rather sharply, but even with the most frequent re-treatment (every 3 weeks) the average level remained approximately the same as that shown at 48 hours after initial application. At the applied dosage of 1.0 p.p.m. of Abate the level of toxicant did not rise above 0.79 p.p.m. during the 13-week period. The same general picture is apparent with the 2.5 p.p.m. treatment. A sustained accumulation of the Abate did not occur with re-treatment at either 3- or 6-week intervals.

To simulate field practices, drums containing 17 gallons of water were treated with the same quantity of granules necessary to provide a 1.0 p.p.m. application in 50 gallons of water. As anticipated, Abate concentrations in drums containing 17 gallons of water remained at a higher level after each re-treatment than those in 50 gallons. The difference in Abate recovery from the two volumes of water decreased with age of treatment but again no significant accumulative effects were noted.

ACKNOWLEDGMENTS. The authors would like to express their thanks to Mr. Anthony M. Dean, Physical Science Aid (Chemistry), and Mr. John Olson, jr., Biological Laboratory Technician, of the Technical Development Laboratories, Aedes aegypti Eradication Program, National Communicable Disease Center, Savannah, Georgia, for their valuable assistance in the chemical and biological testing for this work.

References

BROOKS, G. D., and SCHOOF, H. F. 1965. Simulated field tests of new insecticide formulations against *Aedes aegypti* larvae in 55-gallon water storage containers. Proc. 52nd Ann. Meet. N. J. Mosq. Ext. Assoc., pp. 160–166.

BROOKS, G. D., SCHOOF, H. F., and SMITH, E. A. 1965. Effectiveness of various insecticides against *Aedes aegypti* infestations in water storage drums in U. S. Virgin Island. Mosq. News 25(4):423–427.

BROOKS, G. D., SCHOOF, H. F., and SMITH, E. A. 1966. Evaluation of five formulations of Abate against *Aedes aegypti*, Savannah, Georgia, 1965. Mosq. News 26(4):580–582.

ANOPHELES STEPHENSI LISTON IN EGYPT, UAR.

AMIN M. GAD, PH.D

Research Institute of Medical Entomology, Dokki, Cairo, UAR.

Anopheles stephensi is one of the malaria vectors of the Oriental region. It was first described by Liston (1901), from India. It is considered an efficient vector responsible for city malaria in Bombay, Bangalore and Lucknow, and an important vector under rural conditions in western and northwestern India. In some experimental infections in the laboratory in India (Roy 1943), the percentages of mosquitos acquiring sporozoites were 45.4 for *Plasmodium vivax* and 37.3 for *Plasmodium falciparum*. Infection in nature ranged from 0.2 to 2.6 percent for sporozoites (Boyd 1949).

Within the Oriental Region the distribution of *A. stephensi* lies in India, Pakistan, Burma, and China and, outside this region, it was recorded in the Baluchistan, Iran, Iraq and the Eastern region of Saudi Arabia near the Persian Gulf.

Another variety or subspecies of this species was described by Sweet and Rao (1937) in Marikanave, India, under the name *A. stephensi mysorensis*. Although the two forms are apparently indistinguishable in the larval and the adult stages, Afridi *et al.* (1958) were able to distinguish the subspecies *mysorensis* from typical *stephensi* by means of egg measurements. *A. mysorensis* is considered less hardy than the type form and has more

zoophilic tendencies and hence is less important as a malaria vector.

In Egypt this species has never been recorded before. There is even no hint in the literature on its possible introduction from other countries. In his extensive study on the mosquitos of Egypt, Kirkpatrick (1925) gave a list of species which may possibly be found to occur in Egypt (*A. costalis=gambiae* was mentioned in the list and actually invaded Egypt from Sudan in 1942 & 1950), but no mention was ever made of *A. stephensi*.

Late in October 1966, some specimens of living anopheline larvae were sent to the Research Institute of Medical Entomology for identification. They were collected from Shokheir, an area near Ras Ghareb on the Suez Gulf where new oil fields have been recently discovered. Larvae were found to resemble *A. multicolor* larvae in many respects but differ in the following characters (Fig. 1):

a. Inner, outer and posterior clypeal hairs being fraved and not simple.

b. Posterior clypeal hairs just overreaching the bases of the inner clypeal hairs.

c. No dark spots are present around the bases of the inner frontal hairs.

Other features of the larvae are the poorly developed inner shoulder hair (Fig. 2), the undifferentiated metathoracic and first abdominal palmate hairs (Figs. 3 and 4), the relatively short filaments of the other abdominal palmate hairs being less than half the length of the blade (Fig. 5), and the small rounded anal papillae.

