WORLD HEALTH ORGANIZATION
ORGANISATION MONDIALE DE LA SANTÉ

WHO/VBC/71.267
ORIGINAL: FRENCH

PRELIMINARY REPORT ON POTENTIAL YELLOW FEVER VECTORS IN GHANA

by

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Objectives and programme

The purpose of this five week mission was to study the density and distribution of potential yellow fever vectors, with particular reference to Aedes aegypti, in Northern Ghana where an epidemic of the disease broke out in 1969. It was, in addition, planned to study the relationship between this mosquito and man and to compare its importance as a potential vector to that of other Aedes. Although the first part of this programme was satisfactorily completed, the second part, essentially a long-term project requiring at least a year's research, was only touched on. Furthermore, since it was possible to pin-point transmission foci in only one case (Pong Tamale), the epidemiological aspect was not investigated as thoroughly as was desirable. Lastly, we were able to collect about 20 strains of Aedes aegypti for resistance tests, the results of which will be given later, and to study some genetic criteria.

On arrival in Accra on 11 September, we contacted the public health authorities: Dr Grant, Senior Medical Officer in Charge of Epidemiology, Ministry of Health, and Dr Beausoleil, Regional Medical Officer of Health, Upper Region, as well as Mr J. O. M. Marr, WHO entomologist in charge of the onchocerciasis project at Bolgatanga. On 15 September we drove to Bolgatanga where a laboratory had been set aside for us by the Onchocerciasis Unit and where we found a team of four Technical Officers from the Malaria Service, assigned to the mission by the Ministry of Health, and also a Land Rover and driver. From 16 September to 10 October we surveyed the Upper Region and the Northern Region. From 10 to 15 October we made short visits to several places in the south where yellow fever cases had recently been reported and we concluded by looking at two villages in the coastal area so as to get an idea of the different ecological conditions in Ghana.

A short review of earlier epidemiological and entomological data will precede a report on our findings and their epidemiological consequences. In conclusion, some recommendations will be made on the lines of research which seem most urgent and the prophylactic methods desirable.

Epidemiological and entomological data

Yellow fever has been known in Ghana since the beginning of the nineteenth century, in which it regularly decimated the expatriate communities. A detailed history of the disease from 1900 to 1960 has been given by Scott.[10] The major focus, where the disease was considered endemic, was in the south of the country, in the coastal area and its hinterland within a triangle bounded by a line from Cape Coast to Ho. There was also an epidemic focus in the north of the country above the eighth parallel, whereas cases very rarely occurred in the intermediate forest area. The two foci were independent of each other, except when an epidemic beginning in the south spread to the north via the Volta Region (east) in 1937-1938.

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It is arguable which areas may be termed endemic or epidemic, since nowhere in Ghana, nor in any other West African country, has it been possible to identify the endemic foci where the virus remains in existence between epidemics. This is a large gap in our knowledge and will be discussed below.

Sero-protection tests, generally, it is true, carried out in the wake of epidemics, are positive in 35 to 55% of cases in the north, 10 to 20% in the south and in less than 1% in the intermediate forest zone.

In 1955 an epidemic, with very widely scattered cases, in the Kintampo Region on the northern edge of the forest was considered to be jungle yellow fever. Aedes aegypti was absent or rare but two non-domestic potential vector species were present; Aedes africanus and Aedes luteocephalus, and monkeys were found to be strongly positive to sero-protection tests. (Boorman & Porterfield, 1957).

Cases reported subsequently in the WHO Weekly Epidemiological Record are fairly widely spaced. There were two fatal cases at Tema near Accra in 1959, and, in 1963, one at Kumasi, and two at Damongo. The subsequent entomological survey showed Aedes aegypti to be rare in the latter area.[2]

In July to November 1969 a more serious epidemic broke out. Fatal cases of confirmed yellow fever were reported in hospitals at Jirapa, Navrongo, Bolgatanga and Bakwu in the Upper Region. Five students at the Pong Tamale Veterinary School were infested in July-August and four died. It was only in this instance that the place of infection could be positively identified and this point will be taken up again below. Elsewhere it was impossible to pin-point the villages from which patients had come, particularly as cases of infectious hepatitis are very common at this time of the year and create a serious medical problem for the region. This epidemic was part of the wave of the disease that swept over the savanna areas of West Africa (Nigeria, Ghana, Upper Volta and Mali) in the autumn of 1969.

Lastly, in April of this year two fatal cases were confirmed and two suspected cases reported at Asikasu, and several suspected cases reported at Manso, in the forest zone of the Eastern Region.[a]

Only very fragmentary entomological data on yellow fever vectors in Ghana has emerged from post-epidemic surveys. In most of the country, Aedes aegypti has obviously been found as a domestic species. It was observed in wild breeding sites in the forest zone in the south (Eastern Region) by Surtees.[11] The first quantitative data go back to 1916 to 1920 when MacFie and Ingram reported finding this species in over 80% of places where water had collected. Ingram[5] noted Aedes aegypti in 80% of the 40 places visited in the north. More recently, in 1964,[2] a house index of less than 5% was found at Damongo.

Surveys carried out in 1969 and 1970 following the above-mentioned epidemics gave an index of 8% for Navrongo and Bolgatanga and 5.8% for Paga in the north. At Asikasu in the south the index exceeded 50% and there were up to 10 adult mosquitos per house.

Data on other potential vectors are less informative. Edward[3] has given a list of capture sites. Hamon[4] has collected the data available in a paper covering the whole of West Africa.

