MALARIA EPIDEMIOLOGICAL OBSERVATIONS FROM UNSPRAYED STUDY DISTRICTS IN ETHIOPIA

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INTRODUCTION. Pre-spray baseline data were collected from 16 study districts in Area B of the Malaria Eradication Program in Ethiopia during 1968–1969. The study districts were selected for the implementation of comprehensive epidemiological studies.

DESCRIPTION OF AREAS. The geographical portion of Ethiopia which encompassed the study districts extends generally from the Sudan border to 39° 30′ East and from 7° to 11 40′ North. The total area is situated mostly above 2000 meters altitude but with some areas descending as low as 1000 meters. Human population concentrations are found mainly above 1500 meters. Areas below 1300 meters were generally uninhabited, except that scattered agricultural activity and animal herding are practiced during appropriate seasons.

In most of the areas, varying degrees of rainfall occurred during each month of the year, the heaviest amounts being measured during the period from July to the end of August.

The mean temperatures during the period March 1968 to October 1969 were from 17.6° C to 21° C, with a range of 14° C to 24.4° C.

SELECTION OF THE STUDY DISTRICTS. Preliminary surveys were made throughout the areas and selections of study district sites were based on the results of these surveys and the following criteria:

a. Ecological homogeneity.
b. Rainfall—pattern and amounts.
c. Topography—plains, savannah, forested, escarpment, plateau, etc.
d. Altitude.
e. Habits and occupations of the populace—nomadic, transient workers, herders, etc.
f. Types of anopheline breeding places—seasonal, perennial.
g. A minimum population of 6000.
h. Accessibility—whether the 6000 population could be reached by field workers during all months of the year.

ORGANIZATION OF OBSERVATIONS. Parasitological and entomological observations were carried out concurrently for at least one full year, as described below.

PARASITOLOGICAL. After delimitation and mapping of the areas, a census was taken of the 6000 population, according to name, age, and sex.

An evaluation team, composed of one technician and from two to four evaluators, endeavored to collect at least 1000 blood films per month from all ages in selected houses, including all infants in the study district.

Thus, every individual in the study district, except infants, would have a blood film taken at least two to three times during the year. Sampling of the houses in a study district for blood film collection was organized as shown in the following example.

TABLE 1.—Organization of sampling for blood films.

Month of collection	Starting (and subsequent) houses in each study district
March	1 (7; 13; 19; 25; etc.)
April	2 (8; 14; 20; 26; etc.)
May	3 (9; 15; 21; 27; etc.)

Malaria drugs were not given to any of the persons from whom blood films were taken, nor were these drugs made avail-

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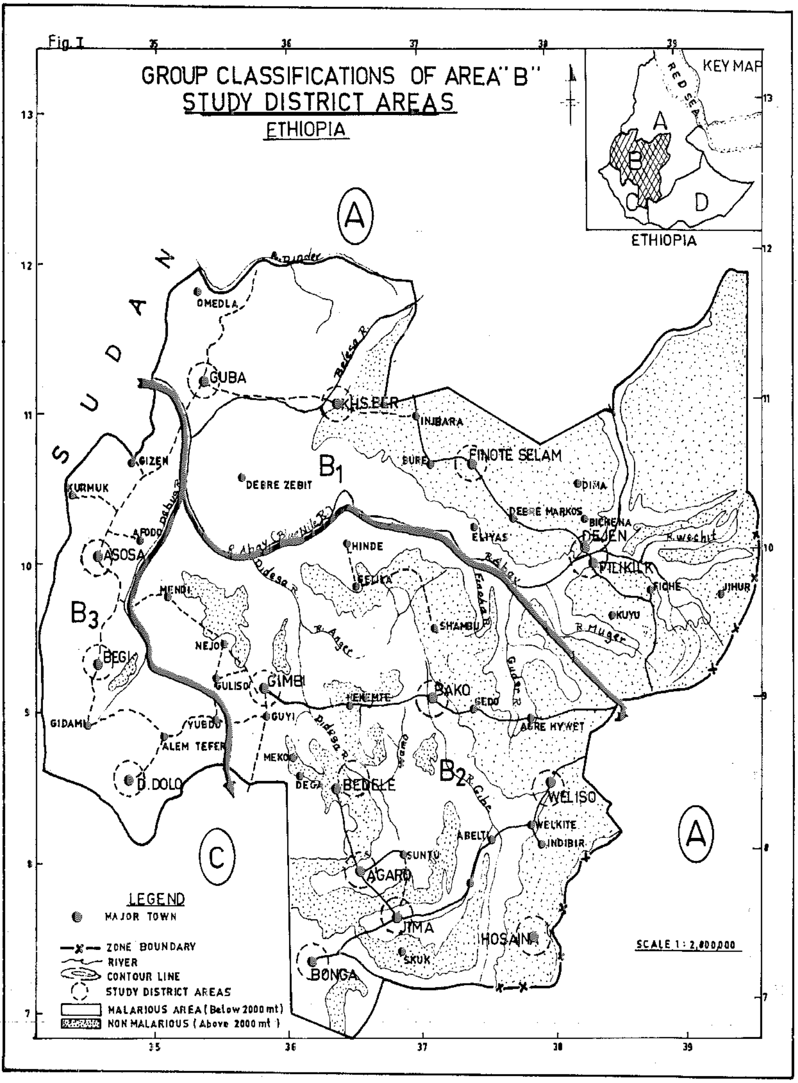
able in the study districts by M.E.S. personnel.

