WORLD HEALTH ORGANIZATION

a 62353

ORGANISATION MONDIALE DE LA SANTE

WHO/Mal/342
26 April 1962

ORIGINAL: ENGLISH

ANOPHELES GAMBIAE GILES AND EPIDEMIC MALARIA IN THE HAUD OF THE NORTHERN REGION OF SOMALI REPUBLIC

by

N. Rishikesh, Ph.D.,
WHO Entomologist, Malaria Eradication Project
Mogadiscio, Somali Republic

Synopsis

A serious problem in the Northern Region of the Somali Republic is the cyclical malaria epidemics occurring among the nomadic stockherders in the southern grazing lands known as the Haud. The only sources of water in the area during the dry months are man-made cement underground tanks and deep wells sunk in the bed of extensive rain pools called "ballehs". Findings indicate that A. gambiae, the vector, breeds in the tanks throughout the year and these tanks thus constitute residual breeding foci from which the species may spread to neighbouring areas in the Haud during the rainy season. The mode of dissemination is by transportation of the adult mosquitos with the portable huts of the nomads and of the immature stages with drinking-water. In a year of good rainfall the species may show a considerable spread in distribution and increase in numbers by the latter part of the main rainy season (April-June). The short duration of the second rainy season (October-November) precludes the possibility of any appreciable build-up in vector density during that period. The ballehs and particularly the small rain-water collections in their vicinity constitute prolific breeding sites for A. gambiae. The wind helps in the dispersal of the species to neighbouring ballehs (natural or man-made pools) when the species has attained a high density at some of them. The sporozoite rate of A. gambiae in the Haud is of a low order, but high density of the vector during the latter part of the main rainy season brings about intense transmission of malaria leading to epidemics. The area is barely populated during the dry months and the sources of infection are believed to be nomads migrating into

the Haud from endemic areas within the territory as well as in Ethiopia. A. gambiae in the Haud is both endophilic and susceptible and is presumably amenable to control by residual treatment of human dwellings. However, owing to the extreme nomadism of the people this method by itself may not prove adequate for bringing about interruption of malaria transmission in the area unless a continuous watch is kept for unsprayed aqals (mat or hide tents) transported into the area and the insecticide is applied at frequent intervals. Breeding of A. gambiae is confined to a few man-made underground tanks at the peak of the dry season and elimination of these remaining breeding foci through larvicidal measures will greatly limit the spread of the species during the rainy season and thereby contribute towards the success of a malaria eradication programme in the territory.

Introduction

Seasonal epidemics of malaria occurring in the Haud of the Northern Region of Somali Republic have taken a heavy toll of human life in the past. Limited outbreaks of malaria are probably an annual occurrence (Wilson, 1951) although severe epidemics occur only at periodic intervals during a year of early and widespread rainfall. A. gambiae is the main and probably the sole vector of malaria in the Northern Region (Glasgow & McInnes, 1943; Wilson, 1949), and it is the only anopheline species found in the Haud. There is an extreme scarcity of water in the Haud during the dry months, marked by a very low prevalence of A. gambiae. In a year of good rainfall, however, the species can exhibit a considerable build-up in density particularly near the ballehs in the Haud. This may lead to epidemic outbreaks of malaria among the nomads, who migrate in large numbers to the ballehs during the rainy season in search of good grazing for their livestock. The present investigation was undertaken to elucidate the residual breeding foci of A. gambiae in the Haud during the dry months and the mode of spread of the species at the beginning of the rainy seasons, as well as other factors contributing to the cyclical epidemics of malaria in the area.

Description of the Haud

The Northern Region of the Somali Republic lies on the southern shore of the Gulf of Aden and is bordered on the west by French Somaliland and on the south by Ethiopia. The mountains in the north of this region slope southwards to form a flat

plateau lying between levels of 3000 and 2000 feet. The southern lower portion of this plateau is known as the Haud and is mostly in Ethiopian territory (vide Fig. I).