Aedes africanus is found in the Northern Region, the Volta Region, and the Brong Ahafo Region. This wild species, whose larvae develop in tree holes, is a recognized jungle yellow

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[a] Information on recent cases was provided by Dr Beausoleil and Dr Grant.

fever vector in Uganda and was suspected to be at least partially responsible for the minor epidemic at Kintampo (Boorman & Porterfield, 1957)

Aedes luteocephalus was also found in this area, as well as all over the Northern Region.

Aedes metallicus is found in the Upper Region and in Accra.

Aedes vittatus, a mosquito very aggressive towards man and implicated in the Sudan epidemics, is present nearly everywhere in Ghana. The Ashanti Region is practically the only area where it has not been reported.

Aedes simpsoni, an important vector in East Africa, is an essential link in the passage of the virus from monkey to man. Present data indicate that it does not bite man in West Africa. This species is present throughout Southern Ghana and at least as far north as Pong Tamale.[6,11]

Lastly, Aedes (Diceromyia) of the taylori-furcifer group (females of the two species are indistinguishable) have been reported at Accra and Tikoradi. However, the species are found in all the savanna areas of West Africa and the present author has also seen them in the Upper and Northern Regions.

Country, population and habitat

On going from south to north in Ghana the volume and pattern of rainfall determine three successive vegetation zones. That part of the coast running from south-west to north-east is bordered by a plain widening towards its eastern end. Rainfall, occurring in two seasons, as is characteristic of a "tetraoric" climate, with peaks in June and October, is less than 1000 mm. The vegetation is of a dry savanna, almost steppe-like type, with bushes and coconut trees along the sea.

Inland, the same type of climate is found, but with a rainfall of 1500 to 2000 mm in conjunction with various types of forest that extend to slightly beyond the seventh parallel. This forest has often suffered from the activities of a dense population and no longer forms a homogeneous mass. Its greatest expanse, consisting of at least three botanically distinct types, lies to the west of the Volta and is a continuation of the Liberian-Ivory Coast forest. A succession of small wooded areas are found in the eastern part, on the Togo border between the 6.3° and the 8°N parallels.

The two areas are separated by a corridor partially occupied by the artificial lake on the Volta and linking the vegetation characteristic of the south to the savanna covering all the country north of the forest. The still heavily wooded country beyond the forest yields place gradually to the savannas of Guinea, and of the Sudan in the extreme north. In the Upper Region, the very extensive areas under cultivation have greatly modified the original vegetation. The rainfall system gradually changes from the equatorial type with four seasons to the tropical type with two seasons. Rainfall varies from 1300 mm in the south to 1000 mm in the north with a peak in August. The rainy season ends in October.

Our survey was thus conducted at the end of the rainy season in the north. However, in the coastal area there had been no rain since June although October should have been the wettest month of the second rainy season.

Population density in the north varies considerably from one district to another. The eastern part and the north-west corner of the Upper Region are densely populated (over 75 and frequently more than 200 inhabitants per square mile). The central western part of this Region as well as the east of the Northern Region are less densely populated (10 to 75 inhabitants per square mile) while the population of the west of this Region is relatively sparse (less than 10 inhabitants per square mile).

Different ethnic groups live in the two northern regions and the local administrative units, often named after the dominant ethnic group, are a fairly good guide to their distribution.[a] Ethnic differences explain the variation in types of housing and methods of water storage, which in other parts of West Africa, particularly in Upper Volta, have a direct influence on the density of Aedes aegypti.[8] For this reason working sites were chosen on the basis of the distribution of the various ethnic groups.

In rural areas (except in the north-west) the dwellings consist essentially of round thatched-roof structures, some of which are used as living quarters, and others for cooking or for storing foodstuffs or even water. These constructions are grouped inside a compound, the whole making up the basic social unit or "household" ("yeirah" in Frafra). There may be from two to 20 of these structures to a compound depending on how many families, generally related to each other, live together. In the western districts of the north (Lawra, Wala, Gonja praparte) the household enclosure contains flat-roofed, closely spaced and interconnected structures giving the visitor the impression of walking through an underground village.

Dwellings are widely scattered among the millet fields, in the heavily populated areas (around Bolgatangana, Bakwu and Lawra) but in most of the Northern Region and the centre-west of the Upper Region they are generally clustered together in villages.

In the larger population centres some buildings of the traditional type still exist but there is an increasing tendency towards rectangular structures, with several rooms, roofed with thatch or corrugated iron. Three or four are generally built around a courtyard to form a "block". Individual houses of varying higher standards of comfort are found, depending on the degree of development.

In all rural dwellings, water is kept in earthenware jars holding 20 to 50 litres. The biggest jars are kept for making "pito" the local beer. Jars are generally kept outside the kitchen but within the compound. This is not however always the case and drinking water may also be stored within living quarters. Both methods of storage are often used together in the same household, but in the western districts of the Upper Region and in the Northern Region it seems more common to keep containers inside dwellings than in the centre and west of the Upper Region. However, there appears to be no general rule even within the same ethnic group, where wide differences have been noted. Water jars are not usually moved and are filled from wells or taps with buckets or small drums. Metal drums holding 200 litres are often used to store water, especially rain water. There are many more of them in the towns than in the country and in some districts of Tamale or the Ashanti town of Konango they were the only storage containers used. In the fishing villages along the coast, metal drums are used outside dwellings and jars inside.

