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FURTHER STUDIES ON THE USE OF THE ARTIFICIAL PIT SHELTER FOR  
SAMPLING OUTDOOR RESTING POPULATIONS OF AFRICAN ANOPHELINES

by

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An entomological assessment of the malaria control campaign in Southern Rhodesia was carried out in the Mazoe valley area of the north-east region from October 1957 to March 1959. Full details of this work, much of which is more of local than general interest, will be published elsewhere. Early in the investigation it became evident that the anophelines we were dealing with - including A. gambiae - were mainly exophilic, and that searching for Anopheles in suitable occupied and untreated African huts was very unproductive in those areas. Experimental huts occupied by human bait and fitted with exit traps - a technique which has been very valuable in many other parts of tropical Africa - also gave disappointing results, indicating a low degree of indoor biting. Special attention therefore was devoted to improving methods of detecting and sampling the outdoor resting population. A study of natural outdoor resting places led to the development of the artificial pit shelter (Muirhead-Thomson, 1958) which has proved of very great value in detecting and sampling the outdoor resting of A. gambiae, the A. funestus group (including funestus, confusus and leesoni), A. demeilloni and A. marshalli.

In the entomological assessment in the north-east part of Southern Rhodesia between 8 and 12 of these artificial pit shelters were dug in and around each experimental village, and the regular catches of blood-fed and gravid female mosquitoes in these pits formed the basis for estimating seasonal changes in the incidence of the suspected main malaria vectors, and of determining their distribution in the different areas. As far as possible the pit shelter catches were supplemented by collections in natural outdoor resting places, such as ravines and shaded stream banks, and in this way a great deal of information has accrued as to the relative value of the pit shelter technique as a method of sampling different species of Anopheles.

Observations were carried out in four distinctly different areas in the Mazoe valley region of north-eastern Southern Rhodesia.

SHAMVA (3000 ft) Mine Compound. A small village which was the scene of Leeson's classical observations on outdoor resting anophelines, 1926-1928. This village was regularly treated with BHC for several years, but treatment was suspended after 1955. This is an intense focus of A. gambiae breeding in the rainy season, and there are ideal natural outdoor resting places along the shaded banks of the Shamvanyana stream.

BUGHU (3000 ft). A native reserve about 10 miles north of Shamva, but very different topographically, being mainly an undulating foothill area from which A. gambiae appears to be naturally absent, and in which A. demeilloni and the A. funestus group are dominant. The houses in this reserve have been treated regularly with BHC since 1950. In this reserve natural outdoor resting places were so diffused that routine sampling of such places proved tedious and unrewarding. In the experimental villages in this reserve we had to rely entirely on the artificial pit shelter without which it would have been extremely difficult to form any idea of the nature and abundance of the exophilic Anopheles, especially in view of the disappointing results obtained by several laborious sessions of catching on human and animal bait.

MADZIWA. A very large native reserve adjoining Bushu and of similar topography, but differing in that one of the experimental villages revealed a specially suitable ravine in which outdoor resting anophelines could be found. A. gambiae appears to be naturally rare in this area, which like Bushu has been treated regularly with BHC since 1951.

UZUMBA. Mazoe river section (altitude 2600-2700 ft). This section of the reserve is 12-15 miles further down the Mazoe valley from the other three areas. The experimental villages were situated close to the river. This is predominantly an A. pretoriensis and A. rufipes area, with A. funestus present at certain times, and A. gambiae normally present in low numbers only. Here also ideal natural outdoor resting places were found in the form of a deep dry ravine running through the experimental village.

The results of comparative samples of outdoor resting anophelines (blood-fed and gravid) taken in artificial pit shelters and in natural outdoor resting places are summarized in Tables 1-6.

The following points call for special comment:

A. gambiae

The only comparative figures available are those from Shamva which refer to the rainy season. These figures show that A. gambiae can be taken regularly in both types of outdoor resting places. The apparent slight preference for the artificial pit shelters may be due to sampling errors, or to the fact that these pits were sited nearer to the village and to the cattle pens. There is no evidence that one type of shelter is more attractive to blood-fed females or to gravid females than another.

A. funestus group

In Shamva mosquitos of this group could be taken in both types of outdoor resting places, with apparently a slight preference for the artificial pits. In Uzumba, where the pits were contrasted with a deep narrow ravine, the preference for pit shelters was much more clearly defined. However, exact comparison between the two areas is rather difficult. In Uzumba the bulk of the collections were made in the dry season, and the "funestus" was mainly A. lesoni. In Shamva, collections were confined to the rainy season, and the "funestus" group here was composed of unknown proportions of funestus funestus, funestus confusus and lesoni.