The Haud constitutes good grazing lands since it produces plenty of grasses and a number of hardy plants and bushes which form important browsing for the stock. Big trees are confined to the seasonal rain pools called ballehs which serve as temporary sources of water. Water may last throughout the year in deep wells sunk in the bed of some of the larger ballehs. A few ballehs have been artificially constructed. In the dry months, the nomads have to depend on rainwater stored in large cement underground tanks, apart from limited quantities of water available in the deep wells referred to above. Numerous tanks have been constructed in the Haud in recent years. They are very variable in size but are approximately 90 feet long, 20 feet wide and 10 feet deep. Excessive evaporation of water is prevented by covering the tanks with a loose thatch-work of dry twigs, supported on top of horizontally laid logs of wood. Until recently, water had to be transported into the Haud in trade trucks from localities such as Guled Haji, Berato and Odweina, where wells sunk in seasonal river-beds constitute permanent sources of water.

The main (Gu) rains fall in the Haud normally from April to June and the Dhair rainy season extends from October to November. Large numbers of stockherders migrate to the Haud during the rainy seasons in search of good grazing for their stock. There is no restriction in the movement of the nomads between the Northern Region and the Ethiopian Haud. Personal effects and portable huts called aqals are transported on the back of burden camels. The aqals consist of a framework of laminated wooden arches which is covered over by mats of woven grass, cured hides, etc. A type of permanent dwelling called the arish is common to the settlements and consists of wooden poles supporting a roof of twigs, coarse grass and soil. The walls are formed of either mud bricks or a loose lattice-work of dry twigs, sometimes packed with mud.

Methods

Spray-catches were repeatedly made from a proportion of the aqals in some of the border settlements in the Haud during both the dry and rainy seasons. The arishes were not examined as it was felt that their relatively large size and open structure precluded satisfactory work of this nature. At the same time a number of cement

underground tanks in the border settlements were examined for the presence of larvae of A. gambiae. Indoor resting collections were also made periodically from settlements in the interior of the Haud where deep wells constitute permanent sources of water. Attempts to collect larvae from these wells were abandoned as a satisfactory inspection was not found possible owing to their narrow and tortuous construction. Both Gilles (1952) and Choumara (1958b) experienced the same difficulty. Descent into the wells is hazardous and too strenuous an undertaking in view of the large number of wells in each locality. Spray-catches were made periodically from aqals found installed near the ballehs and in addition a number of the aqals were examined soon after their transportation from distant places and their re-erection near the ballehs in order to find out whether mosquitos could be transported with the aqals. Tree-holes and termite hills near some of the ballehs were searched to test the possibility of A. gambiae aestivating in such natural shelters during the dry seasons. A few ballehs were inspected at the beginning of the rainy seasons within a week of their becoming filled with rain-water for evidence of the possible aestivation of A. gambiae in the egg stage.

Observations

Five settlements in the Haud, on the boundary between the Northern Region and Ethiopia, were visited at the peak of the main dry season in March 1960 and spray-catches were made from 189 aqals representing 20-30% of the total number of these structures present in these localities. Two unfed, 5 fed and 2 gravid A. gambiae were obtained from Reidapkatumo and Lanmulaho. One hundred and twenty-three cement underground tanks in these localities were inspected and 3 A. gambiae larvae were collected from Reidapkatumo. Later in the same month, 1 unfed and 4 fed A. gambiae were caught from two other border settlements, viz, Ballehdig and Dagahder. No A. gambiae were obtained from Eik, Wudwud and Mussaquder, settlements with deep wells.

The rainy season started rather early in 1960, about the middle of March. A few of the ballehs in the Haud were inspected within a week of their becoming filled with rain-water, but no immature stages of A. gambiae were detected. On the other hand, large numbers of culicine larvae and pupae - about the same stage of growth in each separate water collection - were seen in Balleh Durre, B. Shillalka Akadin and B. Dilalo. B. Daakudin was visited about seven days after the onset of the rainy season and myriads of newly emerged culicines were found resting among the vegetation near the balleh.

