THE DISTRIBUTION OF ANOPHELINE MOSQUITOES IN ETHIOPIA [1]

CHARLES T. O'CONNOR, JR.
Malaria Specialist [2]

The data presented in this paper primarily represent the collection records of Ethiopian Malaria Eradication Service personnel. Other sources include the publications of foreign workers, notably the Italians, and field trip reports of personnel of the United States Agency for International Development (AID) and the World Health Organization (WHO). The records have been kept as complete as conditions would permit through December 1965.

The distribution of the various anopheline species, as delineated through this study, is graphically presented in the accompanying maps. The symbols used are those recommended by the WHO (Gillies *et al.*, 1961).

It will be noted that positive collection records on the maps are generally more numerous in the northern half of the Empire. This results from the division of Ethiopia into four areas in a staged program to permit the initiation of malaria eradication operations in each area over a period of years. Area "A," which represents most of the northern half of the country except the portion west of Adis Abeba,[3] is the only area that has been extensively surveyed by Ethiopian Malaria Eradication Service personnel.

The maps exhibit fairly extensive regions of Area "A," particularly in the high plateau of central Ethiopia, where few positive collections are registered. This situation is primarily a result of the fact that large portions of the region exceed 2000 meters in altitude, and entomological surveys conducted by the Malaria Eradication Service ceased at the 2000-meter contour line.

The numerous positive collection sites in the lake region just south of Adis Abeba can be attributed to the utilization of this region as a study site by the WHO Pre-eradication Project Team in 1964 and 1965. The complete lack of positive sites in Bale Province, in southeastern Ethiopia, is due to the paucity of collection attempts there. This area will be surveyed during later stages of the program.

Positive localities noted outside Area "A" are generally the result of surveys conducted by foreign workers in Ethiopia.

Table 1 exhibits the distribution by province of the 34 anopheline species.

ANOPHELINE FAUNA. Up to the present, the following 34 species and 2 subspecies of anophelines have been found in Ethiopia:

A. adenensis Christophers, 1924
A. ardensis (Theobald, 1905)
A. christyi (Newstead and Carter, 1911)
A. cinereus Theobald, 1901
A. coustani coustani Laveran, 1900
A. coustani tenebrosus Donitz, 1902
A. coustani ziemanni Grunberg, 1902
A. dancalicus Corradetti, 1939
A. demeilloni Evans, 1933
A. d'thali Patton, 1905
A. funestus Giles, 1902
A. gambiae Giles, 1902
A. garnhami Edwards, 1930
A. harperi Evans, 1936
A. implexus (Theobald, 1903)
A. kingi Christophers, 1923
A. leesoni Evans, 1931
A. longipalpis (Theobald, 1903)
A. macmahoni Evans, 1936
A. maculipalpis Giles, 1902

[1] From the Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Atlanta, Ga., 30333.

[2] The work reported here was performed while Dr. O'Connor was on assignment with the United States Agency for International Development (USAID) Mission in Ethiopia. He is presently with CDC's Malaria Eradication Branch, assigned to Haiti.

[3] Also spelled Adis Ababa and Addis Ababa.

TABLE 1.—Anopheline Distribution by Province in Ethiopia.

Province	Species of *Anopheles*																
	adenensis	*ardensis*	*christyi*	*cinereus*	*constani*	*dancalicus*	*demeilloni*	*d'thali*	*funestus*	*gambiae*	*garnhami*	*harperi*	*implexus*	*kingi*	*leesoni*	*longipalpis*	*macmahoni*
Arusi	..	..	X	X	X	..	X	..	X	X	X	..	..	..	..	..	X
Bale	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Begemdir	..	..	X	X	X	..	X	X	X	X	X	..	X	..	..	..	X
Eritrea	X	..	X	X	X	X	X	X	X	X	X	..	..	..	..	..	X
Gemu Gofa	..	..	..	..	X	..	..	..	X	X	..	..	X	X	..	..	..
Gojam	..	..	X	X	X	..	X	..	X	X	X	..	..	..	..	..	X
Harer	..	..	X	X	X	..	X	X	X	X	X	..	..	..	..	X	X
Ilubabor	..	..	X	..	X	..	X	..	X	X	..	..	..	..	..	X	..
Kefa	..	..	X	X	X	..	X	..	X	X	X	X	X	X	..	..	..
Shewa	..	..	X	X	X	..	X	X	X	X	X	..	..	..	..	..	X
Sidamo	..	X	X	X	X	..	X	..	X	X	X	..	..	X	X	..	..
Tigre	..	..	X	X	X	..	X	X	X	X	X	..	..	..	..	..	X
Welega	..	..	X	..	X	..	X	..	X	X	..	..	..	..	..	..	..
Welo	..	..	X	X	X	X	X	X	X	X	X	..	..	..	..	X	X

December 31, 1965.