Water is generally obtained from wells or, in the larger population centres, from piped water supplies. At the time of the survey, only the coastal villages had any water supply problem.

Lastly, it should be noted that in most villages there was a definite surplus of jars and those remaining unused were left uncovered and became filled with rain-water.

Water for chickens and pigeons is often placed in special containers.

In conclusion, it should be noted that there are a great many small jars containing traditional medicines made from pulping or boiling down plants.

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[a] Reference has been made to the maps prepared by the Ghana Government and the United Nations Development Programme: "Ethnic Groups and villages" and "Boundaries of Region and local authorities in Ghana".

Survey methods and assembly of results

Since not all the population centres in the north, nor even all the dwellings in a given village could be visited, a certain number of localities were selected to give a representative cross-section of the ecology, habitat (isolated farms, villages and towns) and ethnic groups. Depending on the size of the population centre, visits were made to between 20 and 100 houses, selected from various districts. In each house drinking water containers and all places where water had collected both inside and outside the compound were examined. Dumps of old tyres and scrap iron were also examined as well as installations around modern buildings.

In establishing the indices, the term "house" was taken to include all the buildings occupied by one family. There were from one to six houses in each compound of traditional dwellings or in each town block. In Northern Ghana, the "house" is obviously a rather vague and unsatisfactory term but it does represent units of comparable size while "households" could vary in size by a factor of 10. A note of the number of households was also taken and this data can be supplied if required.

Since it was the rainy season, only those containers in which there was water likely to harbour Aedes larvae were considered. Thus, of the empty jars and drums, only those in a position to capture rain-water during this season were recorded. Likewise, jars used for preparing beer, coaltar, or preparations for coating walls, etc. were not included. All containers found in the compound whether inside or outside dwellings were considered to belong to the "house". In both cases these larval breeding places were in very close contact with man, especially at dusk, the active period for Aedes aegypti, when the inhabitants generally congregated in their yards. The house index gives the percentage of houses with at least one positive breeding place. The container index gives the percentage of containers harbouring Aedes aegypti larvae. The Breteau index gives the number of positive larval breeding places per 100 houses. These indices are listed in Table 1. The very varied types of outside breeding site are shown in a separate column since it is difficult to fit them into the indices designed for a domestic insect, although they might have been included in the container index.

Adult mosquitos were captured on human bait between 5 and 7.30 p.m., the peak period of Ae. aegypti activity. Results will be given in the body of the text but such captures are too few in number to warrant tabulating.

Lastly, Table 2 lists all sites where potential Aedes vectors of yellow fever other than Aedes aegypti were captured.

Aedes larval breeding places and indices

In the savanna of Northern Ghana Aedes aegypti is mainly a peridomestic mosquito.

Larvae are found in drinking water containers both within and outside dwellings. The percentage of containers affected varies from one village to another, and even from one house to another, depending on the rate at which water is used and the method used to clean the jars. No simple overall picture emerged for any given ethnic group.

During the rainy season, rain-water accumulated in unused jars, broken pots, drinking troughs for pigeons, and medicine jars, which provided more numerous and productive breeding sites than drinking water containers.

It may be that these proportions are reversed in the dry season when the lack of drinking water leads to longer storage periods so that drinking water containers will harbour a greater number of larvae while many other breeding sites will disappear.

Indices were generally noted to be high and Northern Ghana may be considered as a major Stegomyia focus. The Breteau index, one of the most informative indices used in surveys in many other countries of West Africa, was found to be as follows:

over 50: Kusasi District, Northern part of Wala District, Nakpanduri;

between 20 and 50: the other sites visited in the Upper Region apart from Tumu 16, Namgodi 13 and a few small villages. Most of the Northern Region except for the places given in the following paragraph;

below 20: in the Northern Region: Tamale, the two Gonja Districts and some villages in South Mamprussi. In the south: the Ashanti village of Konongo and the villages of the Eastern Region.

In the vicinity of Accra, one fishing village had an index of 70 while a farming village not far away had an index of only 5.

Aedes aegypti is probably present in all villages of Northern Ghana. Indices are generally higher in the Upper Region than in the Northern Region and lower in large towns than in villages. Bakwu is the exception to the rule. The highest indices recorded were in this large town which has a piped water supply.

In Bongo near Bolgatanga no differences were found on comparing the indices for that locality with those for isolated dwellings in millet fields (36 in both cases). There were marked differences between different districts in towns (Tamale, Bolgatanga and Wa), Aedes being abundant where housing standards were lower.

The house indices recorded were higher than those found during a survey made in the dry season (December 1969).

Over the whole of Northern Ghana the Aedes aegypti indices may be regarded as high or even very high.

The figures give a good picture of the density of domestic breeding places. However, other man-made breeding places are sometimes responsible for sometimes intense proliferation of this mosquito.

In towns the significant role played, particularly in the rainy season, by dumps of worn-out tires should be stressed. Such dumps afford numerous and very favourable breeding sites, often more productive than all the other town breeding sites together. Such conditions were noted at Bolgatanga and Jirapa, in particular, in such epidemiologically exposed sites as the lorry station and the hospital yard respectively.

At the Pong Tamale School for Veterinary Assistants, Aedes aegypti larvae were extremely abundant in the rain-water that filled the drains running round the school buildings and also in disused septic tanks.

At Navrongo College, reservoirs and scrap iron dumps were highly productive. On a previous occasion Dr Beausoleil had observed larvae in the laboratory water tanks.