Following the rains, large numbers of nomads were seen migrating from distant places to the ballehs in the Haud, bringing with them their aqals. Spray-catches were made from 48 aqals soon after their re-erection near the ballehs. Two culicines were obtained from a group of five aqals near B. Benyal. Two of these aqals had been transported over a distance of five miles from Mussaquder and had been re-erected only a short time before the collection. The balleh itself was dry and there was reportedly no other body of water nearby. Spray-catches from Mussaquder the same morning had yielded over 200 culicines.

Spray-catches in April from 59 aqals near some of the ballehs yielded 1 A. gambiae each from Balleh Soljogth, B. Samadeko and B. Hakso, which are situated close to one another. One larva of the same species was also obtained from B. Samadeko. Twelve fed and 10 gravid A. gambiae were caught from four of the border settlements, viz, Goondaleh, Reidapkatumo, Lanmulaho and Semitleh. No anophelines were found in Wudwud and Mussaquder during this month.

All human dwellings in the settlements along the boundary as well as a few miles to the interior of the Haud were sprayed with DDT during the latter part of April 1960. An entomological survey made along five of these settlements in May disclosed the absence of anophelines in these localities. A small number of aqals had been left unsprayed with DDT in each settlement, but these also proved negative for A. gambiae. However, 12 female and 4 male A. gambiae were collected from Dagahder, where all the aqals had not been sprayed with DDT intentionally. Twenty-eight larvae of the same species were also obtained from cement underground tanks in Dagahder. The residual insecticide spraying squads had not visited the ballehs and most of the aqals near the ballehs were found unsprayed with the exception of a few which had been transported from one of the sprayed settlements. It was also observed that a good proportion of the unsprayed aqals had been brought in from Ethiopia since the onset of the rainy season. Spray-catches from the aqals near the ballehs yielded an average of over 50 A. gambiae per aqal per day. Prolific breeding of A. gambiae was noticed in the small water collections at the edge of B. Samadeko. Relatively little breeding was evident in the balleh itself. A large majority of the nomads in the area were said to be suffering from malaria and in fact about 40% of the blood smears taken from suspect cases proved positive for P. falciparum. Out of 387 A. gambiae caught indoors, 2 showed salivary glands heavily infected with sporozoites. Control measures

were promptly instituted by the Government, consisting of residual spraying of all the aqals near the ballehs, combined with distribution of antimalarial drugs and larvicidal treatment of the ballehs.

Most of the ballehs were found dry by July. No rains had fallen during roughly the previous six weeks. Collections from aqals seen near five ballehs yielded only 1 A. gambiae each from B. Samadeko and B. Dakudin. Fifteen man-hours were spent in a search to test the possibility of A. gambiae aestivating among tree-holes and termite hills near B. Godleh and B. Marodikhadda which had been dry during the previous two months. No anophelines were found.

Spray-catches from six border settlements during September yielded 1 gravid A. gambiae from Ballehdig. Three fed and 7 gravid A. gambiae were caught from Mussaquder and Wudwud, settlements with deep wells. One unfed, 4 fed and 11 gravid A. gambiae were obtained from aqals near B. Soljogth and B. Samadeko, where some of the deep wells still held water.

A vast migration of the nomads to the region of the ballehs - similar to that witnessed earlier during the Gu rains - took place with the onset of the Dhair rains in October. Spray-catches were made from a number of aqals soon after they had been re-erected near the ballehs. Two fed and 1 gravid A. gambiae were obtained from two aqals near B. Haiyyeh. These aqals had been moved over a distance of three miles from B. Samadeko three days back. One gravid A. gambiae was caught near B. Dubableh from an aqal which was installed there only two days previously and which was transported from a settlement about 15 miles away, the journey having been accomplished in two days with a halt for a night on the way. Another aqal which had been transported over a distance of 12 miles and reinstalled near B. Domodleh a day earlier also yielded a gravid A. gambiae. These three ballehs had been dry since June 1960 and had become filled with water only a week before the date of collection. Intense search revealed no breeding of A. gambiae in the ballehs, and the nearest permanent source of water supply was reported to be seven miles away.