TABLE 1.—*Continued.*

Province	Species of *Anopheles*																
	maculipalpis	*marshalli*	*natalensis*	*nili*	*obscurus*	*paludis*	*pharoensis*	*pretoriensis*	*rhodesiensis*	*rivulorum*	*rufipes*	*rupicolus*	*seydeli*	*squamosus*	*theileri*	*turkhudi*	*wellcomei*
Arusi	..	X	..	..	..	..	X	..	X	..	..	..	..	X	..	..	..
Bale	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Begemdir	..	X	X	..	..	..	X	X	X	..	X	X	..	X	..	..	..
Eritrea	..	..	..	..	..	..	X	X	X	X	X	X	..	X	..	X	..
Gemu Gofa	..	..	..	X	X	X	X	..	X	..	..	..	..	..	..	..	..
Gojam	X	X	X	..	..	..	X	X	..	..	..	..	..	X	..	..	..
Harer	..	X	X	..	..	..	X	X	X	..	..	..	..	X	..	X	..
Ilubabor	X	..	..	X	..	X	X	X	X	..	X	..	X	X	X	..	X
Kefa	..	X	..	X	..	..	X	X	..	..	..	..	..	X	..	..	..
Shewa	..	X	..	X	..	..	X	X	X	..	..	X	..	X	..	..	..
Sidamo	..	X	..	X	..	..	X	..	..	..	..	..	..	X	..	..	..
Tigre	..	..	X	..	..	..	X	X	X	..	..	X	..	X	..	X	..
Welega	..	..	..	..	..	..	..	X	..	..	..	..	..	..	..	..	..
Welo	..	X	X	..	..	..	X	X	X	..	..	X	..	X	..	..	..

December 31, 1965.

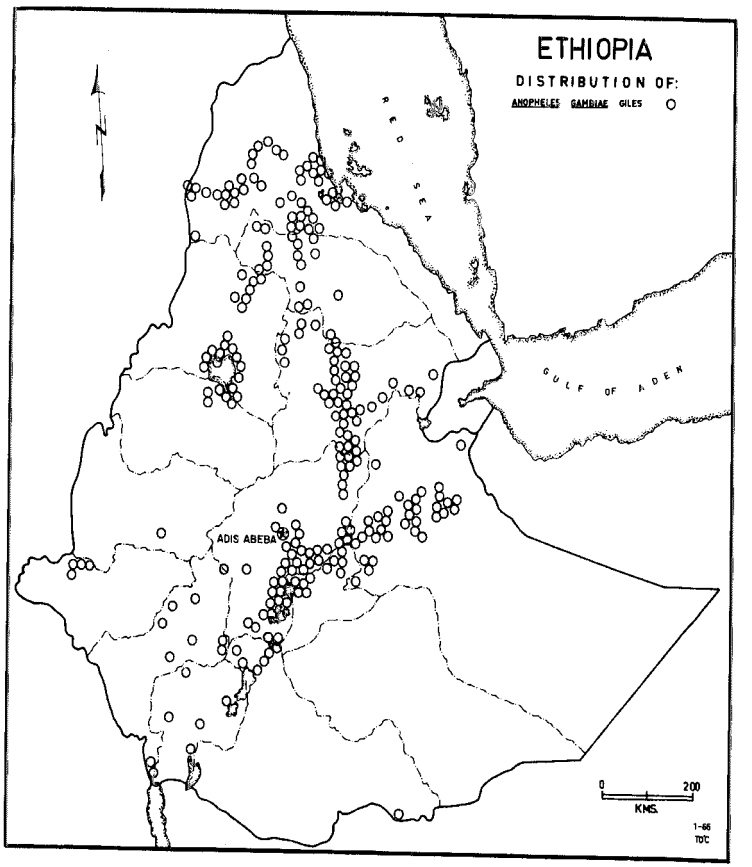

FIGURE 1

A. marshalli (Theobald, 1903)
A. natalensis (Hill and Hayden, 1907)
A. nili (Theobald, 1904)
A. obscurus (Grunberg, 1905)
A. paludis Theobald, 1900
A. pharoensis Theobald, 1901
A. pretoriensis (Theobald, 1903)
A. rhodesiensis Theobald, 1901
A. rivulorum Leeson, 1935
A. rufipes (Gough, 1910)
A. rupicolus Lewis, 1937
A. seydeli Edwards, 1929
A. squamosus Theobald, 1901
A. theileri Edwards, 1912
A. turkhudi Liston, 1901
A. wellcomei Theobald, 1904

Verrone (1962) in his key to anopheline species in Ethiopia also recognized 34 species.

Stone *et al.* (1959) considers *A. adenensis* a subspecies of *A. culicifacies* and *A. macmahoni* a subspecies of *A. sergentii*. Three species, *A. gingeroi* Corradetti and Archetti (1947), *A. erythraeus* Corradetti (1939b), and *A. amutis* De Burca (1943), have been excluded from the list due to the paucity of information concerning the adult stage. *A. gingeroi* and *A. erythraeus* were each described from a single larva, while *A. amutis* was described from a reared male adult and two larval skins.

