AN APPRAISAL OF ADULT MOSQUITO TRAPPING TECHNIQUES USED IN NIGERIA, WEST AFRICA *

by

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The evaluation of the various trapping techniques described here is based upon studies carried out over a period of ten years in both the tropical rain forest and savannah areas of Nigeria. The studies were carried out to estimate the relative importance of different mosquito species in the transmission of malaria and virus diseases, and to obtain information on certain aspects of mosquito biology.

Adult trapping techniques may be divided into two main categories: (1) those where mosquitoes are attracted to a point source, such as to light or a bait animal, and (2) those where adults are caught at rest or in flight without any such attractant.

GROUP 1

1. Light traps.

Light has been used as an attractant for mosquitoes in many parts of the world, particularly in the United States of America, for sampling mosquito populations and for the collection of material for virus isolation studies (CHAMBERLAIN, SUDIA, COLEMAN and BEADLE, 1964). Light traps have been little used in Africa, but some success was obtained in East Africa with mercury vapour lamps (CORBET, 1961).

In Lagos, Nigeria, a "New Jersey" type trap used over a period of 5 years gave disappointing results as catches never exceeded 5 mosquitoes per trap-night, and on many occasions none were taken. This may be contrasted with CHAMBERLAIN's results (CHAMBERLAIN *et al.* 1964) where 263 trap-nights yielded over 25.000 mosquitoes, however, the design of this trap was different. In Nigeria the principal genera taken at light have been, *Hodgesia, Uranotaenia Ficalbia, Mansonia (Coquillettidia)* and *Culex; Anopheles* were taken only occasionnally and *Aedes* were rare, suggesting that they entered the traps more by chance than by any attractive effect of the light source. On one occasion, large numbers of *Aedes aegypti* L. were taken at human bait whereas none were caught in a "New Jersey" trap with a 25-Watt tungsten bulb operating only 9 m. away. Similarly, large numbers of *Mansonia africana* Théo. have been taken at bait in the vicinity of a trap using a 125-Watt mercury vapour discharge lamp, but they neither entered the light trap nor were attracted to a white sheet positioned near the trap. Trials with discharge lamps suggested that sodium vapour lamps were more attractive to small Nematocera than mercury or cadmium vapour lamps of comparable power. Low power light sources

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such as 25-Watt tungsten lamps and parafin lamps also attracted male mosquitoes. These results, and the success of low power battery traps as used by CHAMBERLAIN *et al.* (1964), suggest that mosquitoes may be attracted more to light radiating at the red end of the spectrum, therefore further trials with low power light sources are justified.

The principal disadvantage of light traps is the large catch of insects of other orders that is invariably taken. The sorting of such mixed catches is both tedious and time consuming. Further, unless some type of killing agent is used delicate insects are prone to damage by the larger elements of the catch, rendering identification difficult or impossible. Killing agents, however, must be selected with care when mosquitoes are required for virus isolation, since one of the characteristics of an arbovirus is its sensitivity to these chemicals.

2. Bait catches.

The technique of the 24-Hour catch, developed largely by HADDOW and his colleagues in East Africa (HADDOW, 1954), is now a standard method for investigating the biting behaviour of arthropods throughout the world. When insects are not required for information on cyclical diel activity, the catching period may be abbreviated to 1700-2400 hrs. for investigations of virus vectors, or to 1800-0600 hrs. if malaria vectors are required. The catch may also be reduced if data on seasonal incidence is wanted, as long as the catching period includes at least part of the peak biting period of the species concerned. These reductions result in a considerable lowering of the cost of the catches, and the high labour cost is one of the chief limitations of the method. Besides measuring cyclical activity and seasonal variations the human bait catch has been used in Nigeria to establish the vertical distribution of mosquitoes (MATTINGLY, 1949a and b - BOORMAN, 1960 a and b), to assess the degree of exophagy of malaria vectors (SERVICE, 1963) and to compare the biting rates in normal huts with those in huts treated with insecticides (SERVICE, in press).

If variations in individual attractiveness are to be eliminated several people must be employed in the catches and used in strict rotation (MATTINGLY, 1949a - HADDOW, 1954). Recent work (KETTLE, 1963) has shown that in the genus *Culicoides* certain species or groups of species are not equally attracted to the same individual as are other species. It was also found that the relative attractiveness of an individual varied with the time of day or night. A similar careful appraisal of the attractive properties of man to mosquitoes would be of value.