An entomological survey of the Haud in November revealed an extremely low prevalence of A. gambiae in the area. The ballehs had become dry since the time they were replenished by the Dhair rains of October.

Spray-catches made in December yielded no A. gambiae from Eik, Wudwud and Horufadi, and from aqals found scattered near B. Dooleh and B. Samadeko. On the other hand, 4 unfed, 4 fed and 16 gravid A. gambiae were obtained from some of the border settlements, viz, Lanmulaho, Ballehdig, Dagahder and Semitleh.

Monthly collections made during the first quarter of the year 1961 did not yield any A. gambiae from aqals near the ballehs and the settlements with deep wells. However, collections from the border settlements included 7 unfed, 32 fed and 2 gravid A. gambiae in January, 8 unfed, 26 fed and 17 gravid A. gambiae in February and 7 fed and 7 gravid A. gambiae in March. Eighteen larvae of A. gambiae were obtained from two of the border settlements in January, and 97 larvae of the same species were obtained from these settlements in February. No search for larvae was made in March.

Discussion

The observations show that uninterrupted breeding of A. gambiae occurs in the cement underground tanks of some of the border settlements throughout the year, and that these tanks constitute residual breeding foci from which the species may spread to neighbouring areas in the Haud during the rainy season. The density of the species remains low, particularly during the dry months, owing presumably to unfavourable climatic factors affecting the adult and the fact that the available breeding water is stale and polluted with organic matter and is shaded from the sun by the thick covering of the tanks. In the course of a dry season survey of the Haud, Gilles (1952) found fair numbers of larvae of A. gambiae in a tank in Goondaleh, one of the border settlements. He also noticed adults resting on the wall of the tank and later collected 14 female A. gambiae from human dwellings in the locality. Two male A. gambiae were seen resting on the wall of a tank in Reidapkatumo and Gilles assumed that the species was breeding in this locality also, although no larvae were found. Gilles was of the opinion that breeding in these tanks had not aided in the spread of A. gambiae in previous years since the tanks invariably became dry long before the beginning of the rainy season. This view does not hold true at the present for the reason that many more tanks have been constructed since 1952, and all the available water is not fully consumed before the subsequent rainy season. Choumara (1958a) has called attention to the fact that many of the tanks had never been dry for some years and were therefore capable of permitting continuous breeding of A. gambiae. In the

course of the present study, June, July and August were the only months of the year during which neither larvae nor adults of the species have been found in these settlements. However, it is very likely that the species was present in these settlements at the time of the negative collections, but in such low numbers as to escape detection. It is also to be borne in mind that spray-catches were not made from any of the arishes which constitute a high proportion of the human dwellings in these localities and A. gambiae sheltering within them would have escaped capture. Choumara (1958a), for instance, collected 9 A. gambiae from some of the arishes in Goondaleh whereas he found none within the aqals. Further, a thorough inspection for larvae has not been found possible as it is neither practicable nor permitted by the owners to remove the cover from the tanks so as to fully expose the water surface. The tanks are moreover so numerous that it is only feasible to examine a certain proportion of them.

The deep wells appear to be of little significance as residual breeding foci of A. gambiae in the Haud during the dry season. The environmental and breeding conditions obtaining in these settlements are presumably not conducive to prolonged breeding of A. gambiae and the species is eliminated from these localities during the course of the dry months.