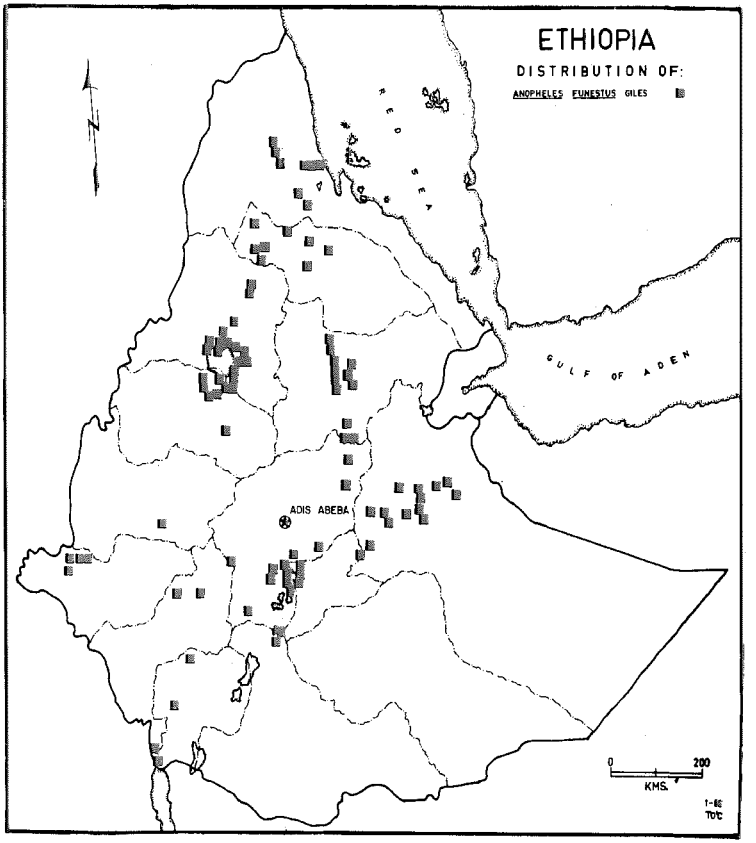

FIGURE 2

The female adult of none of the three proposed species has been described. Neither *A. erythraeus* nor *A. amutis* is recognized by De Meillon (1947) and Gillies *et al.* (1961).

The data available do not present a constant differentiation of the members of the *A. coustani* group (*A.c. coustani, A.c. tenebrosus,* and *A.c. ziemanni*). Therefore, the three subspecies have been placed together under the name of the type species.

As can be seen from the maps, *A. gambiae* has been found in 13 of the 14 provinces that comprise the Empire. The ubiquitous nature of this species is evidenced by the fact that it has been encountered almost everywhere that it has been sought. Its preference for small, natural unshaded collections of water, such as produced by rain, permits both extensive and intensive development. Temporary breeding places created by man are generally recognized as being among those most important to the species, although Jolivet (1959) found larvae along the shores of the islands in the middle of Lake Zwai.

A. funestus has also been found in 13 provinces in Ethiopia, but much more widely scattered than *A. gambiae.* A major factor in the relatively localized