Recent human bait catches in the Lagos area (BOORMAN, unpublished data) have indicated that the clearance of land for farms or road building may profoundly affect the mosquito fauna, particularly in reducing or eliminating the less common species. The habits of certain species may also vary in different localities, and sometimes over even short distances. Thus, over most of Nigeria *Ae. simpsoni* (Theo.) does not bite man, but an anthropophilic strain has been found in transitional forest-montane vegetation at over 450 m. in Bamenda area of the Cameroon Republic (YABA, ann. rept., 1952). In Western Nigeria *Ae. africanus* (Theo.) bites mainly at tree-canopy leval, but in part of Eastern Nigeria it has been found biting at ground level (BOORMAN, unpublished data). In a village in Western Nigeria, about 80 km. from the coast, *Ae. aegypti* exhibited profound differences in its biting cycles between catching stations separated by only a few hundred mètres (BOORMAN, 1960a). In the same locality the maximum seasonal incidence of *M. africana* occurred during June, whereas 16 km. from the coast the peak seasonal incidence was in September, and in coastal localities the peak was in January (BOORMAN, in press, and unpublished data).

A variation of the human bait catch that has been used in Nigeria is a modification of the bait net catches of GATER (1935). In this modified version a man sleeps under a mosquito net that is firmly tucked in except for a gap along one side through which hungry mosquitoes enter. The limitations of this method were demonstrated in a series of catches in Kaduna, N. Nigeria, where direct catching methods gave 26 mosquitoes species of which *Anopheles gambiae* Giles, *A. funestus* Giles and *A. nili* (Theo.) formed only 51 per cent. of the catch. In the bait net catches, performed simultaneously in the same village, these three species now formed

98 per cent. of the total catch, and *A. coustani* Lav. was not taken, whereas in the direct catches it was more common than *A. nili* (SERVICE, 1963). Whether certain species are reluctant to enter the nets to feed or whether they are able to escape after feeding was not determined, but this sampling method is clearly selective. In East Africa it has been shown that *Ae. africanus* is reluctant to enter expanded metal cages containing sentinel monkeys (HADDOW, SMITHBURN, DICK, KITCHEN and LUMSDEN, 1948). Moreover HAMON (1964) finds that cattle under bait nets attract species that bite man but which do not enter nets when human bait is offered. It appears that species not exhibiting a strong degree of anthropophily are easily deterred from entering these nets, and that in the present trials certain species failed to enter nets. In Singapore Colless (1959) discovered that unbaited nets may attract considerable numbers of mosquitoes, the importance of this phenomenom should be assessed in other areas where this method is used. It is obvious from these findings that reservations must be made in assessing the relative importance of anthropophilous mosquitoes by bait net collections.

Mosquitoes can be caught direct from tethered animals by man visiting them at regular intervals, but the method has the disadvantage that his presence may well attract mosquitoes that are not normally associated with the bait animal. The alternative is to employ traps that allow mosquitoes to enter in order to bite, but prevent them from leaving afterwards. However, it is most likely that such traps yield a differential catch, as exemplified by the bait net catches. It follows that great care must be exercised in comparing the results of catches from traps of different design. Caution is also needed when comparing results from two or more animals. Simultaneous use of differents baits in close proximity may lead to confusion of the attractive principals involved, and mosquitoes entering one trap may have been attracted in part by another bait animal (REID, 1961). These difficulties were realised by REID (1961) who considered that a suitable distance between baits was probably 45 m., but obviously if the distance is too great they may be unintentionnally placed in different ecological habitats. Also, if different baits are not used simultaneously, but in succession, varying climatic conditions may affect the catches, and fluctuations in the seasonal abundance of the mosquito fauna must be taken into account.

In Nigeria where goats, sheep, pigs and monkeys (*Erythrocebus patas patas* Scheber) were placed in a magoon trap for a month at a time, goats were maintained in a second trap situated about 14 m. away to act as a control and to reflect any seasonal fluctuations in mosquito densities (SERVICE, 1964d). The attraction of mosquitoes to horses and cows, which were too large to place in the magoon traps, was assessed by fitting exit traps to the doors of their stables, which were separated by about 9m. It is considered that in these experiments the relative attractiveness of the various hosts was measured. This must not be confused with host preferences. If the baits are placed in such a position that the mosquitoes receive stimuli from both baits, they are offered a choice and host preferences are measured, but if they are separated by greater distances so that no choice is offered, the relative attractiveness of the hosts is obtained.