It is evident that adult A. gambiae are transported from permanent breeding foci to new breeding sites along with the aqals of the migrating nomads. The 2 culicines obtained near B. Benyal in March 1960 were transported with the aqals from Mussaquder about five miles distant. Three A. gambiae collected from aqals near B. Haiyyeh in October 1960 had evidently been brought in with the aqals over a distance of three miles from B. Samadeko, in which locality evidence obtained during the previous month showed local breeding of the species in some of the deep wells. The A. gambiae caught near B. Domodleh and B. Dubableh were also transported with the aqals from settlements with permanent sources of water supply and at a distance of 12 to 15 miles. Indirect evidence of transportation of A. gambiae through burden camels or lorries has been recorded by Choumara (1959). He found an A. gambiae in a house in Hargeisa at a time when there was no known breeding place within 18 miles of the town. Spread of A. gambiae by transport has also been recorded elsewhere by various workers (vide De Meillon, 1957). The A. gambiae collected near B. Dakudin in July 1960 had presumably been transported in a different manner either in the larval or pupal stage

through drinking-water brought in from Mussaquder about five miles away. All the aqals near this balleh were said to have been in the same area during the previous two months and the anopheline therefore could not have been imported with an aqal. The mosquito was not locally bred since the balleh had been dry for over a month and the nearest waterpoint was reported to be five miles away. Thus, adult A. gambiae transported with the aqals and immature stages of the species transported with drinking-water are responsible for giving rise to new breeding foci in the Haud at the beginning of the rainy season. The ballehs which are prolific breeding sites of A. gambiae during the rainy season are situated close to one another so that the species may readily spread to neighbouring ballehs when breeding had become established in some of them. A steady south-west wind which starts blowing in the Haud about the middle of May (Hunt, 1951) helps in the dispersal of A. gambiae between neighbouring ballehs.

Gilles (1952) records the possibility of continuous breeding of A. gambiae on a limited scale in the shallower type of wells in localities such as Beratc and Haraf along the northern border of the Haud. The same author found no evidence of residual breeding foci of A. gambiae in the south-west part of the Haud lying in Ethiopian territory, although he recognized the possibility of the presence of the species in these areas in such low numbers as to render their detection a matter of considerable difficulty. Continuous breeding of A. gambiae also occurs in the northern foothill areas, but according to Gilles, invasion of the Haud from these distant localities is open to doubt. However, present observations show that the nomads move from waterpoint to waterpoint and thus accomplish long journeys in stages and transportation of A. gambiae with the aqals may help in the gradual spread of the species in the Haud from the northern permanent breeding foci.

The numerous culicine larvae and pupae found breeding in some of the ballehs during the first week after the onset of the rainy season had presumably emerged from eggs aestivating during the preceding dry months. On the other hand, no immature stages of A. gambiae were observed at the same time. Negative findings would also indicate that A. gambiae does not survive the dry season in the adult stage in parts of the Haud where the only sources of water are the seasonal ballehs. These observations corroborate the view held by Wilson (1951) that A. gambiae does not survive the dry season in the Haud either as aestivating adults or the immature stages.

Data of indoor resting collections indicate that a considerable build-up in density of A. gambiae occurs in the Haud, particularly near the ballehs, six to eight weeks after the onset of the main rainy season. These rains normally start in April and continue sporadically till the beginning of June. The dry weather starting in June brings about a steady decline in vector density. It is reasonable to assume that local transmission of malaria in the Haud is normally limited to a short period coinciding with the latter part of the main rainy season when alone the vector density remains sufficiently high to maintain transmission. This contention is also borne out by the observations during the severe epidemic of 1951 when a general increase in malaria notification was evident towards the end of May and the epidemic started declining by the middle of July (Medical Department Annual Report, 1951). An increase in the number of A. gambiae occurs in the Haud also during the Dhair rainy season, but normally owing to the short duration of the rainy season and the relatively low amount of rainfall, the ballehs which are the most prolific breeding sites become dry long before there could be an appreciable build-up in vector density comparable to that during the main rainy season.