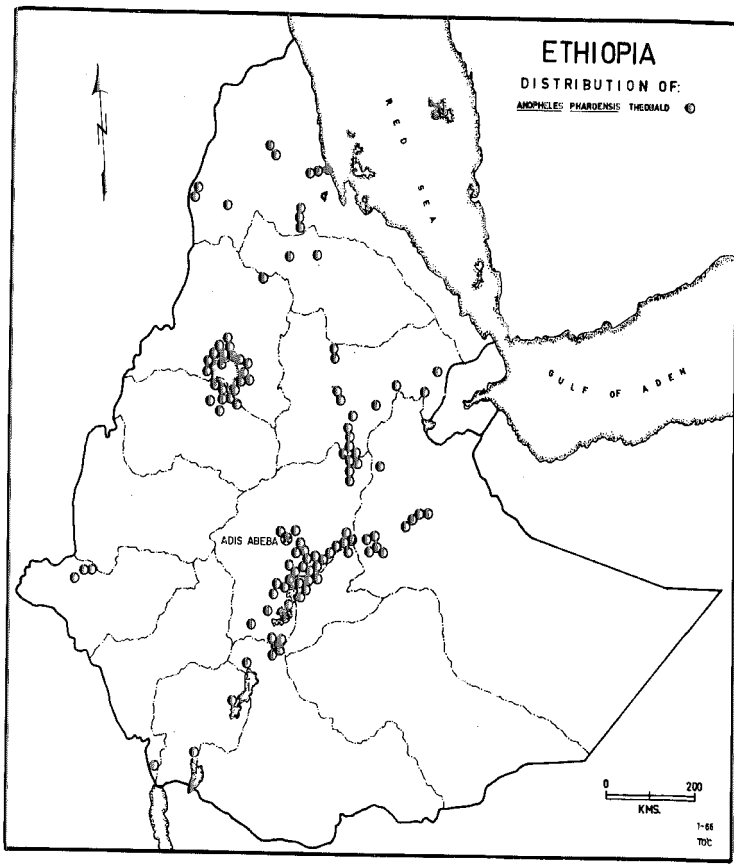

FIGURE 3

nature of this species is its tendency to breed in large, more or less permanent bodies of water where shade is available. The swamps along the Baro River in western Ethiopia provide an environment that permits *A. funestus* to exceed *A. gambiae* in numbers throughout most of the year. At Bahir Dar, Covell (1952) found seven species of anophelines breeding in permanent papyrus swamps at the southern edge of Lake Tana. Both *A. funestus* and *A. gambiae* were present, but the former was collected in far greater numbers than any of the other six species.

Like *A. funestus, A. pharoensis* breeds in shaded permanent water found in swamps, along lake shores, in rice fields, and in irrigation ditches. The maps show much the same distribution as is the case with *A. funestus* in localities along the Baro and Awash Rivers, Lake Tana, and the lake region south of Adis Abeba. Jolivet (1959) stated that *A. pharoensis* seems to be more widely distributed than *A. gambiae* from the lowlands to the high plateau and is very common in irrigated areas.

VECTOR STATUS. *Anopheles gambiae* is

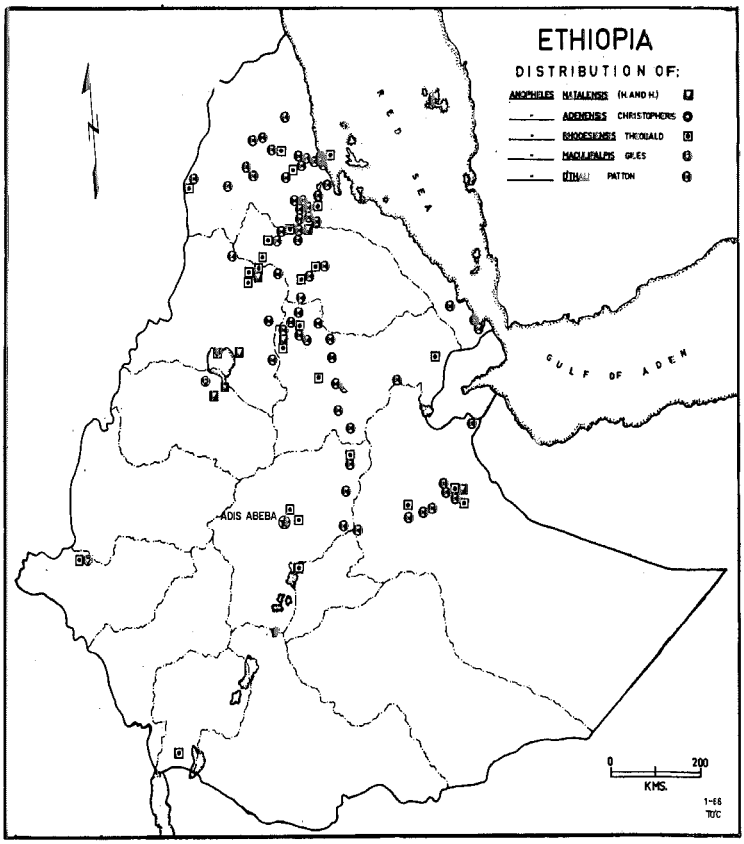

FIGURE 4

generally considered to be the most important vector of malaria in Africa. De Meillon (1947) stated that the species is responsible for intense malaria wherever it occurs. In Ethiopia, according to Giaquinto-Mira (1950), *A. gambiae* is chiefly responsible for the epidemics in almost all districts. Jolivet (WHO, 1959–60) and Melville *et al.* (1945) further stated that there is no doubt that *A. gambiae* is the principal malaria vector in Ethiopia.

Records of salivary gland dissections to confirm the vector status of suspected anophelines other than *A. gambiae* in Ethiopia are scarce. AID technicians dissected 146 specimens of *A. gambiae* from the Kobo-Chercher area in May and August, 1956, but found no positive salivary glands. Rice (USAID, 1955–65), also working in the Kobo-Chercher region of Welo Province, reported three salivary gland infections from 100 *A. gambiae* dissected. During April and May, 1956, in the same area, 50 *A. gambiae* were found to be negative for both sporozoites and oocysts.