Fortunately a few larvae could be reared up to the adult stage and when examined proved to be not *A. multicolor* but possess the following characters which belong to *A. stephensi*:

a. Costa with 4 alternating light and dark spots.

b. Abdominal segments 2–7 with scales on terga but not with laterally projecting tufts of scales.

c. Femorae and tibiae speckled and the apical segment of the hind tarsus dark.

d. Female palp somewhat shaggy at base, apical segment all white-scaled, preapical white band about as broad as the apical, occupying the tip of segment 3 and the base of segment 4 and a third narrow pale band situated between segment 2 and 3. Few white scales are present on the dorsal surface of segment 3.

A trip to the area was soon made and other living specimens were collected and bred to the adult stage. *A. stephensi* identification was confirmed, this being not only the first record of this mosquito in Egypt but also the first in the African continent.

Of much interest is the type of breeding place where *A. stephensi* larvae were found. The area is about 1½ kilometers from the Suez Gulf, 35 km. south of Ras Ghareb, a small town built to accommodate workers of oil fields in the area. Breeding places were found at the periphery of a large salt water pool in the form of scattered small pits nearly circular, ranging from 30 to 120 cm. in diameter and 40 cm. in depth. Salt crystals were present at the edges of these pits and water analysis revealed that it contained 18.9 parts inorganic chlorides per thousand which is about 65 percent sea water.

In India, *A. stephensi* breeds in wells, cisterns, fountains, garden tanks and tubs and in water contained in all sorts of receptacles around houses. In rural areas larvae are found in pools, in stream beds, margins of streams, seepages, irrigation channels and springs. All these places contain obviously fresh water or at most slightly brackish water, but the adaptation to breed in water with such degree of salinity is certainly peculiar. It is interesting to recall that Russell and Mohan (1963) were able to establish colonies of *A. stephensi* (type) in cages with larval pans containing up to 80 percent sea water.

Another peculiar adaptation of this species is its success in breeding in wells, cisterns and containers which rendered this species responsible for a severe malaria epidemic which occurred in 1908 in the densely crowded city of Bombay (Christophers, 1949). Covell (1949) also stressed this point by indicating that in general there is but little transmission of malaria

in built-up areas of the Oriental Region because the great majority of malaria carrying mosquitoes were unable to adapt themselves to strictly urban conditions, but that *A. stephensi* provided an exception to this rule, being responsible for a serious amount of malaria transmission in some of the most important cities in peninsular and northwestern India, e.g., Bombay, Lucknow, Bangalore and Calcutta.

Outside the Oriental Region *A. stephensi* is a recognized vector in Iraq, Muskat and Bahrein Islands (Hackett, 1949), and it was responsible for the high endemicity of malaria in the Eastern Province in Saudi Arabia prior to DDT residual spraying in 1948 as well as again