In spite of the low sporozoite rate exhibited by A. gambiae in the Haud, intense local transmission of malaria occurs as a result of a high build-up in density of the vector during the latter part of the main rainy season. The Haud, particularly the vicinity of the ballehs, is barely populated during the dry months (December to March), and therefore the fresh sources of infection which set off local transmission during the rainy season are believed to be nomads arriving from outside endemic foci. According to Wilson (1949) such endemic areas exist around the sandy river beds in the northern hills and epidemic spread may occur from them under suitable conditions The nomads crossing over from the Ethiopian Haud and more southern parts of Ethiopia are also presumably responsible for spreading infection this side of the boundary. Choumara (1958a) held the opinion that major endemic foci involving the Haud lie in Ethiopia. Evidence for importation of malaria from across the border is available. Thus, a total of 208 blood smears were obtained in January 1960 from nomads migrating from Ethiopia and suspected to be carrying infection to the Northern Region of the Somali Republic, and out of these, 112 smears showed P. falciparum trophozoites or gametocytes or both (Rishikesh, 1960). Nearly 45% of the blood smears collected in a similar manner in January 1961 also proved positive for P. falciparum.

A. gambiae in the Haud is largely endophilic and susceptible to DDT, and is therefore presumably amenable to control by residual treatment of human dwellings. An entomological survey soon after the annual spraying operations in the Haud (April 1960) showed an apparent disappearance of the species from the border settlements visited except one in which locality all the aqals were left unsprayed with DDT intentionally. Extreme nomadism prevalent in the area, however, causes a continuous turnover of the aqals in any particular locality thus rendering it difficult to ensure total coverage. Further, during and after the spraying operations, migrating nomads are continuously transporting into the Haud aqals from unsprayed areas within the country as well as over the border in Ethiopia. Consequently, residual treatment of the aqals alone may not prove an adequate method for achieving interruption of transmission in this area, unless a continuous watch is kept for unsprayed aqals transported into the area, a system of entomological checking is instituted and the insecticide is applied at frequent intervals.

During the dry months, breeding of A. gambiae is confined to the man-made cement underground tanks and perhaps to some of the deep wells. Most of these tanks and wells dry up long before the onset of the rainy season, and it appears feasible therefore to eliminate the species from the few remaining breeding foci at the peak of the main dry season through larvicidal measures. Such a process would largely limit the spread of A. gambiae in the Haud during the rainy season and thereby contribute towards the successful interruption of malaria transmission in the Haud. It is relevant to mention here the possibility of a limited amount of infiltration of A. gambiae into the Haud from the northern permanent breeding foci and the Ethiopian Haud with the onset of the rainy season and the formation of many new breeding sites. Further, any larvicide used in this area must necessarily be non-toxic to vertebrates since the water under treatment will be utilized for drinking by both man and his livestock including the camels which drink large quantities of water at a time.

Conclusions

Continuous breeding of A. gambiae occurs in the man-made cement underground tanks in the Haud and these tanks constitute residual breeding foci from which the species may spread to neighbouring areas during the rainy season. The density of the species, however, remains low in the border settlements during the greater part

of the year owing presumably to unfavourable climatic factors affecting the adult and the nature of the available breeding water. The species does not appear to survive the dry seasons in localities in the Haud where deep wells constitute the permanent sources of water supply. These wells are thus of little or no significance as residual breeding foci of A. gambiae in the Haud. A. gambiae is eliminated during the course of the dry season from those parts of the Haud where the ballehs constitute the only sources of water since there is no evidence so far of the species aestivating in these sites either in the adult or egg stages during the dry months. Reinfestation of the ballehs during the rainy season occurs from the residual breeding foci within the Haud as well as from the permanent breeding foci outside the area. The mode of spread is transportation of adult anophelines with the aqals of the migrating nomads and of the immature stages with drinking-water.