In the WHO Awash Valley Pilot Project at Marti in January and February, 1957, a total of 633 *A. gambiae* dissections

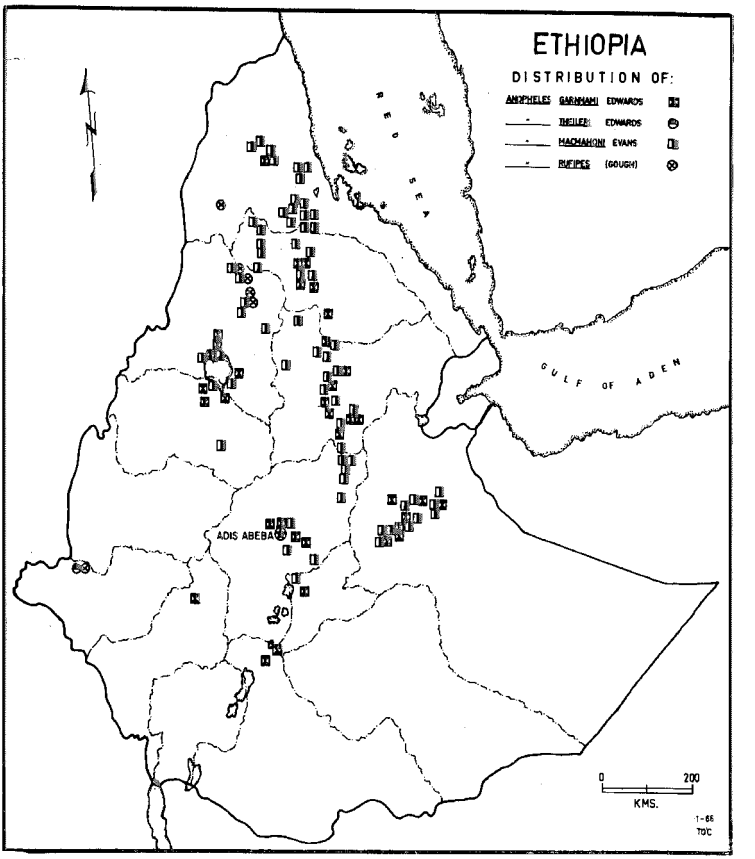

FIGURE 5

yielded one specimen with positive glands (0.15 percent). During a 6-month period in 1958, Jolivet (1959) made 630 dissections of the species with negative results. At Gambela, McDonald (USAID, 1955–65) dissected four *A. gambiae* and failed to find a positive specimen. He also dissected 13 *A. pharoensis*, 5 *A. nili*, 3 *A. wellcomei*, 2 *A. coustani*, and 1 *A. rufipes* with negative results. Rishikesh (WHO, 1963–65) examined 402 *A. gambiae* at Bati and 56 at Bery near Nazareth in Shewa Province in the summer of 1963, but found no positive glands.

A great deal of entomological work was carried out by the WHO Pre-eradiction Project Team in the lake region of Shewa and Sidamo Provinces south of Adis Abeba during 1964 and 1965. A total of 7,740 dissections were performed. Of these 4,594 involved *A. gambiae*, but only 9 specimens of this species were found to have positive glands (0.2 percent). Dissections of 2,694 *A. pharoensis*, 357 *A. funestus*, and 95 *A. demeilloni* yielded no positive specimens.

Although *A. funestus* is generally considered to be the second most important vector in Ethiopia, particularly of endemic malaria, there are few records of dissec-