Thus no survey can confine itself to the traditional domestic breeding places but should also take into consideration the problems posed by warehouses, tire dumps, the installations of modern buildings, etc. A survey of all possible breeding places is out of the question. For this reason it is essential to locate infected sites as accurately as possible so that not only the general conditions for Aedes development may be established but also the particular circumstances favouring yellow fever transmission determined.

No careful search for Aedes aegypti natural breeding sites has ever been carried out in Northern Ghana. This would be a long-term task and one beyond the scope of our mission. Nevertheless, tree-holes were looked for but found to be rare, and those which were examined (12 in all) held only Culex. In Northern Ghana, wild breeding sites are hardly likely to rival domestic ones in importance. In the south it is quite another matter, but, although Surtees'[11] work has already been mentioned, there has never been any attempt to evaluate the relative importance of the wild and domestic populations in their relations with man.

Aedes vittatus is a mosquito breeding in holes in rocks, generally at the beginning of the rainy season when its more slowly developing predators have not yet infested the water in its breeding places. Later in the season its larvae disappear from these biotopes. In fact, none of the many rock holes examined contained Aedes larvae. On the other hand, Ae. vittatus larvae were found in domestic pots and drinking troughs for pigeons exposed to the sun in a high proportion of the localities visited. There were never many breeding places to a village (a maximum of four at Paga). Granite outcrops and piles of boulders containing many pockets of water are common all over the Upper Region. Such biotopes should be examined again at the start of the rainy season since many Aedes vittatus breeding places might then be found.

The other potential Aedes yellow fever vectors, generally species breeding in tree-holes, were not found in the larval state. This survey was not particularly concerned with tracking down such larvae, since it is generally a very arduous task. Some Aedes simpsoni larvae were found in taro leaf axils at Pong Tamale but this was all.

Adult mosquitos and their contact with man

Information on the proportions in which the various potential yellow fever vectors bite man was obtained from a series of captures made on man between 5 p.m. and 7 p.m. in different types of habitat in the region, i.e. Bolgatanga (market and hospital), Navrongo (school), Pong Tamale (school), Jirapa (hospital), Yendi (town), Bakwu (town), Pongo (rural area), Nakpanduri (village and rest house). Each place was visited once only.

Although this was the time of the year when these mosquitos multiply and capture was effected during the hours of their peak activity, the results are considered to be no more than very incomplete pointers since there were too few data to be of effective use. The results were as follows:

At Bakwu: 10 Ae. aegypti per man per evening both inside yards and in the adjoining streets. 1 Aedes of the furcifer taylori group.

At Bongo, in a region with scattered rural dwellings: 10 Ae. aegypti and 1 Ae. vittatus per man per evening.

In the town of Yendi where all main roads are lined with trees in a district with few Ae. aegypti breeding places: 1.3 Ae. aegypti + 1.3 Ae. luteocephalus + 1 Aedes gr. furcifer taylori per man per evening.

At Nakpanduri, in the village: 3 Ae. aegypti + 0.7 vittatus + 1.3 Aedes gr. furcifer taylori. Near the rest house at the top of a wooded cliff 1500 m from the village: 10 vittatus + 36 Aedes gr. taylori furcifer + 9 Ae. metallicus + 6 Ae. luteocephalus + 2 Ae. aegypti per man per evening.

At Pong Tamale, around the classrooms of the Veterinary Assistants' School: 28 Ae. aegypti + 0.25 Ae. vittatus + 0.25 Aedes gr. furcifer taylori per man per evening.

In the grounds of the school at Navrongo: 12.5 Ae. aegypti + 0.2 Ae. gr. furcifer taylori per man per evening.

At Jirapa hospital: 32 Ae. aegypti per man per evening in the vicinity of the tire dump and 6 per man per evening, 50 m away from the breeding place.

At Bolgatanga hospital: 4 Ae. vittatus + 1 Ae. aegypti per man per evening. Capture operations in town near the market were disturbed by the crowd.

The above figures show that although Ae. Aegypti predominates in villages this is no longer the case away from the population centres where their breeding places are situated (Nakpanduri rest house, Bolgatanga hospital).

Aedes aegypti females are found to be extremely numerous in the immediate vicinity of major breeding places, often those of a special nature (Pong Tamale school, tire dumps at Jirapa). In villages elsewhere they are much less numerous even when, as at Bakwu, larval indices are very high.

Lastly, it should be noted that although most Ae. aegypti captured were of the black variety characteristic of continental Africa, 10% of the specimens from Bakwa and Bongo were of the light coloured variety generally found in African coastal areas.

Ae. vittatus were rarely captured but must be more abundant at the beginning of the rainy season, at least in the Upper Region.

Although Aedes of the taylori-furcifer group were found everywhere they were only abundant at Nakpanduri in the heart of the wooded savanna.

Ae. luteocephalus and Ae. metallicus were too rarely captured to call for comment.

Epidemiological considerations

No survey carried out one year after an epidemic could lead to any final identification of the vector or of modes of transmission, particularly as the contamination site was not accurately known in most cases. However, some likely epidemiological hypotheses may be put forward.

The only place of infection known with certainty was at the Pong Tamale Veterinary School. From information given by the Director it appeared that the Aedes aegypti situation was probably the same as it had been the year before. Since these mosquitos were produced in abundance near the classrooms, the latter were the very places they entered to bite students, and they did so in large numbers. Peak activity of the mosquito coincided with the times when classes were held. It is reasonable to suppose that in this case Aedes aegypti was responsible for transmission.