A considerable build-up in density of A. gambiae is possible in the Haud six to eight weeks after the onset of the rains, and the ballehs and particularly the small water collections in their vicinity become prolific breeding sites of the species. The wind helps in the dispersal of A. gambiae to neighbouring ballehs when the species has attained a high density level at some of them. The onset of the dry weather brings down the vector density to a low level, and thus the possibility of local transmission of malaria in the Haud is limited to a short period coinciding with the latter part of the main rainy season when alone the density of the vector is sufficiently high to maintain transmission. The short duration of the Dhair rainy season normally precludes the possibility of any appreciable build-up in vector density during that period.

High densities of the vector during the latter part of the main rainy season bring about intense transmission of malaria among the nomads congregating in large numbers in the Haud, particularly near the ballehs. Local transmission is believed to originate from fresh sources of infection in the persons of nomads arriving from endemic areas north of the Haud and over the border in Ethiopia.

A. gambiae in the Haud is both endophilic and susceptible, and is therefore presumably amenable to control by residual treatment of human dwellings. However, owing to the extreme nomadism of the people this method by itself is not considered fully adequate to effect interruption of malaria transmission in the area unless a constant watch is kept for unsprayed aqals transported into the area and the insecticide is applied at frequent intervals as indicated by entomological findings.

The elimination of A. gambiae from the few residual breeding foci of the species in the Haud at the peak of the main dry season through the use of a safe larvicide will largely limit the spread of the species during the subsequent rainy season and thereby contribute to the successful interruption of malaria transmission in the area.

Acknowledgements

I would like to thank the National Health Department personnel who helped me with the entomological collections. I am particularly obliged to Messrs Hassan Jabriel and Farah Sahil who served also as interpreters. I am very grateful to Mr D. Payne, WHO, for supervising the collections at some of the localities and for his valuable help in procuring the blood smears which have yielded useful information.

REFERENCES

1. Choumara, R. (1958a) Somaliland 3, WHO Malaria Survey and Control Project, First Quarterly Report

2. Choumara, R. (1958b) Somaliland 3, WHO Malaria Survey and Control Project, First Evaluation and Second Quarterly Report

3. Choumara, R. (1959) Somaliland 3, WHO Malaria Survey and Control Project, Second Evaluation and Fourth Quarterly Report

4. De Meillon, B. (1947) The anopheline of the Ethiopian geographical region, South African Institute for Medical Research, Johannesburg