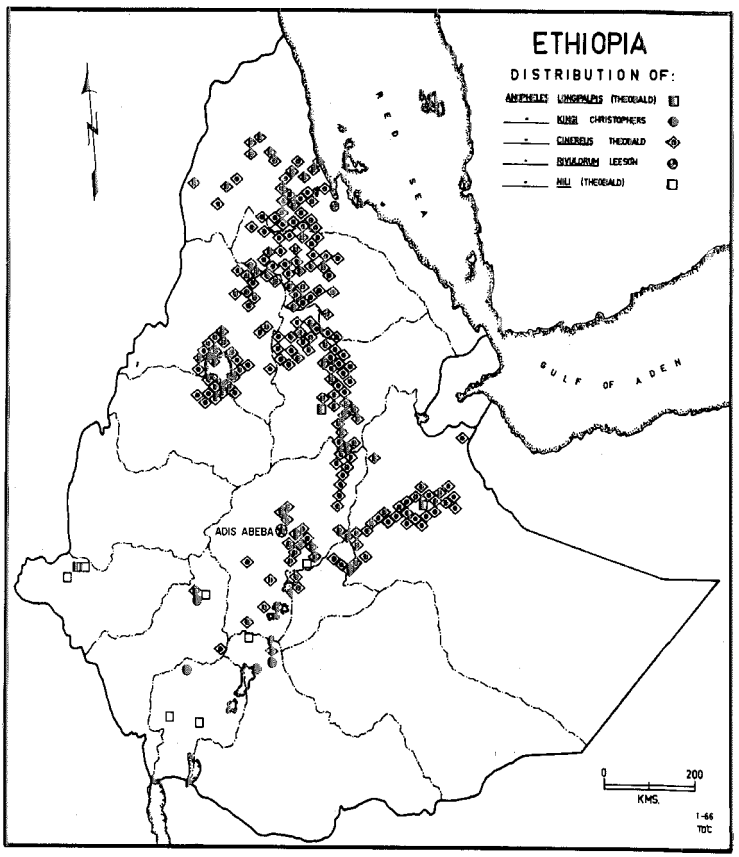

FIGURE 6

tions for sporozoites in this species. In March, 1959, at Gambela, Ilubabor Province, where *A. funestus* outnumbers *A. gambiae* during most of the year, Najjar, of USAID, (USAID, 1955–65) dissected 70 *A. funestus* and found one positive (1.4 percent). Jolivet (WHO, 1959–60) considered *A. funestus* an important vector in Gambela, but stated that it is too rare in some areas to play an important part in malaria transmission. On the other hand, Melville *et al.* (1945) felt that this species undoubtedly plays a part in malaria transmission in Jima, although *A. gambiae* is the main vector. De Meillon (1947) lists the results of salivary gland studies of this species by workers from various parts of Africa. Of particular interest are the positive rates reaching 9.4 percent in Uganda and 15.79 percent in neighboring Kenya to the south of Ethiopia.

A. pharoensis has been found naturally infected in Egypt, Nigeria, and Kenya (De Meillon, 1947), and Jolivet (WHO, 1959–60) stated that Ovazza once found this species infected in Ethiopia (original reference unavailable). In his epidemiological studies in Welo Province, Cor-

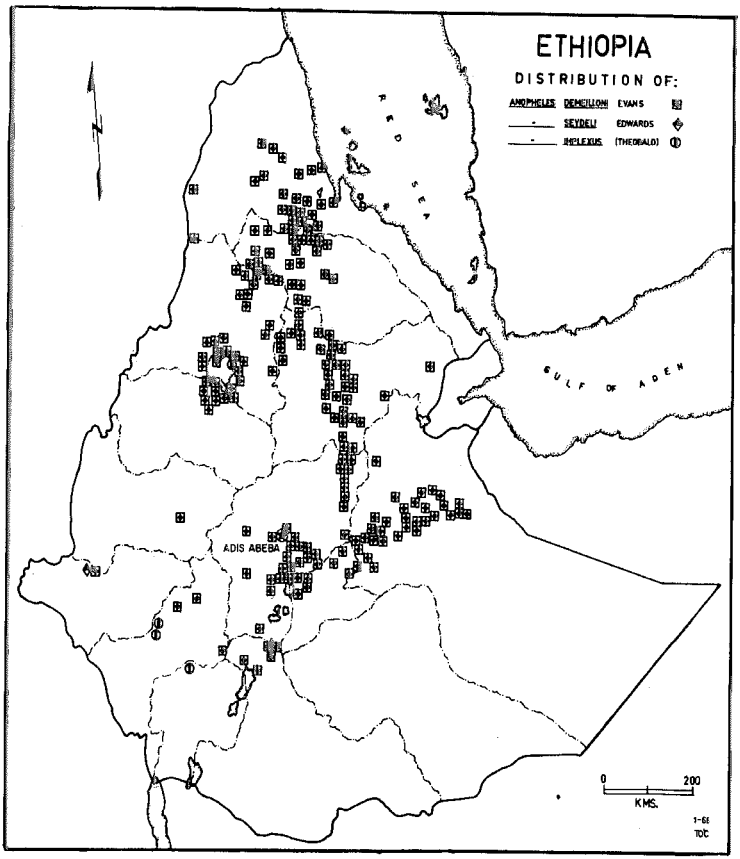

FIGURE 7

radetti (1940) reported that *A. pharoensis* seems to be a less important vector than *A. gambiae*. At Wonji Plantation, south of Nazareth in Shewa Province, Dr. Solomon, plantation physician, reportedly found an infected specimen. In regions of permanent waters such as lakes and irrigated areas, this species becomes abundant and where it is the only anopheline present, it must be regarded with suspicion.

Giaquinto-Mira (1950) dissected "some" *A. coustani ziemanni* from Bari D'Ethiopia in Harer Province during a malaria outbreak (year not stated) and found positive glands in one specimen. De Meillon (1947) stated that no natural infections of this variety had been reported. There are no conclusive data available to determine the status of other varieties of *A. coustani*. De Meillon believes that *A. rhodesiensis* should be added to the list of malaria carriers in Ethiopia because both natural (Sierra Leone) and experimental infections have been confirmed.