A. "demeilloni-funestus" group (predominantly A. demeilloni with varying proportions of other members of the funestus group)

The small sample from Madziwa, where a choice of resting places was available, indicates that this group also is found more readily in artificial pit shelters. In Bushu, collections were confined to artificial pit shelters, and no such comparison was possible. The pit shelters however were undoubtedly very attractive, as 28 collections between March 1958 and March 1959 yielded a total of 911 blood-fed and gravid females of this group.

A. marshalli

The small sample from Madziwa, where a choice was available, indicates a bias for the artificial pit shelter. In Bushu this species was taken regularly in pit shelters - 181 blood-fed and gravid females in 28 collections.

A. rufipes

The overall figures from Uzumba, where a choice of resting places was available, indicate that 81% of the A. rufipes taken outdoors were collected in the natural ravine. A breakdown of the figures tabulated in Table 5b reveals a further interesting seasonal difference. In the dry season 28% of the total outdoor collection were recorded from pit shelters, whereas during the latter part of the rainy season only 1% of the total was found in the pits. Under the latter conditions, therefore, collections restricted to the pit shelters would have completely underestimated the outdoor resting population of A. rufipes in this area. This seasonal change in resting preference may possibly help in interpreting the findings in Bushu, where pit shelters alone were sampled. In the hot dry weather, A. rufipes was found regularly in pit shelters (56 in 10 collections) whereas in the rainy season only four females were found in seven collections. In Bushu therefore the very low catches in the rainy season are capable of two distinct interpretations. The low figure might be a reflection of a natural low incidence of A. rufipes at that season, or it might simply be due to the fact that in the rainy season the bulk of the outdoor resting population has shifted to the widely diffused natural resting places, where they are virtually undetectable.

A. pretoriensis

The overall figures from Uzumba indicate that 88% of the total blood-fed and gravid females were taken from the natural ravine, and only 12% from the pit shelters. A breakdown of the figures - Table 6b - reveals seasonal differences in resting preference similar to those exhibited by A. rufipes, the shift to natural resting places being almost complete in the rainy season.

From these figures it is clear that the artificial pit shelter is of rather limited value in assessing the outdoor resting population of both A. rufipes and A. pretoriensis, and that during the rainy season this technique alone may completely fail to reveal the existence of those species at high population densities. The similar trends of these two species with regard to seasonal change in the selection of outdoor resting sites require further investigation, especially in view of the fact that in some areas it is difficult to find the ideal type of ravine or concentration site which yielded so many mosquitos at Uzumba. In such areas, with no detectable concentration sites, a high population of outdoor resting A. rufipes and A. pretoriensis could remain completely undetected and unsuspected during the rainy season. This point may be of more than academic interest as both these species have been found infected with malaria parasites in this reserve, and it is not yet possible to say whether these are of human or non-human origin.

TABLE 1. A. GAMBIAE. RECORD OF BLOOD-FED AND GRAVID FEMALES TAKEN IN 15 PARALLEL COLLECTIONS IN (a) 8 ARTIFICIAL PIT SHELTERS, AND (b) CREVICES IN THE BANKS OF A STREAM, SHAMVA, JANUARY - APRIL 1958

Artificial pit shelters			Natural crevices		
Blood-fed	Gravid	Total	Blood-fed	Gravid	Total
143	160	303	63	61	124

TABLE 2. A. "FUNESTUS". RECORD OF BLOOD-FED AND GRAVID FEMALES TAKEN IN 15 PARALLEL COLLECTIONS IN (a) 8 ARTIFICIAL PIT SHELTERS, AND (b) CREVICES IN THE BANKS OF A STREAM, SHAMVA, JANUARY - APRIL 1958

Artificial pit shelters			Natural crevices		
Blood-fed	Gravid	Total	Blood-fed	Gravid	Total
54	38	92	27	23	50

TABLE 3. A. "FUNESTUS" (MAINLY A. LEESONI).  
NUMBER OF BLOOD-FED AND GRAVID FEMALES TAKEN IN 37 PARALLEL COLLECTIONS  
IN (a) 12 ARTIFICIAL PIT SHELTERS, AND (b) DEEP DRY RAVINE,  
KONDO VILLAGE, UZUMBA RESERVE, JULY 1958 - MARCH 1959

Artificial pits	Ravine	Total
228	45	273

TABLE 4. A. "DEMEILLONI-FUNESTUS".  
NUMBER OF BLOOD-FED AND GRAVID FEMALES TAKEN IN 8 PARALLEL COLLECTIONS  
IN (a) 12 ARTIFICIAL PIT SHELTERS, AND (b) A DEEP RAVINE,  
MADZIWA, OCTOBER 1958 - MARCH 1959