5. Glasgow, J. P. & McInnes, D. G. (1943) E. Afr. med. J. 20, 176

6. Gilles, M. T. (1952) Report on a dry season survey of anopheline breeding in the Haud (Somaliland Protectorate)

7. Hunt, J. A. (1951) A general survey of the Somaliland Protectorate, 1944-1950

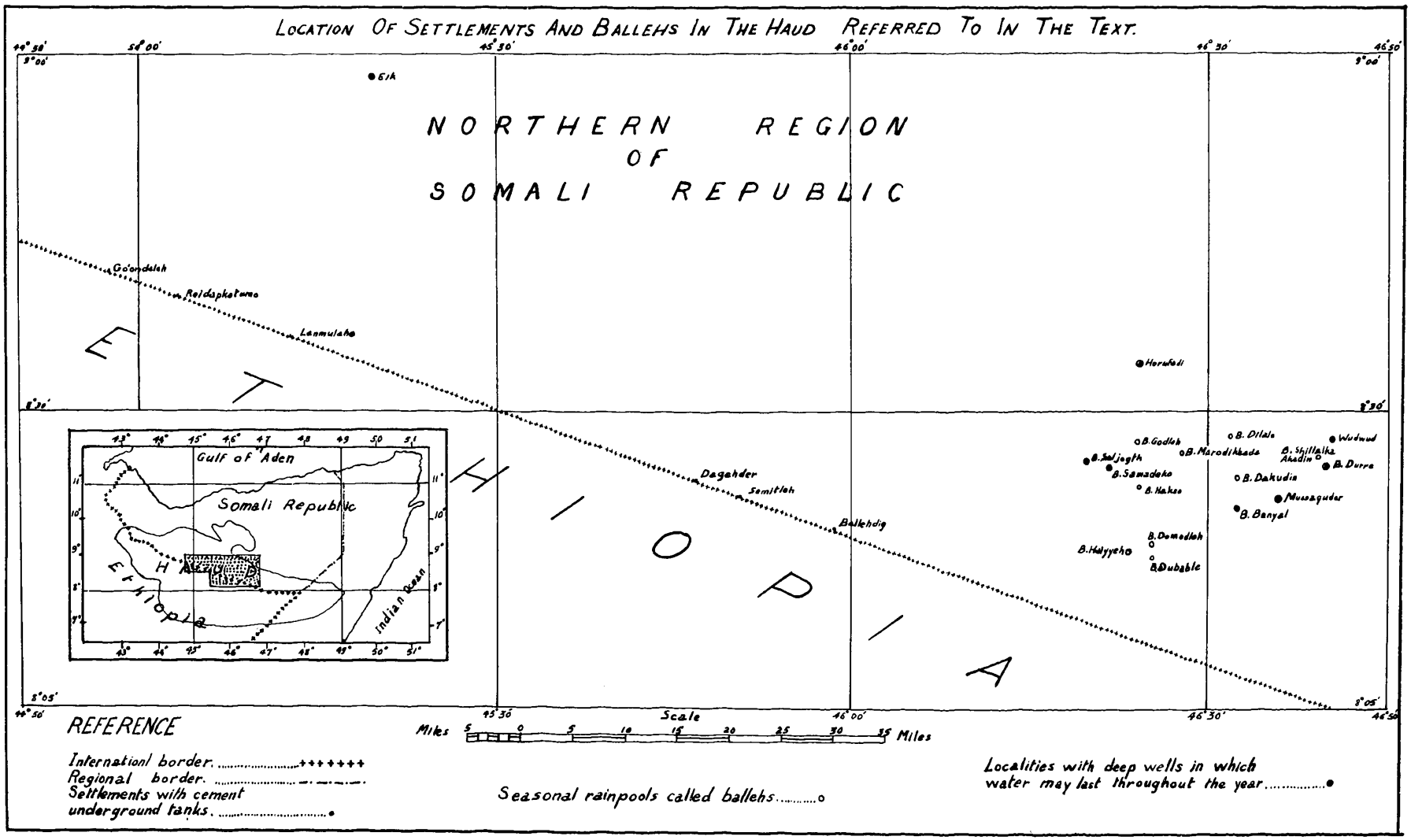
8. Medical Department Annual Report, 1951

9. Rishikesh, N. (1960) Somaliland 3, WHO Quarterly Field Report for January to March 1960

10. Wilson, D. B. (1949) Malaria in British Somaliland, E. Afr. med. J. 26, No. 10

11. Wilson, D. B. (1951) Report on malaria in Somaliland

LOCATION OF SETTLEMENTS AND BALLEHS IN THE HAUD REFERRED TO IN THE TEXT.



REFERENCE

International border. .....+++++++

Regional border. .....

Settlements with cement underground tanks. .....•

Seasonal rainpools called ballehs.....o

Localities with deep wells in which water may last throughout the year.....•

The purpose of the WHO/Mal Series of documents is three-fold:

(a) to acquaint WHO staff, national institutes and individual research or public health workers with the changing trends of malaria research and the progress of malaria eradication by means of summaries of some relevant problems;

(b) to distribute to the groups mentioned above those field reports and other communications which are of particular interest but which would not normally be printed in any WHO publications;

(c) to make available to interested readers some papers which will eventually appear in print but which, on account of their immediate interest or importance, deserve to be known without undue delay.

The issue of a paper in this series does not therefore constitute formal publication and a paper so issued may, with the agreement of the author and WHO, be published in a WHO periodical or elsewhere.

Authors alone are responsible for views expressed in signed articles. The mention of manufacturing companies or of their proprietary products does not imply that they are recommended or endorsed by the World Health Organization.