thion as *A. taeniorhynchus*. These data confirm the previous observations made in the field (Mount *et al.*, 1972).

In our opinion, a relatively quick knockdown is a desirable characteristic for mosquito adulticides. The $KC_{90}$'s given in Table 1 show that resmethrin, pyrethrins, tetramethrin, and naled produced quick knockdown (within 1 hour) with $KC_{90}$'s of one-half to only slightly higher than their respective $LC_{90}$'s. Malathion had moderate knockdown and a $KC_{90}$ about 70 percent higher than the $LC_{90}$. Fenthion, chlorpyrifos, Plant Protection PP-511, Montecatini L-561, and Dowco 214 had relatively poor knockdown.

The acute oral toxicities (Table 1) for rats indicate that most of the ten adulticides are at least as safe as malathion. Only fenthion, chlorpyrifos, and naled are markedly more toxic to rats than malathion.

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# EFFECT OF AGRICULTURAL SPRAYING ON *ANOPHELES ALBIMANUS* DENSITIES IN A COASTAL AREA OF EL SALVADOR[1]

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INTRODUCTION. In connection with malaria investigations in Central America, several investigators have reported a marked reduction in the vector *Anopheles albimanus* populations following the aerial application of insecticides in cotton growing areas. In coastal plain regions of Guatemala, El Salvador, Honduras, and Nicaragua, the insect pests of cotton are treated with very large quantities of organochlorine and organophosphorus insecticides, applied by aircraft during five or six months of the year. Rachou *et al.* (1965) reported that the application of insecticides by airplane to the cotton fields reduced the anopheline density and shortened the periods of high malaria transmission in a study area near Acajutla, El Salvador. Georghiou (1972) in his studies of insecticide resistance of *A. albimanus* in Central America stated that anopheline densities show a dramatic decline during the cotton spraying season in spite of abundant rainfall.

For the past four years the Central American Malaria Research Station (CAMRS) has been investigating the epidemiology of malaria in various parts of El Salvador. One component of these studies has been the routine measurement of

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easonal changes in *A. albimanus* populations. During 1972 it was possible, in ne of these study areas, to record the pplication of cotton pest insecticides and neasure densities of *A. albimanus,* on a veekly basis, and to compare these obervations with similar ones carried out n a nearby non-cotton growing area.

MATERIALS AND METHODS. One CAMRS oastal study area is a 100 square kiloneter tract of low-lying land 10 kiloneters east of the port city of La Libertad. The area is mainly an agricultural one, vith five large haciendas engaged in coton cultivation and cattle production. The limate of El Salvador is of the monsoon ype, with marked rainy and dry seasons. The rainy season begins gradually in April or May, and tapers off in October, with he average rainfall in the months of December through March only about 20 nillimeters. Malaria is endemic, and inidence of the disease was at a relatively igh level during 1972.

Adult *A. albimanus* densities were neasured by weekly captures in large tables at three different haciendas. Durng these captures, all resting anophelines were collected from walls and ceilings of the stables for an hour from 7 to 8 p.m. A single New Jersey light trap was operated one night a week all night long, in a village near the center of the district. Breeland (1972) reported that light traps and stable collections were efficient methods for measuring anophelism in coastal El Salvador.

Larval *A. albimanus* densities were measured weekly by hand dipping in 16 selected breeding sites. These were chosen so as to represent all of the larval habitat types found in the area, including rivers, permanent swamps, estuaries, irrigated pastures and drainage canals.

Information on the timing and amount of cotton spraying was collected from the administrators of the haciendas. All spray planes operated from four privately owned landing strips. Accurate information on actual gallons of finished spray delivered to the cotton fields by week was not available, but total number of spraying flights per week was recorded, and this was considered to be a measurement of the intensity of spray application, since all spray planes employed carried approximately the same volume of insecticide.

In order to compare *A. albimanus* adult density fluctuations in cotton and non-cotton areas, a capture point was established at Hacienda Santa Emilia, 6 kilometers west of La Libertad, well removed from cotton fields. Captures of resting anophelines in the stable at this hacienda were done in the same way and on the same nights as captures in the stable of the cotton area.

RESULTS AND DISCUSSION. Adult densities of *A. albimanus,* measured by stable captures and light trap, began to build up in May, following the onset of the rainy season, in both the areas under investigation. In the cotton growing area (Figure 1) the density remained high until mid August and then declined abruptly and remained low or negative until December. Presented in this same figure are weekly data on numbers of spray plane flights, which showed a marked increase in late August and reached a peak in October. The decrease in *A. albimanus* adults coincided with the increased application of insecticides to the cotton fields. In the non-cotton area (Figure 1) adult densities remained relatively high throughout the rainy season. Rainfall data are presented in this figure, and rainfall was approximately equal in both cotton and non-cotton study areas during 1972.