At other places in the north, only the hospital in which cases were diagnosed was recorded and the villages from which patients came were not known. However, aegypti indices (Breteau index) were everywhere over 10, the threshold value below which epidemics are not considered to spread.[8] In addition, this is the dominant Aedes species in towns and villages.

Inter-human transmission in towns and villages is likely to be largely through Ae. aegypti. Nevertheless, other Aedes, particularly Ae. vittatus, may have played a secondary role in various places.

At present there are no data on any appearance of this epidemic among the wild fauna, particularly monkeys, three species of which (patas, baboons and green monkeys) are fairly common in Northern Ghana. In adjoining areas of Upper Volta, over 50 per cent. of monkeys recently examined gave positive yellow fever serological tests. The virus can only pass from monkey to man and vice versa through forest Aedes species (vittatus, luteocephalus, africanus, metallicus, furcifer taylori, etc...) since Aedes aegypti is rarely found far away from human

habitations. In view of the ecological similarities between Upper Volta and Northern Ghana it is very likely that this process took place. Consequently, the 1969 epidemic should not be definitely limited to an outbreak of human cases transmitted by Ae. aegypti as it might also possibly have been linked with an epizootic, particularly among monkeys, in which wild Aedes might have been implicated.

In the forest zone of Southern Ghana, at Asikasu, the different cases appearing in April 1970 were closely investigated by Dr Grant and Dr Herron (personal communication). Patients came from the same family or were close neighbours. The aegypti index for the village was 50 per cent. and the patient's house itself contained eight aegypti per room. This was almost certainly a minor inter-familial epidemic transmitted by aegypti and the first patient might have been infected in the neighbourhood of Manso where several highly suspicious cases were reported during the same period. It will never be possible to tell whether the virus was of jungle origin or if it came from the 1969 epidemic in the north. However, the first supposition should not be dismissed, particularly in view of the time lag between the end of the epidemic in the north and the appearance of cases in the south.

The all too frequent use of the conditional tense in any discussion of yellow fever epidemiology in West Africa merely reflects the vagueness of and the gaps in our knowledge of this subject. It is true that a high number of positive serological tests are known to have been given by monkeys in Northern Ghana at one time and in Upper Volta more recently, but no natural focus where the virus is maintained in the absence of man during inter-epidemic periods has yet been detected, so that the origin of the virus responsible for inter-human epidemics still remains unknown. The primary purpose of yellow fever studies is to locate natural foci in order that the real reservoirs of the virus and its transmission cycles among animals and from animals to man may be determined. The epidemiological patterns for jungle yellow fever which have been so excellently worked out for East Africa are not directly applicable to the West of the continent, for Ae. simpsoni, the transmission agent between monkey and man in Uganda, is not anthrophilic in West Africa. In addition, monkeys do not seem numerous enough to be the only reservoirs of virus. Nevertheless, they may constitute good clues in the search for natural foci.

Sporadic occurrence of microepidemics or isolated cases during the last few years at Kitampo, Damongo and more recently Asikasu, indicates that such natural foci may exist in the centre and south of Ghana. Intensive epidemiological, virological and entomological surveys, started as soon as isolated cases occur, would give the best chance of locating such foci. Further study of such foci would be a long-term project calling for a strong team of specialists (virologists, entomologists and zoologists).

The delimitation of natural foci and research into how they operate is one of the essential bases for drawing up a yellow fever prophylaxis plan aiming at the elimination of trigger points for epidemiological outbreaks.

Alongside this intensive research programme, a series of simple studies on the mosquitos responsible for interhuman epidemics might even now be considered, and simple and effective methods envisaged for controlling Ae. aegypti, the principal vector.

Both these mosquitos and the other potential vectors should be quantitatively mapped to locate epidemiologically exposed regions. Their population dynamics should also be studied in the various bioclimatic zones. This data should be fairly easy to obtain for Ae. aegypti, but more difficult in the case of wild species where other data, such as the range of their trophic preferences, their vector capacity and the extent of their contacts with man must also be gathered.

Vector control

Ae. aegypti control is primarily directed against the larvae. Health education combined with improvement of water supply would be the ideal method. Removal of all old pots, the cleaning and putting under cover of all unused containers, the bi-weekly replacement of water in drinking troughs for pigeons and chickens, etc. are all simple domestic hygiene measures that would considerably reduce the number of breeding places. The problem of drinking water storage may be partially solved by piping water into villages. This would, in particular, eliminate the need for keeping large stocks of water in metal drums. Yet although great progress has been made, not all villages will have piped water supply in the immediate future. Even where this has been done it will be difficult to get the population to stop using the traditional earthenware jars in which the water becomes clear and cool. An example of this is seen at Bakwu, a town with a good water supply but where the Breteau index is as high as 200. However, thorough cleaning of jars and complete replacement of water every three or four days would considerably reduce the number of breeding places.

As regards collective hygiene, the incidence of Ae. aegypti may be considerably reduced by eliminating or putting under cover, large dumps of worn-out tires, by covering water tanks and reservoirs, and by having properly functioning drains.

Most of the measures recommended here have long been known to the health services and even to the population. In many villages, the inhabitants destroyed drums, jars or pots or emptied out any remaining water before the team's visit, which showed them to be aware that they had not followed health service instructions. In other places, holes had been made in tires to allow water to run out but only on top of the tire where they were of no use.