Artificial pit shelters	Ravine	Total
71	11	82

TABLE 5a. A. RUFIPES.  
NUMBER OF BLOOD-FED AND GRAVID FEMALES TAKEN IN 37 PARALLEL COLLECTIONS  
IN (a) 12 ARTIFICIAL PIT SHELTERS, AND (b) A DEEP DRY RAVINE,  
KONDO, UZUMBA, JULY 1958 - MARCH 1959

Artificial pit shelters	Ravine	Total
178	829	1 007

TABLE 5b. A. RUFIPES.  
NUMBER OF BLOOD-FED AND GRAVID FEMALES TAKEN IN PARALLEL COLLECTIONS  
IN ARTIFICIAL PIT SHELTERS AND IN RAVINE, ACCORDING TO SEASON

	Dry season (July-October) 22 collections		Rainy season (February-March) 6 collections	
	Number found	% of total	Number found	% of total
Pit shelter	108	28	3	1
Natural ravine	278	72	410	99
Total	386		413	

TABLE 6a. A. PRETORIENSIS. NUMBER OF BLOOD-FED AND GRAVID FEMALES  
TAKEN IN 37 PARALLEL COLLECTIONS IN (a) 12 ARTIFICIAL PIT SHELTERS AND  
(b) A DEEP DRY RAVINE, KONDO, UZUMBA, JULY 1958 - MARCH 1959

Pits	Ravine	Total
62	463	525

TABLE 6b. A. PRETORIENSIS.  
NUMBER OF BLOOD-FED AND GRAVID FEMALES TAKEN IN PARALLEL COLLECTIONS  
IN ARTIFICIAL PIT SHELTERS AND IN RAVINES, ACCORDING TO SEASON

	Dry season (July-October) 22 collections		Rainy season (February-March) 6 collections	
	Number found	% of total	Number found	% of total
Pit shelter	51	24	1	0.5
Ravine	163	76	253	99.5
Total	214		254	

## Discussion

In appraising the value of the artificial pit shelter as a sampling technique for outdoor resting populations of anophelines, there are two main considerations. Firstly, there is the severely practical value of the technique in so far as it provides a simple and speedy way of collecting several species of mosquito in localities where other methods have proved either ineffective or too time-consuming. The second consideration, and the one which is the more difficult to determine, is to what extent this pit shelter sample represents a valid sample of the outdoor resting population at all seasons of the year. On the one hand, it might appear that the pit shelter, representing an ideal concentration site, might give an exaggerated conception of the mosquito population existing at any one time. On the other hand, it could equally well be argued that the area of resting place provided by these pit shelters is only a minute fraction of the total area provided by all available natural outdoor resting places in that locality, and that in this way the pit shelter sample might grossly underestimate the mosquito population.

These are basic problems of mosquito sampling which require much more critical investigation than they have been given in the past. The present preliminary report deals only with crude comparisons of the distribution of resting anophelines between two types of outdoor resting place, and we cannot assume under such widely different conditions - pit shelter versus natural resting place - that equal catches indicate equal preferences. Only on an experimental basis, in which known numbers of mosquitos in captivity (or marked and released in nature) were offered a free choice of the two different types of resting places, would we be justified in talking about preferences.

The results so far suggest a distinct difference between the reactions of one group of anophelines - A. gambiae, A. funestus and A. demeilloni - and another group represented by A. rufipes and A. pretoriensis, with regard to distribution between artificial pit shelters and natural ravines or shaded banks. Further progress towards

interpreting these findings might be made by studying the age composition of the different samples, to find out to what extent the sharply marked differences observed in the distribution of A. rufipes and A. pretoriensis between the two types of outdoor resting sites at different seasons of the year were due to seasonal differences in the age composition of the mosquito populations sampled.

#### SUMMARY

Further work on the artificial pit shelter in Southern Rhodesia has confirmed its efficiency with regard to A. gambiae, A. demeilloni, A. "funestus", and A. marshalli. In the case of A. rufipes and A. pretoriensis the pit shelter has proved a much less attractive outdoor resting place than natural ravines and crevices in shaded banks. In this latter group the preference for natural outdoor resting places rather than pit shelters is much more marked in the rainy season than in the hot dry season. The implication of these findings is discussed in relation to the validity of sampling techniques used to study outdoor mosquito populations.

#### REFERENCE

Muirhead-Thomson, R. C. (1958) Bull. Wld Hlth Org. 19, 1116