The insecticides used on cotton during the growing season were parathion and methyl parathion, malathion, azudrin, DDT, carbaryl and several others. Some of the applications were made using the ultralow volume technique. It is likely that this heavy application of a great variety of insecticides had a lethal effect on the larval forms of *A. albimanus,* through contamination of the breeding places, and also on adults in their natural

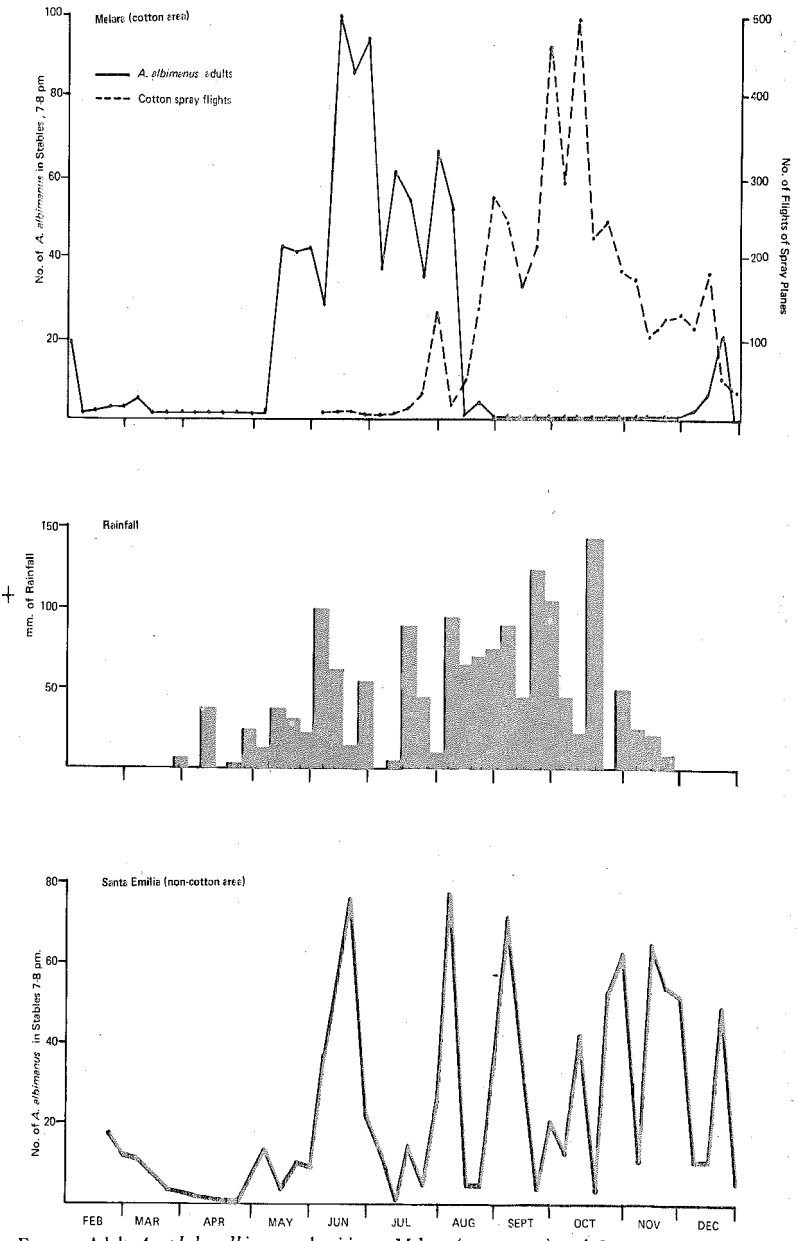


FIG. 1.—Adult *Anopheles albimanus* densities at Melara (cotton area) and Santa Emilia (non-cotton area), with records of rainfall and cotton spray flights by week, in 1972.

daytime resting places. Out of the 16 breeding sites checked weekly for larvae, 15 of them were found negative at the end of August, and remained so until December. The single exception which remained continuously positive was a cattle watering pond, situated at the northern limit of the district. This was the farthest removed breeding place from cotton fields in the study area.

The cotton growing areas of coastal El Salvador are also malaria problem areas due to insecticide resistance of the vector, poor quality housing, human population migrations and other factors. Many malariologists believe that the future of malaria control in these areas must involve the use of integrated control programs. In the planning of these, advantage could be taken of the fact that during a part of the year cotton spraying drastically reduces *A. albimanus* populations in certain areas. In this way agricultural insecticide spraying could become one component of integrated malaria control projects.

SUMMARY. Weekly observations were made, during 1972, of *A. albimanus* larval and adult densities in a cotton growing area of coastal El Salvador. Measured by stable and light trap captures, the adult densities began to build up in May, following the onset of the rainy season, and declined abruptly at the end of August. This decline coincided with the increasing application of insecticides to cotton fields by aircraft. Most breeding places of *A. albimanus* also became negative at the same time. In a non-cotton area, adult densities also began to build up in May, but remained relatively high until December, the beginning of the dry season. The reduction of vector populations by agricultural spraying could be taken advantage of when planning integrated control programs in cotton growing areas.

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