A health education campaign directed towards all sections of the population, including health service officials, should create a general awareness of the problem and provide at least a partial solution.

However, experience has shown that such measures are insufficient and that, at least during epidemics, insecticides must also be used.

DDT and BHC are readily available and have been used for a long time but the development of resistance to these two products makes their continued use increasingly uncertain. Nothing is known of the susceptibility of Ae. aegypti in Ghana to insecticides, and 20 strains were collected for laboratory tests. As soon as these have been completed the authorities concerned will be informed of the results.

At present the larvicide of choice is Abate. It is extremely active and will kill all larvae present at concentrations of less than 0.01 mg per litre. Since it has no toxic effect on man under normal conditions of use and has no offensive taste or smell, it is an ideal product for treating drinking water. In Upper Volta, treating jars with 1% Abate granules eliminates larvae for a period of one month, even when the water is changed, since the product adheres to the porous walls. The theoretical dose required is 1 mg of pure product per litre of water.[8] During epidemics, in cases where this product is not available, DDT may be used for peri-focal spraying (around breeding places) and house spraying provided that resistance to this product is not high. More recently, some authors have advised aerial application in emergencies, in the form of Ultra Low Volume Spraying of organophosphorus compounds (malathion, fenitrothion, naled) or carbamates (arprocarb). Such treatment has the advantage of reaching some relatively wild species such as Ae. vittatus.

To conclude this report, some recommendations on research and prophylaxis will be made.

Conclusions

Northern Ghana and the Upper Region in particular may be considered as an extensive Stegomyia focus. The interhuman epidemic of 1969 seems to have been transmitted by Ae. aegypti but there may have been a parallel epizootic among wild animals, particularly monkeys, transmitted by wild Aedes capable of passing the virus from animals to man and vice versa.

It would be advisable for studies to be carried out over the whole of Ghana to determine the density of Aedes aegypti, its contacts with man and its breeding places whether domestic, urban or wild (this last has particular importance in wooded areas). It is also desirable to know how susceptible to insecticides this mosquito is in various regions particularly in areas where residual insecticides have been used for malaria control.[a]

A second area of investigation is the study of the relationships between the various species of potential Aedes yellow fever vectors and man in towns, hamlets, cultivated fields and anywhere else man may come into contact with these mosquitos. This would be a long-term project for several semi-permanent stations representing various ecological and human environments, and would have to be directed by highly qualified staff.

Lastly, each case of yellow fever should be investigated by very thorough epidemiological, virological and entomological surveys to determine the origin of the virus. This is one way of finding possible natural foci. The problem concerns not only Ghana but all of West Africa. It would be advisable for the WHO Regional Office to organize a team of specialists to take immediate action not only during epidemics but whenever apparently isolated cases occur. The present author believes, moreover, that teams such as this have already been set up in recent years and have taken action in several areas in Liberia, in particular. In the writer's opinion such a team should, apart from giving advice on preventive measures, conduct, or rather prepare for research by locating natural foci. For such work, action should be taken not only during epidemic outbreaks but also when isolated cases occur.

The Ghana Health Authorities are concerned with stepping up health education. The elimination of domestic and peri-domestic breeding places might be included in such programmes. At this stage there is no point in separating Aedes control from control of other mosquitos, Culex fatigans in particular, which harasses city dwellers in tropical regions by its aggressiveness at night and which in many places is a vector for Bancroft's filariasis. Dr Ganicky, WHO Advisor at Accra, told me of his wish to see anti-mosquito prophylaxis included in the syllabus for an eight week health education refresher course which was to be given at Accra. This would be an excellent idea.

In addition, there is a very good network of health officers responsible for matters of hygiene. They should follow a course of further training at the regional level since it is they who will have to deal with urban breeding places in areas under the authority of municipalities, public works (tire dumps), hospitals, schools, etc. Such breeding places are frequently as important as domestic breeding places.

Entomological research is carried out by the Ghana Health Service whose Malaria Service has a very good team of technicians with a sense of responsibility and degree of competence which were very evident to us. There is another small team with a young trainee entomologist at the National Institute of Health. In addition, Dr Grant is considering entomological training for staff seconded to the regions. These persons should be able to carry out density counts of Aedes aegypti fairly quickly and to collect strains for insecticide tests. A few more experienced entomologists are needed to organize and direct research into the Aedes-man relationship. WHO can undoubtedly help in the education and further training of the staff required.

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[a] The best method of standardizing results is to gather Aedes aegypti eggs from as many localities as possible, either by means of trap breeding places or by breeding larvae. The eggs should be sent to a well equipped laboratory where small colonies would be raised for use in tests.

ACKNOWLEDGEMENTS

We should like to express our grateful thanks to the Ghana Health Authorities, in particular Drs Beausoleil and Grant, who provided us with all the personnel and facilities needed for our mission, Mr J. O. M. Marr, WHO Entomologist who very efficiently prepared the ground for our mission and who gave us constant assistance during it, Dr Chinnery and Dr Herron whose welcome and support at Accra were much appreciated.

We should also like to thank Technical Officers J. Tumfud, J. A. Klutze, V. L. Ampah and P. K. Aparku and also Mr Yaro Frafra, all of whom very willingly undertook the many extra hours of work that our heavy workload entailed.