In the above experiments sheep attracted about twice the number of mosquitoes as did goats, but there was little difference in the actual species caught except in the order of abundance in which they were taken. The most common species feeding on these animals were : *A. coustani, A. coustani* var. *ziemanni* Grünberg, *A. hancocki* var. *brothieri* Edw., *A. rufipes* Gough, *A. rufipes* var. *ingrami* Edw., *A. squamosus* Theo. and *M. uniformis* Theo. Pigs attracted about the same number of mosquitoes as goats and the catch in each case was similar. Only 16 mosquitoes were taken from the monkey baited trap, of which 10 were *Culex pipiens fatigans* Wiedermann. It is possible that species normally biting monkeys were poorly represented at ground level (HADDOW and DICK, 1948), or were reluctant to enter magoon traps. Horses attracted about twice the number of mosquitoes as did cows, but apart from this there was little difference in the catches. In each instance *A. hancocki* var. *brothieri* and *A. rufipes* var. *ingrami* were the commonest species. In all the catches culicine mosquitoes were poorly represented, they formed only 9 and 13 per cent. of the catch from the exit traps and magoon traps respectively. In considering the whole series of catches, it is obvious that no very close comparisons between the two series can be made since different trapping techniques were used, but the general impression gained was that essentially the same species of mosquitoes were attracted to all animals, with the exception of the monkey.

Precipitin tests performed on some blood-fed individuals from the magoon and exit traps

showed that a small percentage (1.4-9.4 %) had no fed on the bait animals, but had taken a blood meal prior to entering the traps. Caution is therefore required in interpreting results from any baited traps.

Another type of trap, "Trinidad no. 10" trap (BROOKE WORTH and JONKERS, 1962), was used with some success in the Lagos area of Nigeria; a typical series of results for two species is shown in Table 1.

Table 1 - Catches per trap-night of two species of mosquitoes in "Trinidad n° 10" traps, in town or forest, at ground level or in tree (6-9 m.), with mice or lizards as bait.

Locality and bait	M. annetti	M. aurites
(March-June, 1962)		
Town, ground, mice.	0.14	0
Town, ground, lizards.	0.08	0.22
Town, tree, mice.	1.40	1.30
Town, tree, lizards.	0.24	2.04
(February-June, 1963)		
Forest, ground, mice.	0.84	0.03
Forest, ground, lizards.	0.02	0.02
Forest, tree, mice.	4.50	0.25
Forest, tree, lizards.	0.21	0.20

Although the number of mosquitoes collected per trap-night was small, usually only 2-3, but occasionally as many as 40, the use of a dozen traps at any one time, provided a steady source of mosquitoes for virus isolation that would not have been obtained by more conventional baited catches. This was particularly so in the case of *M. annetti* Theo. and *M. aurites* Theo., which were of special interest as a virus belonging to Casal's Group B was recently isolated from the latter species in Uganda (ENTEBBE, ann. rept., 1963). In Yaba, a built up surburb of Lagos, lizard baited traps at ground level attracted more mosquitoes than mouse baited traps, although at tree-top level the reverse was true. *M. annetti* and *M. aurites* were both markedly arboreal in their habits, and were attracted equally to mice in these situations, but with lizard baited traps, *M. aurites* was ten times more common than was *M. annetti*. In a forest area near Lagos, a wider variety of species were taken. *M. annetti* and *M. aurites* were again found to be arboreal in habit, but here *M. annetti* was found to be twenty times more frequent at tree-top level in mouse baited traps, in contrast to being taken in equal numbers to that species in the same situation in Yaba. *Hodgesia nigeriae* Edw. was not caught in any traps in Yaba, although it was frequent in light trap catches in the locality; in the forest it showed a marked preference for entering mouse baited traps at ground-level. The two principal anthropophilous mosquitoes in the forest were shown by bait catches to be *M. africana* and *Ae. nigricephalus* Theo, but they were only taken very occasionnally in the traps; whether this was due to their reluctance to enter the traps or whether they were no attracted to mice or lizards was not demonstrated. Both species, however, feed readily on mice in the laboratory.

