep wire (4 ft. wide, 6-in. mesh)	65	
Nails, hinges and bolts for doors	50	
Labour	1000	
Transport	500	
Total	2752	(£137 12s.)

Methods

Two verandah-trap huts, a simple hut used as a temporary laboratory, and another hut for storing the screens of the verandah traps, were built in the Umbugwe area of Tanzania. Fences of sheep wire enclosed each verandah-trap hut to prevent cattle, sheep and goats damaging the huts and drinking the water in the ant-moats. The basis of the technique is that two verandah traps, on

opposite sides, are put into use for trapping nominally half of the number of mosquitos leaving the hut by the eaves, while the other two sides are left open to allow mosquitos to enter the hut. In the studies described in this paper, a window trap was also fitted in each of the two operational verandah traps (the other two windows being closed) in order to compare egress by the two different routes. In practice, the pair of verandah traps in use is changed weekly, *i.e.*, the east and west traps alternate with the north and south traps. The screens of the verandah traps remain in position throughout the week, and the traps are entered for searching through their detachable doors. The window traps are fitted at 4 p.m. and removed at 7.30 a.m. the following day.

The work was done by a resident assistant field officer and four mosquito collectors. Apart from a preliminary study in which hand-catches were made of mosquitos resting indoors, the daily routine comprised (1) a ' resting count ' made of mosquitos indoors, (2) a collection, by sucking tubes, of mosquitos in the verandah traps, (3) removal of window traps and collection of the mosquitos in them. All mosquitos were classified as unfed, fed or gravid, those resting in the hut being counted and classified *in situ*.

Results

It was possible that the addition of the verandahs to the basic design of the window-trap hut might affect mosquito behaviour. Preliminary studies were therefore made, in which hand-catches and collections from a single window trap placed in the east wall were taken in an unscreened verandah-trap hut and in an ordinary window-trap hut. The results of 35 collections between 16th December 1963 and 28th January 1964 are shown in Table I. These show that the additional verandahs had apparently no effect on the resting habits and egress into the window trap of *A. gambiae* and *M. uniformis*.

TABLE I. *Day-time resting and egress into a window trap fitted to a simple window-trap hut and to an unscreened verandah-trap hut*

Abdominal condition	Nature of observation	Verandah-trap hut		Window-trap hut	
		A. gambiae	*M. uniformis*	*A. gambiae*	*M. uniformis*
Unfed, fed and gravid	Percentage resting on roof	95 (2279)	64 (22)	69 (7475)	60 (97)
Fed only	Percentage egress	8 (2559)	76 (88)	11 (7882)	81 (469)
Unfed only	Percentage egress	91 (501)	98 (51)	95 (4005)	96 (186)

The numbers of mosquitos collected are shown in parentheses. The percentages resting on the roof are of mosquitos caught in the hut.

The record of 95 per cent. of *A. gambiae* resting on the grass undersurface of the roof of the hut with a verandah was more typical of the proportion normally observed in the same position in simple window-trap huts (Smith, 1962) than the 69 per cent. recorded in this preliminary trial. It was therefore concluded, from earlier observations and from the results of this verandah-trap hut (Table I), that the two types of hut gave similar results in respect of percentages of mosquitos resting and making egress into window traps. Therefore, when a window trap was also in place, mosquitos caught in the verandah traps would essentially represent the unassessed fraction leaving through the eaves. Unpublished results obtained from the other verandah-trap hut (unscreened) were similar to those obtained from its facsimile and recorded in Table I.

TABLE II. *Day-time resting and egress of* A. gambiae *and* M. uniformis *into window traps and through the eaves into verandah traps*

	A. gambiae								*M. uniformis*							
	Unfed		Fed		Gravid		Total		Unfed		Fed		Gravid		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Resting indoors	28	13	807	81	67	11	902	49	6	8	20	9	6	—	32	10
Egress by windows	170	80	129	13	488	78	786	43	20	26	65	31	1	—	86	28
Egress by eaves	14	7	56	6	68	11	138	8	50	66	128	60	14	—	192	62
Total	212	100	992	100	623	100	1826	100	76	100	213	100	21	—	310	100

Counts or collections were then made with the verandah traps fully operational, *i.e.*, with screens fitted on two verandahs on opposite sides of the hut and with a window trap placed to extend into each of the two verandah traps (the other two windows being closed). The total number leaving by the eaves was assumed to be twice the number caught in the two verandah traps. The results of collections of *A. gambiae* and *M. uniformis* from 29th January to 29th February 1964 are shown in Table II. The results show that 51 per cent. of females of *A. gambiae* in all gonotrophic stages left the hut each night, with 85 per cent. of the egress occurring by the window traps and 15 per cent. by the eaves. In the case of *M. uniformis*, on the other hand, 90 per cent. left the hut each night, with 31 per cent. of the egress occurring by the window traps and 69 per cent. by the eaves. When recently fed mosquitos only were considered, it was found that 19 per cent. of *A. gambiae* left on the night of feeding, with 70 per cent. of the egress occurring by the window traps and 30 per cent. by the eaves. In the case of *M. uniformis*, 91 per cent. of recently fed mosquitos left on the night of feeding, with 34 per cent. of the egress occurring by the window traps and 66 per cent. by the eaves.

Discussion

The results from the verandah-trap huts are in line with those obtained from the same area by the more cumbersome methods of surrounding a window-trap hut by a cage of mosquito-netting. For example, it was found that 12 per cent. of recently fed females of *A. gambiae* entered the window trap compared with 10 per cent. leaving by the eaves, and that 10 per cent. of recently fed females of *M. uniformis* entered the window trap compared with 72 per cent. leaving by the eaves (de Zulueta & Cullen, 1963; Smith, 1963). The techniques used with the present design of verandah-trap hut are practicable and would appear to be suitable for studying the egress of any species of mosquito that enters houses. It is concluded that, owing to the high proportion of individuals of *M. uniformis* that leaves by the eaves, the verandah-trap hut is of a more suitable design for studying the house-frequenting habits of this species, and of other species with similar habits, than the simple window-trap hut.

Summary

A description is given of a verandah-trap hut designed to assess the egress and survival of mosquitos escaping through the eaves of the type of window-trap hut used in insecticide testing in East Africa.

Fifty-one per cent. of females of *Anopheles gambiae* Giles in all gonotrophic stages and 19 per cent. of those recently fed left the hut each night, with 15 and 30 per cent., respectively, of the egress occurring through the eaves.

Ninety per cent. of females of *Mansonia uniformis* (Theo.) in all gonotrophic stages and 91 per cent. of those recently fed left the hut each night, with 69 and 66 per cent., respectively, of the egress occurring through the eaves.

It was concluded that, owing to the high proportion of individuals of *M. uniformis* that leaves by the eaves, the verandah-trap hut was of a more suitable design for studying the house-frequenting habits of this species, and of other species with similar habits, than the simple window-trap hut.

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The verandah-trap hut.

FIG. 1. One verandah trap with window trap in position. FIG. 2. The hut in operation.