ENTOMOLOGICAL. Observations were implemented in four adjoining indicator localities of each study district during 22 days monthly, for at least one year.

Personnel assigned to each study district were two technicians supervising five insect collectors. Additional supervision was made on a regular basis by the zone entomology supervisor and by headquarters supervisory staff and international advisors.

COLLECTION OF RESULTS. The interpre-



tation of total study district results was influenced by several factors, a list of which would include:

1. Refusal of some people to cooperate in the giving of personal information and allowing blood films to be taken.
2. Some of the study districts were not ecologically homogeneous, i.e., within individual study districts there was significant epidemiological variation among localities.
3. Point correlation of parasitological and entomological results, was complicated by the disparate areas of sampling. Blood films were collected from a monthly differing population of 1000 throughout the study district area, while entomological observations were made monthly in one contiguous area.

Study of the results obtained suggested regional differences in malaria incidence and vector behavior. In this respect, it was indicated that results of all study districts could be classified into three general groups, based on:

a. Rainfall pattern
b. Vector prevalence and behavior
c. Parasitological trends, influenced by a. and b. above
d. General physiographic differentiation. (Wolde Mariam 1970)

Accordingly, the Area B study districts were categorized, as shown in Table 2.

Uniform entomological activities guidelines have allowed the pooling of observational results. The pooling has been according to group classification and observational means have been derived.

Epidemiological indices used were:

Climatological
a. Rainfall
b. Temperature

Entomological
a. Indoor resting collections—IRC. (Average vectors/house/month)
   (1) *An. gambiae*
   (2) *An. funestus*
b. Man biting rates. (after Garrett-Jones 1964)
   (1) *An. gambiae*
   (2) *An. funestus*
c. Bloodfed vectors to humans index. (*An. gambiae* + *An. funestus* col-

TABLE 2.—Categorization of study districts.

Study districts *	Observations began	Group classification	Physiographical classification
1. K.H.S. Ber	May 1968		
2. Guba	May 1968		
3. Finoteselam	May 1968	B_1	North Central Massifs
4. Debre Markos (Dejen)	June 1963		
5. Fitche (Filiklic)	April 1968		
6. Bako	Mar. 1968		
7. Jimma	Apr. 1968		The Shewan Plateau and part of the Southwestern Plateau
8. Bedele	July 1968	B_2	
9. Bonga	July 1968		
10. Weliso	May 1968		
11. Hosaina	Oct. 1968		
12. Agaro	Oct. 1968		
13. Begi	Oct. 1968		
14. D. Dolo	Oct. 1968	B_3	The Baro Lowlands
15. Asosa	June 1968		
16. Gimbi	April 1968—omitted from group classification because of negative epidemiological results.		

* See map Figure 1.

lected = average vectors/house/month, divided by the number of average persons (sleepers) per house per month). (Garrett-Jones & Shidrawi 1969). The uniform average of 3.6 persons was used for the calculations.

Parasitological (total positives ÷ total slides collected x 100=% positive).

a. Infant positives

b. 1/12 to 9 years of age, positives

c. All positives (all age groups)

RESULTS. AREA B_1—In different parts of this area, transmission occurred during all months of the year, the highest number of indigenous infant positive cases having been observed during the period October through January. After the rainfall peak in July, the steadily increasing *An. gambiae* and *An. funestus* populations reached highest densities in September. In November and December, a sharp drop in density, characteristic of the dry season, occurred. The high prevalence of *An. gambiae* in night-biting and indoor-resting collections, as compared with the lower prevalence of *An. funestus* in similar indices underlined the role of *An. gambiae* as primary vector, as both anopheline indices were correlated with parasitological indices.

AREA B_2—Malaria transmission is perennial in varying parts of this area, with infant positives found in all months. The highest numbers were observed during the period, June through September. Relative to the perennial transmission, the vector densities reached peaks in August, diminishing slightly in September before a sharp decline in October due to the reduction of breeding places. The bloodfed human index peak occurred in September, one month after the indoor-resting and man-biting peaks of *An. gambiae*. The *An. funestus* indoor-resting peaks were also reached in September. The one month disparity observed between the peak of the bloodfed human index and the other vector indices was apparently influenced by the high cattle density and the mixed human—animal houses in some study districts of Area B_2. Results of the precipitin analysis of 144 *An. gambiae* bloodmeal smears collected in mixed human-animal houses of Bako study district, showed that 2 were man-bovid, 1 was sheep-goat, and 140 were bovid.

The main period of increased vector activity in this general area extended from July to September.

An. gambiae in indoor-resting and night-biting collections were found in higher total numbers than *An. funestus* in similar collections. Monthly infant positivity trends correlated well with the *An. gambiae* observational trends, indicating the dominant role of this species in the transmission of malaria. The total numbers of adult *An. gambiae* females collected in individual study districts of this group were higher than in other study districts of Area B.