GROUP 2

1. Out of door resting sites.

The search for mosquitoes in their outdoor resting places has met with variable success in differents parts of Africa (MUIRHEAD-THOMSON, 1948 - WILLIAMS, WEITZ and Mc CLELLAND 1953 - GILLIES, 1954 - SERVICE, 1963). In a forest locality in Southern Nigeria relatively few adults could be found resting amongst vegetation (BOORMAN and SERVICE, 1960), but in uninhabited riverine vegetation in the Northern Guinea Savannah of Nigeria better succes was obtained. Examination of vegetation, tree-holes, rodent-holes, cracks and crevices in the ground

resulted in the discovery of adults of : *Uranotaenia mashonaensis* Theo, *U. annulata* Theo, *Ae. luteocephalus* (Newstead), *Ae. wendyae* Service, *Ae. circumluteolus* (Theo), *Ae. lineatopennis* Theo, *C. rima* Theo, *C. rubinotus* Theo, *C. inconspicuosus* Theo, *C. invidiosus* Theo, *A. gambiae* and *A. funestus*. Males and unfed females predominated in all these collections. In villages a greater proportion of *Anopheles* were found and an examination of hut eaves, tree-holes, rodent-holes and vegetation yielded 13 anopheline species, including *A. gambiae* and *A. funestus* (SERVICE, 1963). Culicine mosquitoes were rarely found in these sites, and only 1 *Uranotaenia*, 1 *Mansonia* and 3 *Culex* species were caught. The use of aerosol dispensers containing pyrethrum was found to be of value in inducing adults to leave inaccessible cracks and crevices (SERVICE, 1963), however, this method was unsuccessful when tried in a village in Western Nigeria.

2. Indoor resting mosquitoes.

The use of knockdown space sprays in huts and houses is now standard practice in assessing the densities of the endophilous species. When performed early in the morning, as is the usual procedure, only endophilous species will be caught, and the endophagous but exophilous mosquitoes such as *A. nili* will be overlooked. Further, in certain areas *A. gambiae* and *A. funestus* may be highly endophagous but also exhibit a varying degree of exophily, consequently indoor biting rates assessed on results of spray sheet collections will be misleading.

Although exit traps fitted to huts do not catch all mosquitoes leaving them, unless all other exits are sealed, they appear to trap a representative sample, and have been used in Nigeria in comparing the exodus and physiological condition of malaria vectors leaving sprayed and unsprayed huts (SERVICE, 1964a and b). When their position in huts was reversed they acted, contrary to previous findings, as efficient entry traps, and showed that blood-fed and semi-gravid, as well as unfed, *A. gambiae* and *A. funestus* entered huts.

It has been shown (SERVICE, 1964c) that apart from the general trend of huts nearest the breeding source to have larger densities of *A. gambiae* and *A. funestus* than those further away, certain huts, irrespective of their position, consistently yield more adults than others. It was also found that huts which were attractive to *A. gambiae* were also attractive to *A. funestus*. No obvious factor could be found to account for the discrepencies in the densities in the various huts, and although the number of occupants had some bearing on this, there was no direct simple correlation. Spray sheet collections performed at half hourly intervals from 0430-0730 hrs. failed to show any significant difference in the numbers of mosquitoes resting in the huts at these times, that is, no dawn exodus, as observed by MUIRHEAD-THOMSON (1948) in Lagos, was demonstrated. These findings show that there is an urgent need for studying the factors responsible for the fluctuations in mosquito densities in huts, and into the movement of malaria vectors in them. The fact that blood-fed and semi-gravid mosquitoes entered huts, shows that considerable more movement in and out of huts occurs than is generally appreciated. It is also important to be able to assess the duration of the length of stay of vectors in huts, as the pick up of insecticides in sprayed huts is dependent on this factor.

CONCLUSIONS

It will be evident from the above examples that the species of mosquito taken depends not only upon locality, time of day and year, ecological factors and the bait used, but also upon the type and design of the trap. Variations between individual traps, not readily apparent to the human eye, but detectable by mosquitoes, must also be taken into account. Apart from financial and material considerations, the final selection of any particular sampling method must depend to a large extent upon the purpose of the catch. Where a comprehensive sample of the mosquito fauna is required as many methods as possible should be used to overcome the individual bias of any one technique. Furthermore, different trapping methods should if possible be performed simultaneously so that seasonal and annual fluctuations in mosquito densities are eliminated and comparisons between various traps can be made.

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