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TABLE 1. AEDES AEGYPTI INDICES IN GHANA

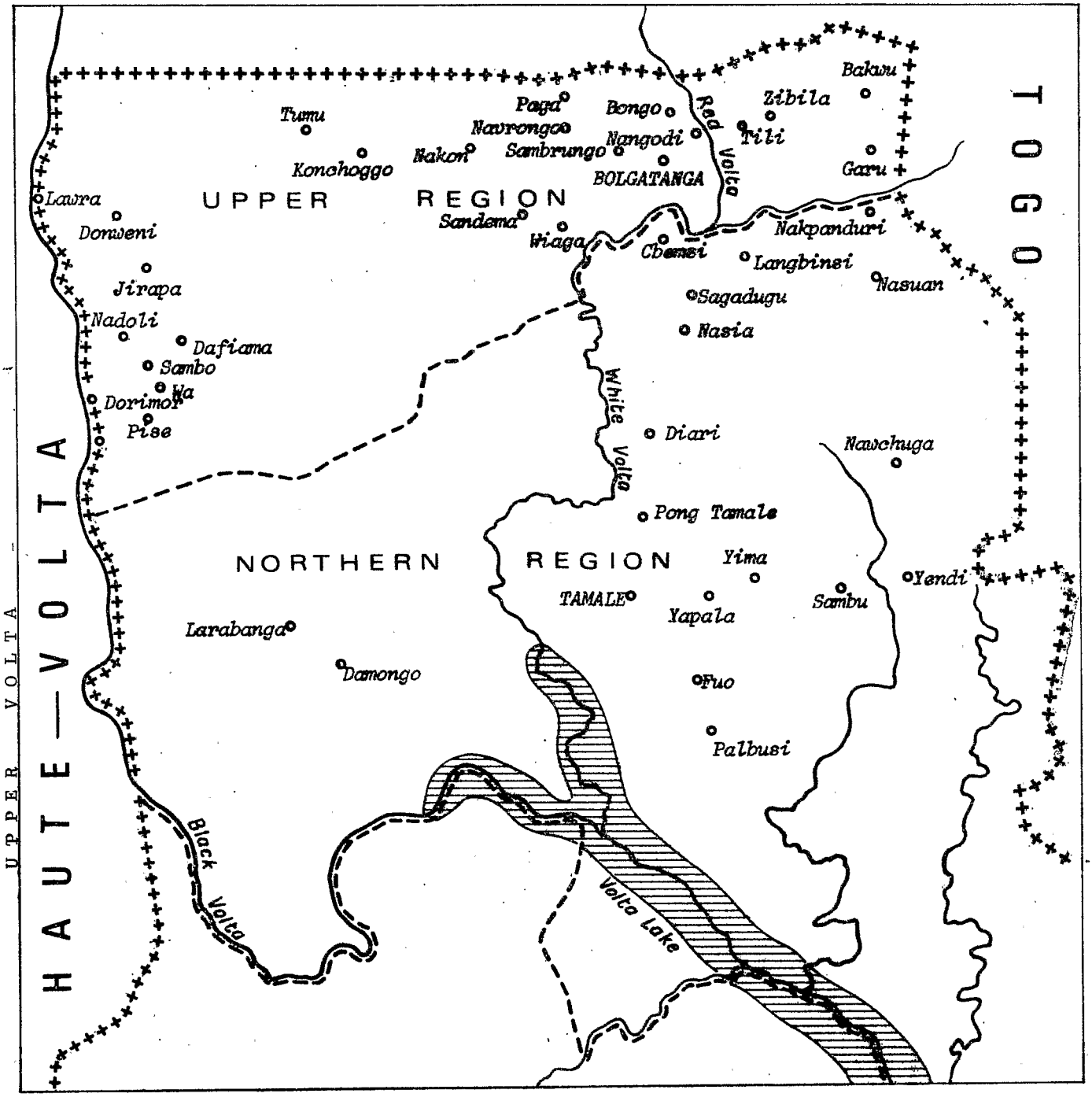
TABLEAU 1. INDICES D'AEDES AEGYPTI AU GHANA

Region Région	Local authorities Autorités locales	Locality Localité	Long.	Lat.	Houses visited Maisons visitées	No. positive Nombre positifs	House Index Index maison	Containers examined Containers examinés	No. positive Nombre positifs	Container index Index container	Breteau index Index Breteau	Other positive outside breeding places Breeding places visited Autres gîtes extérieurs positifs Gîtes visités
UPPER REGION	Kusasi	Bakwu	0,15 W	11,04 N	31	28	90	125	63	50	203	7/8 tyres and scrap iron - pneus et ferrailles
		Garu	0,11 W	10,52 N	26	21	81	116	32	28	123	8/11 abandoned containers - récipients abandonnés
		Zebila	0,28 W	10,56 N	20	8	40	72	10	14	50	2/13 scrap iron - ferrailles
		Tili	0,33 W	10,53 N	20	11	55	70	12	17	60	4/10 abandoned pots - poteries abandonnées
	Fra Fra	Namgodi	0,40 W	10,52 N	47	5	10	87	6	7	13	0/9 outside containers - récipients extérieurs
		Bolgatanga	0,52 W	10,47 N	105	18	17	270	23	8,5	22	16/29 tyres - pneus, 1/21 jars - jarres
		Bengo	0,48 W	10,54 N	52	15	29	140	19	14	36	2/16 pots - poteries
		Sambrungo	0,56 W	10,48 N	23	12	52	54	12	22	52	3/17 pots - poteries
	Kassena	Navrongo	1,05 W	10,54 N	42	9	21	139	14	10	33	22/75 various breeding places - gîtes diver
		Paga	1,06 W	10,59 N	25	6	24	65	7	11	28	
		Nakon	1,27 W	10,48 N	15	3	20	30	4	13	27	
	Builsa	Sandema	1,16 W	10,44 N	50	13	26	120	15	12	30	0/8 pots - poteries
		Wiaga	1,15 W	10,39 N	20	4	20	47	6	13	30	7/19 tyres - pneus
	Tumu	Konchoggo	1,42 W	10,51 N	19	3	16	31	3	9	16	0/5 pots - poteries
		Tumu	1,59 W	10,52 N	50	8	16	118	8	7	16	5/15 pots and tyres - poteries et pneus
	Lawra	Lawra	2,53 W	10,39 N	60	24	40	162	26	16	43	3/5 tyres - pneus
		Jirapa	2,42 W	10,32 N	52	13	25	118	16	13	30	20/22 tyres - pneus
		Donweni	2,43 W	10,39 N	52	18	34	106	20	19	38	
	Wala	Dafiama	2,34 W	10,25 N	36	16	44	102	22	21,5	61	
		Nadoli	2,40 W	10,22 N	30	12	40	100	18	18	60	
		Sambo	2,33 W	10,14 N	31	27	87	115	35	30	113	
		Wa	2,30 W	10,03 N	71	17	24	159	18	11	25	2/31 pots - poteries
		Dorimon	2,41 W	10,02 N	34	7	20	123	8	6	24	
		Pise	2,40 W	9,57 N	36	15	42	86	17	20	47	
		Vere	2,36 W	9,56 N	222	3	14	75	3	4	14	
