CONTROL OF *AEDES* DISPERSING ALONG A DEEP RIVER VALLEY

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The City of Edmonton controls mosquitoes mainly by larviciding over an area which extends from two to three miles beyond city limits (Fig. 1). Nevertheless, every spring mosquitoes in annoying numbers appeared on the playgrounds and golf courses along the North Saskatchewan River Valley, which passes through the center of the city. In 1958 and 1959 an attempt was made to determine the origin of these mosquitoes and to devise a means for their control.

Edmonton lies on a flat plain from which most trees have been cleared. The river valley and tributary ravines are wooded with spruce and poplar except in areas cleared for recreation and pasture. The floor of the river valley lies about 50 meters below the plain, and the width of the valley between its rims ranges from 1,000 meters along the straighter stretches to 1,500 meters at bends. Most pools producing mosquitoes are found on the plain to the west and northwest of the city.

In 1958 larviciding was carried out effectively, and no pools within the control area were missed. Outside of the control area adult emergence was studied using

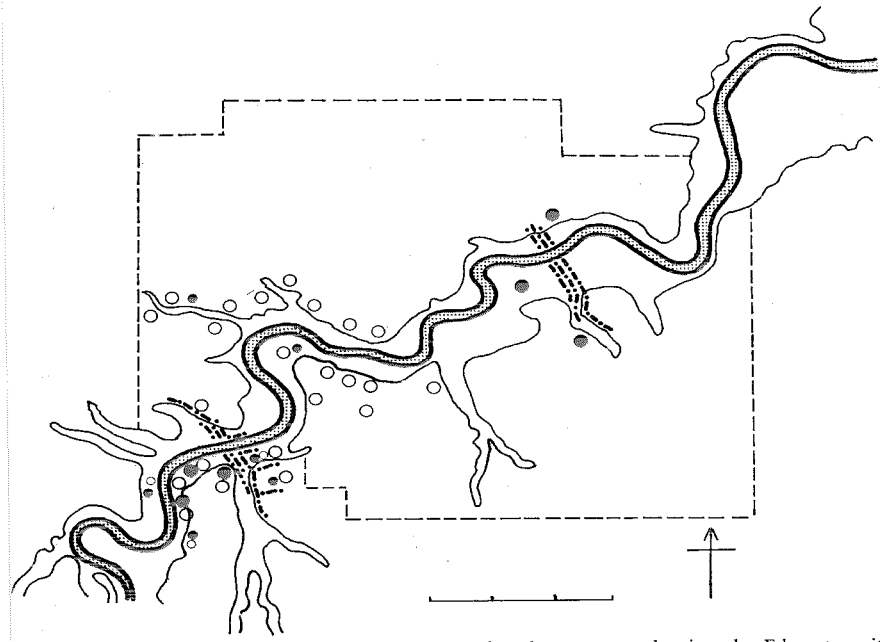

FIG. 1.—The distribution of *A. cataphylla* swarms plotted on a map showing the Edmonton city limits (broken line), the North Saskatchewan River, the rim of its valley and tributary ravines (2175 ft. contour). The dot-dash lines represent lindane barriers. 1958 swarms are shown as open circles, 1959 as dots; large symbols represent large swarms. Scale shows miles.

rearing cages set up in pools as described by Twinn (1950). Two light traps of the type described by Haufe and Burgess (1960) were set up, one in the river valley and one on the plain, near the center of the city. Observations on biting and swarming were made daily inside and beyond the control area.

Emergence of *Aedes cataphylla* Dyar began on May 14 and was nearly complete by May 19. Beginning on May 14 *A. cataphylla* mosquitoes were taken in small numbers by the light traps. Few were seen on the wing prior to the evening of May 17 when huge swarms were found in the river valley near the center of the city. Thereafter much swarming occurred in and along the river valley and tributary ravines in the western part of the city, and less in the eastern part. Very few mosquitoes were found elsewhere in the control area.

Few *Aedes fitchii* (Felt and Young) and *Aedes excrucians* (Walker) emerged before May 28; and few *Aedes stimulans* (Walker) before May 30. Within the city these banded-legged mosquitoes were trapped and encountered in increasing numbers beginning on May 25, so that by June 3 these mosquitoes were present in annoying numbers. Their distribution within the city, assessed by collecting biting females, was similar to that of *Aedes cataphylla.*

The occurrence and distribution of mosquitoes within the city did not seem to be related to weather systems. No cold fronts had passed over the city and surface winds had been variable both in speed and direction. Rather it seemed likely that the mosquitoes had entered the city along the valley-ravine system. To check the plausibility of this hypothesis micrometeorological conditions on the plain, in the river valley, and in tributary ravines were studied in detail (Klassen, 1962).

When insolation is weak or absent and winds on the plain are less than about 9 mph., temperatures and wind speeds are lower and less variable in the ravines and in the valley than on the plain. During the day wind speeds less than 5 mph. were observed during less than one-third of the hours in the valley and during less than one-fifth of the hours on the plain. By contrast, at night wind speeds less than 5 mph. were observed during three-quarters of the hours in the river valley and during one-third of the hours on the plain. Except on rainy days the relative humidity usually falls from high values at night to less than 30 percent during the forenoon, and begins to rise earlier in the afternoon in the ravines and valley than on the plain. For example, on June 5 the relative humidity had reached 70 percent at 1900 hours in a ravine, at 2100 hours in the valley, and at 2200 hours on the plain. Thus, conditions favouring mosquito activity exist more frequently in the valley and tributary ravines than on the plain.