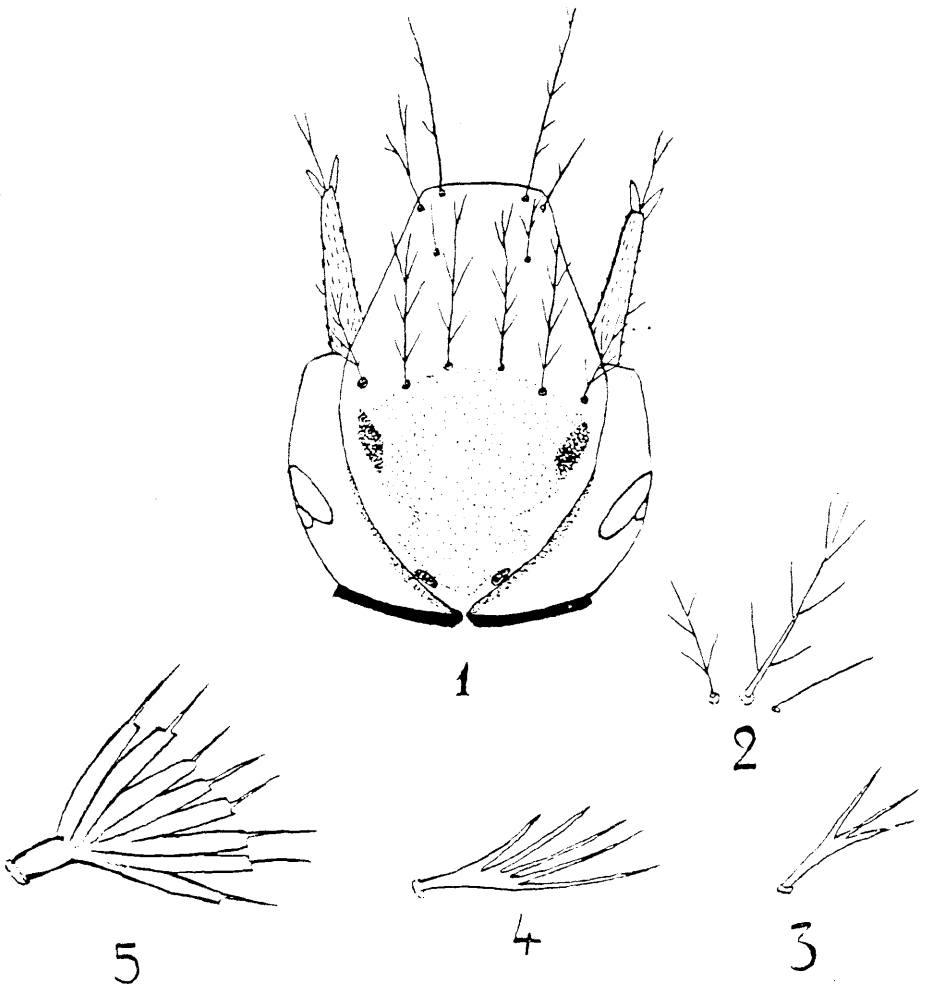

FIG. 1.—Head of fourth stage larva of *Anopheles stephensi*. FIG. 2.—Shoulder hairs (right side). FIG. 3.—Metathoracic palmate hair. FIG. 4.—First abdominal palmate hair. FIG. 5.—Fifth abdominal palmate hair.

after the appearance of its DDT-resistant strain in 1955 (Zahar, unpublished report). The species was also responsible for malaria epidemics which occurred in Iraq and Iran in 1957, leading also to the discovery of DDT-resistance in both countries.

The question might now arise whether *A. stephensi* is indigenous in the Red Sea area or could it have been transported from other countries. The nearest seaport to the breeding area is Ras Ghareb but it is a local port and does not receive ships from foreign countries. Moreover, Saudi Arabia, which is the nearest country in which this mosquito exists, is free from *A. stephensi* in its western parts and it is only recorded from the eastern region near the Persian Gulf. Thus it is not likely that the mosquito had recently invaded the Red Sea area from abroad but, more likely, it has established itself for a long time but did not attract attention earlier, owing to its existence in areas far from human activities. When such activities were started in the area because of the discovery of new oil fields, the mosquito was soon detected. There are similar instances of the occurrence of some anopheline mosquitoes in certain localized areas in Egypt and not elsewhere in the country, viz., *A. rupicolus* and *A. turkhudi* in Sinai (Gad, 1957) and *A. algeriensis* in Siwa Oasis in the Libyan Desert (Gad, 1956).

Since *A. stephensi* is an efficient malaria vector, as mentioned above, and since Shokheir is likely to expand to a town similar to Ras Ghareb in the near future, measures have been already taken to prevent malaria transmission in the area. Larviciding of all breeding places with oil will be carried out periodically together with burning of all shrubs in the vicinity which might provide shelter for adult mosquitoes. Blood films of all inhabitants of the Red Sea Area wil be taken and malaria positive cases will be given the radical cure. Moreover, any newcomer to the area will be examined for malaria parasites and treated before settling. A detailed survey of the Red Sea area will be undertaken in spring 1967.

ACKNOWLEDGMENT

The author wishes to express his thanks to Dr. R. Seif El-Din and Dr. H. Shouhdi of the Egyptian Oil Field Company for facilitating his trip to Shokheir and for their enthusiastic interest and cooperation.

References

AFRIDI, M. K., TALIBI, S. A., RASHID, S. A., and HUSAIN, M. Z. Y. 1958. Identifications of races of *A. stephensi* prevalent in the federal Karachi area by measurements of their ova. Pak. J. Hlth. 8:71.

BOYD, M. F. 1949. Epidemiology: factors related to the definitive host (in Malariology edited by M. F. BOYD. Saunders). 608.

CHRISTOPHERS, R. 1949. Endemic and epidemic prevalence (in Boyd's Malariology, Saunders). 698.

COVELL, G. 1949. Malaria control in the Oriental Region (in Boyd's Malariology, Saunders). 1439.

GAD, A. M. 1956. Mosquitoes of the oases of the Libyan Desert. Bull. Soc. Entom. Egypt 40:131.

GAD, A. M., and DARWISH, R. O. 1957. Mosquitoes collected in Southern Sinai. Bull. Soc. Entom. Egypt 41:535.

HACKETT, L. W. 1949. Malaria control in the Palearctic Region (in Boyd's Malariology, Saunders). 1416.

KIRKPATRICK, T. W. 1925. Mosquitoes of Egypt. Government Press. Cairo.

LISTON, W. G. 1901. A year's experience of the habits of *Anopheles* in Ellichpur. Indian M. Gaz. 36:411.

ROY, D. N. 1943. The role of *Anopheles subpictus* Grassi as a carrier of malaria. J. Mal. Inst. India 5:117.

RUSSELL, P. F., and MOHAN. 1963. In Russell's *et al.* Practical Malariology, Oxford University Press 215.

SWEET, W. C., and RAO, B. A. 1937. Races of *A. stephensi* Liston. Indian M. Gaz. 72:665.