Mara, according to Giaquinto-Mira (1950), considered *A. d'thali* a vector, but only in exceptional cases. De Meillon (1947) stated that the vector status of

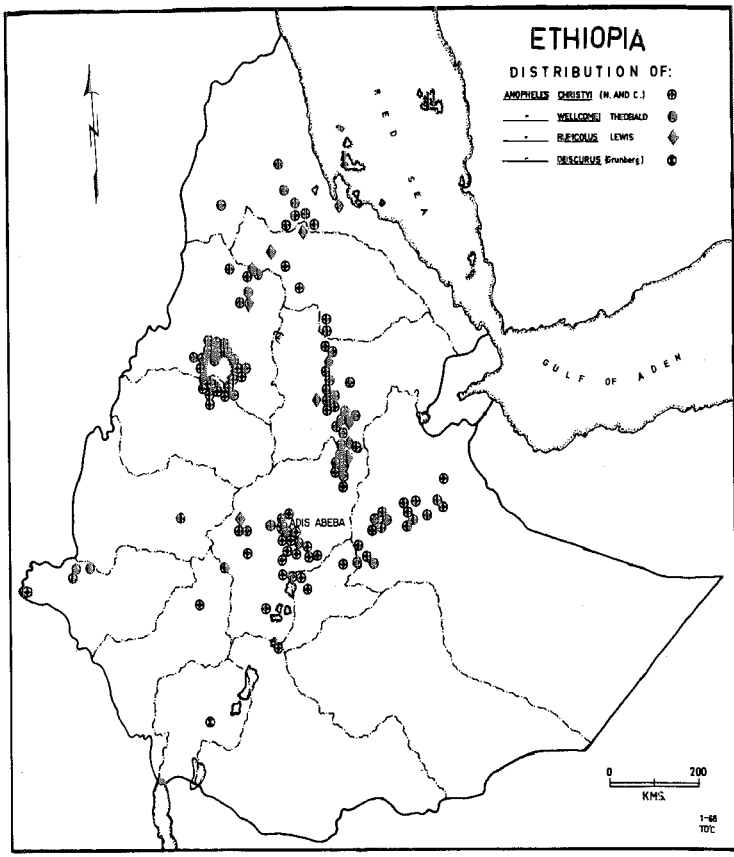

FIGURE 8

this species is a matter of doubt because of the lack of dissections.

The vector status of the other anopheline species found in Ethiopia which are known to be susceptible to either natural or experimental salivary gland infection is, at present, considered to be of academic importance. This is primarily a result of the gravity of the widespread presence of *A. gambiae,* one of the most efficient vectors in the world. Another factor is the paucity and localized nature of other species found to be infected elsewhere. For example, *A. nili,* found naturally infected in the Belgian Congo, Liberia, and Sierra Leone; *A. maculipalpis,* found infected in the French Cameroons; and *A. paludis,* found infected in the Belgian Congo (De Meillon, 1947); are found in a few local situations, but their presence is overshadowed by that of *A. gambiae.*

The vector status of such species as *A. rupicolus, A. seydeli, A. rivulorum, A. macmahoni,* and *A. wellcomei* has not been definitely established by workers in any part of their range.

ACKNOWLEDGMENT. The author wishes to acknowledge the encouragement and

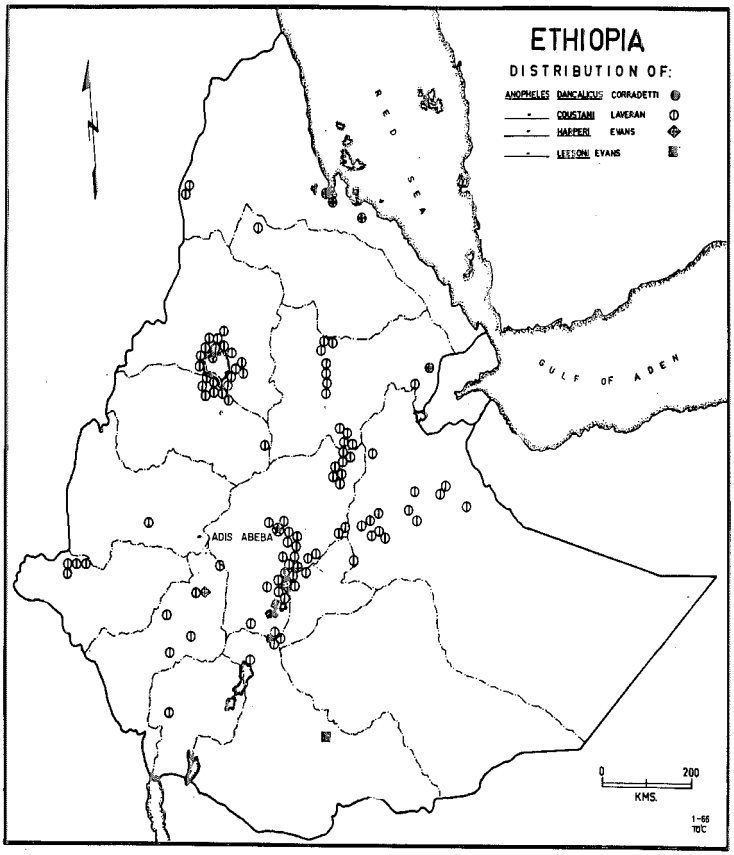

FIGURE 9

assistance of Dr. D. J. Pletsch, formerly Chief Malaria Advisor to USAID/Ethiopia, during the course of this study.