AREA B_3—Malaria transmission is perennial in varying parts of this area. From the results collected, it was seen that high indigenous infant positives occurred from January through August.

There were no sizable vector peaks, as compared with the other areas. Observational results showed high *An. funestus* densities, including increased bloodfed human indices during December, continuing into January, diminishing somewhat but continuing through May. *An. gambiae* was absent in both indoor-resting and man-vector contact studies during the period January through May.

The alternative seasonal vectorial dominance roles of *An. gambiae* and *An. funestus* is a suggested possibility, the dominance of *An. funestus* being from January to June and that of *An. gambiae* from June to January, with considerable overlapping.

ANOPHELINE COLLECTIONS. *An. gambiae* Species B, was identified from three parts of Area B. (personal comm. Dr. G. Davidson). Species C was found in one study district, the first report of this species in the northeastern African area.

An. funestus adult collections were considered as *An. funestus* group, in the absence of more definitive identifications, since the common pictorial identification keys used in the study districts "lumped" *An. funestus, An. leesoni, An. rivulorum,* and *An. macmahoni* together (Veronne 1962).

Gillies and de Meillon (1968), state that "the females of *An. macmahoni* resemble *An. funestus* very closely and may be inseparable." *An. funestus, An. leesoni, An. rivulorum,* and *An. macmahoni* were identified in larval collections.

An. pharoensis, a well collected species found resting and biting outdoors in some parts of DDT sprayed Area A and suspected of being a vector in Ethiopia, was found in limited numbers in the Area B study districts. A total of 5 adults was collected resting indoors and 16 collected by all methods throughout the study district areas.

An. nili, implicated as a vector by Krafsur (1970) in Gambella which is adjacent to Dembidolo Sector (B_3), was seldom collected by all methods in B_3. In the entire B_3 area, only 3 specimens were collected by all methods in Dembidolo and 1 specimen in Asosa. One hundred sixty-five *An. nili* were collected by all methods in Area B_2, 19 in Bako study district, 1 in Agaro study district, and 145 in Jimma study district.

VECTOR PREVALENCE AND ALTITUDE. All study district localities were charted according to month, altitudinal range, and mean altitude or collection. Total *An. gambiae, An. funestus* and *An. pharoensis* specimens collected resting indoors during the period from March 1968 to November 1969 were tabulated. From each study district except Gimbi because of the minimal collections, total anopheline densities per locality of collection in each study district were extracted and categorized according to the mean altitude where the collection was made.

The highest densities of *An. gambiae* were collected within the altitudinal range of 1490 to 1800 meters. Eight localities situated below 1700 meters had relatively high vector densities and eight localities, ranging from 1720 to 2000.5 meters mean altitude, also had relatively high vector densities. The altitudinal range of high vector collections was 1410 meters to 2000.5 meters. There appeared to be no positive correlation between vector prevalence and altitudinal strata in the areas studied.

Further investigations into localized and general factors, including meteorology and physiography may provide additional information relative to explanations for the high prevalence of vectors in, for example, Jimma Locality 72 at an altitude of 1800 meters and where 2265 *An. gambiae* were collected, as contrasted with two localities of Gimbi study district, numbers 48 and 43, with respective mean altitudes of 1740 and 1760 meters, where no vectors were collected. As shown in Table 3, the Gimbi study district area had a climatological pattern similar to the Jimma area; the total rainfall was higher in Gimbi.

CONCLUSIONS. From information collected by the Ethiopian Malaria Eradication Service in 16 unsprayed study districts during one full year, the consolidation of the results according to a group classification basis, has been a positive approach in helping to understand some of the aspects of the malaria epidemiology in the areas studied.

The vectors, *An. gambiae* and/or *An. funestus* were present throughout the year in various areas of Area B. *An. nili* was collected in minimal numbers.

An. gambiae and *An. funestus* have been implicated previously as primary and secondary vectors in other areas of Ethiopia. Entomological findings, as correlated with parasitological results, revealed no contradictions, except in Area B, where the possibility of alternative seasonal vectorial dominance of *An. gambiae* and *An. funestus* is suggested.

Malaria transmission was found to occur throughout the year in 13 of the study district areas. Three study district areas, Gimbi, Bonga, and Dembidolo, were found to be virtually free of malaria transmission.

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TABLE 3.—Rainfall and mean temperatures in two study district areas.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	R.F. total
Gimbi													
R.F. mms.	26.8	7.7	42.1	109.8	237.5	364.4	342.5	457	381.1	186.5	39.4	12	2206.8
Temp. ° C	*	24.8	21.5	20.1	21.4	22.6	15.7	19	19.8	19.8	16.7	18.3	..
Jimma													
R.F. mms.	41.6	47.6	98.4	154.2	138.5	232.5	219.8	215.6	188.7	81.5	57.2	39.3	1514.9
Temp. ° C	16.5	18.8	19.9	20	19	17.5	18	18.9	18.3	16.8	18.1	17.3	..

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