NORTHERN REGION	South Mamprusi	Nakpanduri	0,11 W	10,38 N	30	13	43	100	18	18	60	0/12 various - divers
		Nasuan	0,10 W	10,30 N	40	9	22	67	9	13	22	
		Nasia	0,48 W	10,09 N	32	6	19	64	6	9	19	
		Gbemsi	0,50 W	10,23 N	32	4	12	88	5	6	16	
		Langbinsi	0,33 W	10,24 N	34	16	47	113	19	17	56	3/4 tyres - pneus
		Sagadugu	0,39 W	10,22 N	31	4	13	81	5	6	16	
	Eastern Dagomba	Yendi	0,01 W	9,26 N	49	18	37	168	21	12	43	4/8 jars - jarres
		Nowchugu	0,05 W	10,05 N	16	3	19	42	4	10	25	1/3 jars - jarres
		Sambu	0,05 W	9,25 N	20	8	40	43	9	20	45	
	Tamale	Tamale	0,51 W	9,23 N	98	7	7	263	7	2,6	7	
	Western Dagomba	Yapala	0,35 W	9,22 N	11	0	0	21	0	0	0	
		Yimahinayili	0,40 W	9,22 N	12	1	8	22	3	13	25	
		Pong Tamale	0,50 W	9,40 N	40	11	27	96	12	12	30	Extensive breeding places at the school - Enormes gîtes de l'école
		Diari	0,52 W	9,52 N	23	7	30	50	8	16	35	
	Eastern Gonja	Fuo	0,38 W	9,16 N	23	2	9	43	2	4,6	9	1/4 tyres - pneus
		Palbusi	0,32 W	9,00 N	11	2	18	23	2	9	18	
	Western Gonja	Damongo	1,49 W	9,05 N	75	10	13	152	14	9	19	9/26 tyres and others - pneus et divers
		Larabanga	1,52 W	9,12 N	7	0	0	22	0	0	0	
ASHANTI REGION	Kumassi	Konongo	1,13 W	6,37 N	14	0	0	28	0	0	0	3/13 tyres - pneus
EASTERN REGION	West Akin	Asikasu	0,34 W	5,46 N	20	3	15	53	3	6	15	0/31 various - divers
	Abuakwa	Akwatia	0,48 W	6,02 N	53	2	4	77	2	3	4	11/15 tyres and pots - pneus et poteries
ACCRA REGION	Ga Damgbe	Pram Pram	0,07 E	5,43 N	21	10	48	54	15	27	70	
	Shai	Nyighenya	0,13 E	5,48 N	21	1	5	21	1	3,5	5	

TABLE 2. OTHER SPECIES OF AEDES COLLECTED IN GHANA

TABLEAU 2. AUTRES ESPECES D'AEDES RECOLTEES AU GHANA

Species Espèces	Region Région	Locality Localité	Larvae Larves	Females Femelles
Aedes vittatus	Upper Region	Bolgatanga	+	+
		Pago	+	
		Navrongo	+	+
		Zebila	+	
		Tili	+	
		Bakwu	+	+
		Garu	+	
		Bongo	+	+
		Sandema	+	
		Tumu	+	
		Lawra	+	+
		Sambo	+	
		Wa	+	+
		Nadoli	+	
	Northern Region	Nakpanduri		+
		Pong Tamale		+
		Langbinsi	+	
		Sagadugu	+	
Aedes simpsoni	Northern Region	Pong Tamale	+	
Aedes metallicus	Northern Region	Nakpanduri		+
Aedes luteocephalus	Northern Region	Nakpanduri		+
		Yendi		+
Groupe furcifer-taylori	Upper Region	Navrongo		+
		Jirapa		+
		Bakwu		+
	Northern Region	Nakpanduri		+
		Yendi		+
		Pong Tamale		+



Prospections sur Aedes aegypti au Nord Ghana

Aedes aegypti survey in Northern Ghana