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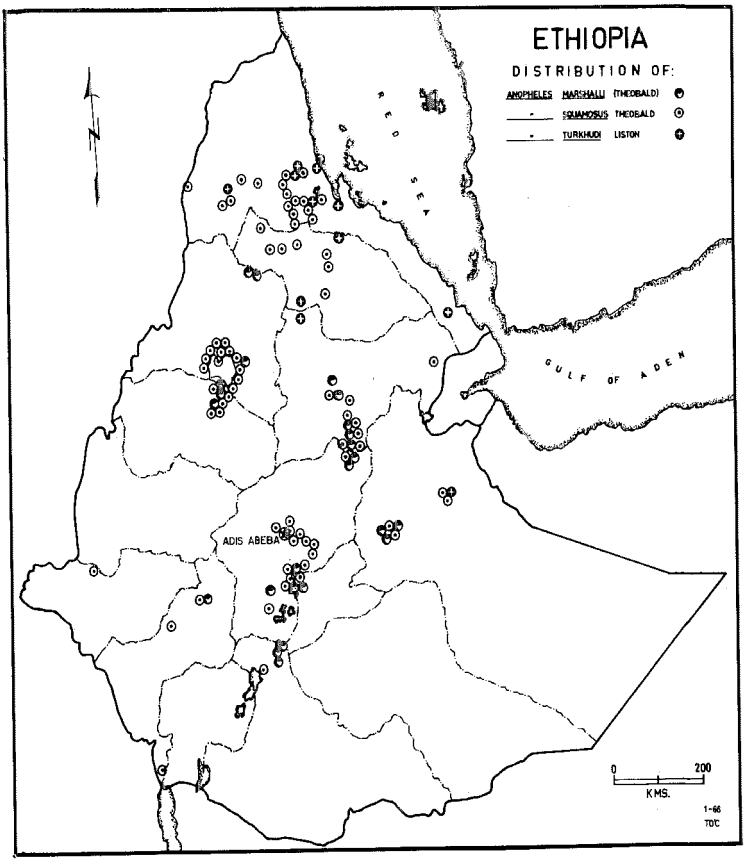

FIGURE 10

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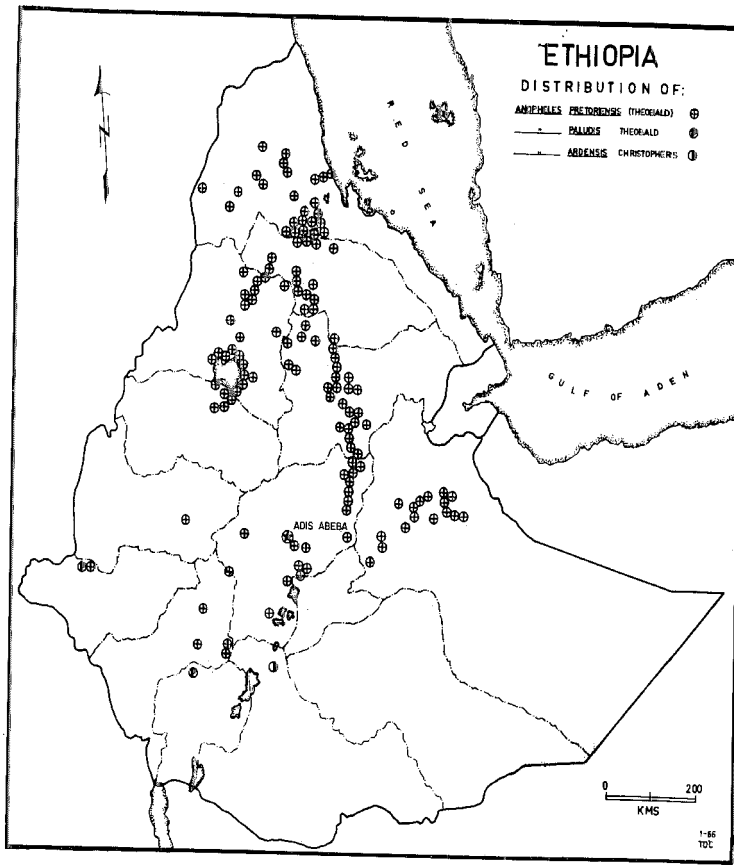

FIGURE 11

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