Observations and studies on the behavior of mosquitoes led to the hypothesis that mosquitoes enter the city via the river valley. (An account of this work is being published elsewhere.) To test this hypothesis lindane barrier strips were laid down across the river valley near the east and west city limits. Three 100-yard-wide swaths separated by untreated intervals of equal width constituted each barrier. The application of the barrier was delayed as long as possible to allow the poplars to come into leaf and augment the carrying surface for the insecticide. This happens a few days prior to the peak of emergence of *A. cataphylla.*

During a calm at dawn on May 13 1959, the first barriers were applied by means of the Stearman PT-17 at 0.3 pound lindane per acre, with lime, the only available material, as a carrier at 20 pounds per acre. At dawn on May 15 the barriers were renewed with a wettable powder suspension in 20 gallons of water per acre to deposit the same quantity of lindane. The aircraft was flown at about 30 feet above ground. Wind on the plain was four miles per hour but less than this in the valley. The droplet spectrum sampled

by means of jump cards ranged from one micron to 387 microns, with a mass median diameter of 129 microns. This barrier was similarly renewed on June 2 during favorable meteorological conditions.

The task of evaluating the effect of the lindane barriers by comparing the distribution and density of mosquitoes with those found in 1958 was greatly facilitated by the discovery that *A. cataphylla* mosquitoes again swarmed at the same sites where *A. cataphylla* mosquitoes had swarmed in 1958. Emergence of *A. cataphylla* occurred between May 15 and May 17. In the river valley west of the city numerous large swarms were observed during the evening of May 15. These mosquitoes frequently abandoned the swarm-markers, and moved about in diffuse groups at a height of 4 to 12 feet above the valley floor. Few mosquitoes were observed on the plain and none were observed within the barriers nor within the river valley between the barriers.

During the evening of May 16, one entomologist was stationed in the valley south of the river and just west of the barrier on the western side of the city. A second entomologist was stationed east of this barrier. The first received 23 bites and saw three swarms each consisting of several hundred males. The second entomologist received three bites and saw three male swarms totaling 46 males. A third observer keeping watch along the entire valley between the two barriers saw six male swarms, or an estimated total of less than 200.

On May 17 and 18 observations in parts of the city other than the river valley revealed no mosquitoes. External to the control area to the south and west of the city, mosquitoes were found molesting livestock. During the evening of May 19, thirteen observers attempted to assess the density of mosquitoes on both sides of the barriers. During the evening, the temperature in the valley fell from 55° F. to 53° F. and the relative humidity rose from 16 to 43 percent; only 13 mosquitoes were taken. On subsequent evenings large swarms were again observed external to the barriers.

Emergence of the banded-legged mosquitoes occurred between May 30 and June 2. During seven evenings one observer encountered 16 females between the barriers.

DISCUSSION. The nearly complete and unprecedented absence of mosquitoes from the center of the city suggests that the mosquitoes followed the valley and were destroyed by the barriers. Stage *et al.* (1937) published a map for the dispersion of *Aedes vexans* (Meigen) and *Aedes aldrichi* D.&K. (=*sticticus* Mg.) which indicates that these mosquitoes tend to follow the valley and tributaries of the Columbia River. According to Horsfall (1955) mosquito dispersion during the dry season in the Transvaal is limited to the wooded river valleys.

Restriction of mosquitoes to the valley and ravines is probably related to the fact that they have abundant vegetation, while the plain has only isolated wooded areas. Hearle (1926) believed that mosquitoes venture far from cover only during particularly favorable conditions. Further, Horsfall (1955) found that the movement of mosquito populations may be restricted to the undergrowth of a forest area.

SUMMARY. In spring, two separate influxes of mosquitoes occur along the North Saskatchewan River valley within the City of Edmonton. Since Edmonton lies in the center of an area in which all larvae are killed, these mosquitoes originate from pools several miles from the city. *Aedes cataphylla* appear first, followed several days later by *Aedes fitchii, Aedes excrucians,* and *Aedes stimulans.* Soon after adult emergence occurs in the field, mosquitoes appear in the city. It is suggested that the mosquitoes move along the river valley into the city. In 1959 shortly before emergence occurred in the field, lindane was applied to the vegetation in strips across the valley near the city limits. In the valley beyond the city limits mosquitoes appeared in large

numbers as they had in 1958. However in the section of the valley within the city, very few mosquitoes appeared in comparison to the number which had been present in 1958.

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STUDIES ON ORGANOPHOSPHORUS-TOLERANCE IN *AEDES AEGYPTI*

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INTRODUCTION. Larval selection with malathion applied to the Penang strain of *Aedes aegypti* resulted in an increase in malathion-tolerance and a great increase in DDT-resistance (Brown and Abedi, 1960). The physiological mechanism of the tolerance proved not to be an increase in detoxication, but a decrease in absorption into the larvae (Matsumura and Brown, 1961a), which was shown not only with malathion but also with DDT. The purpose of this investigation was to ascertain whether selection with malathion, or with parathion, would induce similar tolerance increases in other strains of this species. Biochemical investigations were also made to determine whether there was any increase in detoxication of malathion or parathion, or any decrease in absorption of malathion, parathion or DDT.

MATERIAL AND METHODS. The susceptible strain chosen for selection originated from Kongolikan, Upper Volta, in the interior of West Africa. This strain had been maintained without exposure to insecticides by Dr. J. M. Doby, University of Rennes, France, who kindly supplied the stock to this laboratory in early 1961; its LC_{50} to DDT was .003 ppm, a record for susceptibility in *A. aegypti*. The DDT-resistant strain originated in Trinidad, in the southern Caribbean area, and had been maintained in our laboratory for 3 years, during which time its LC_{50} to DDT had slightly reverted to 0.25 ppm.

Substrains were submitted to larval