FIELD TESTS WITH ABATE AND DURSBAN INSECTICIDES FOR CONTROL OF FLOODWATER MOSQUITOES IN THE TENNESSEE VALLEY REGION

JOSEPH C. COONEY AND EUGENE PICKARD

Environmental Biology Branch, Division of Environmental Planning, Tennessee Valley Authority, Muscle Shoals, Alabama

ASTRACT. The effectiveness of Dursban and Abate insecticides[1] on mixed broods of floodwater mosquitoes was studied in both the field and laboratory. Prehatch and posthatch treatments were conducted with a 1 percent granular formulation of each insecticide, and an emulsifiable concentrate (EC) formulation of Dursban was tested when applied before hatching. Granular Dursban applied at the rate of 0.10 pound of active ingredient per acre (0.10 lb a.i./ac) 10 to 14 days before flooding remained effective as long as 30 days after treatment and through two distinct broods of mosquitoes. Dursban EC applied in the same manner and at the same rate was effective initially, while Abate granules applied similarly were ineffective. Dursban and Abate granules applied after hatching at the rate of 0.10 lb a.i./ac were highly effective in controlling larvae of *Aedes canadensis* and *Aedes sticticus*. Dursban was effective over a prolonged period, while Abate was only initially effective. Laboratory bioassays showed that Dursban applied in granular form at the rate of 0.10 lb a.i./ac remained effective for more than 25 days, even when subjected to intermittent flooding and drying cycles. Granular Dursban applied at the rate of 0.05 lb a.i./ac was ineffective after 2 days. Dursban exhibited no detectable effect on three groups of nontarget organisms but may have been detrimental to isopods. Abate had no detectable effect on any species of nontarget organisms included in our observations.

INTRODUCTION

In the Tennessee Valley region, as well as in other portions of the Southeast, floodwater mosquitoes cause considerable annoyance to man and animals by their aggressive biting habits. They may also be involved in the transmission of various pathogenic organisms (e.g., dog heartworms have become an increasing problem in certain areas of the Tennessee Valley, and, according to Bemrick and Sandholm (1966), *Aedes vexans*, the dominant floodwater mosquito in these areas, is a potential vector).

Production of floodwater species of mosquitoes related to water level management along the main stream reservoirs of the Tennessee River is a serious problem from March through June when heavy spring rains cause excessively high reservoir levels. Localized flooding and production of floodwater mosquitoes occur throughout the summer and early fall, but normally these populations are not related to reservoir water level management but more so to local heavy rains and inadequate drainage. *Ae. sticticus* and *Ae. canadensis*, companion woodland pool mosquitoes, occur in early spring in conjunction with a few early *Ae. vexans*. These are followed in late spring and early summer by *Ae. vexans*, *Ae. atlanticus*, and *Ae. trivittatus*. With increasing water temperatures from June through September, the following species may become prevalent: *Psorophora confinnis*, *P. cyanescens*, *P. varipes*, *P. ciliata*, *P. ferox*, and *Ae. vexans*. Intermittent inundation of floodwater pools may produce numerous generations each year.

Studies of promising insecticides that are residually effective but have only minimal effects on nontarget organisms are essential to an effective and ecologically sound control program. Investigations of two such compounds are reported in this paper.

Abate (o,o,o',o'-tetramethyl o,o'-thiodi-p-phenylene phosphorothioate) and Dursban [o,o-diethyl o-(3,5,6-trichloro-2-pyridyl) phosphorothioate] have been successfully used for several years to control larval mosquitoes. Mulla *et al.* (1966) demonstrated

[1] Use of larvicide names is for identification purposes only and does not constitute endorsement by the Tennessee Valley Authority.

the biological activity of Abate and Dursban in the laboratory against larval *A. albimanus* and *Culex quinquefasciatus* and in the field against *C. tarsalis.* Ludwig and McNeil (1966) reported on the effectiveness of Dursban on *Ae. aegypti* and *C. quinquefasciatus* larvae in the laboratory, and field tests demonstrated its residual effectiveness against *Ae. sollicitans.* Lake *et al.* (1967) studied the effectiveness of Abate granules in woodland pools against early spring *Aedes* larvae, while Barnes *et al.* (1967) tested Abate (formulated in three types of briquettes) against *C. pipiens pipiens* larvae. Moore and Breeland (1967) evaluated aerial applications of Abate and Dursban for control of *A. quadrimaculatus* larvae, and Mulla *et al.* (1969) applied these insecticides from drip cans to control *Ae. nigromaculis* larvae. Additional tests by Sjogren and Mulla (1968) further evaluated drip applications of Abate and Dursban against *C. pipiens-quinquefasciatus.* Lofgren *et al.* (1967) in Thailand tested the effectiveness of Abate and Dursban against *Ae. aegypti* larvae breeding in concrete water storage jugs. Tawfik and Gooding (1970) showed that both Abate and Dursban were effective against spring floodwater *Aedes* in Alberta, Canada. More recently Washino *et al.* (1972) reported on the effectiveness of Dursban against *C. tarsalis* and *A. freeborni* larvae in California. Concurrently they studied the effects of Dursban on nontarget organisms and in 1972 reported that at least one species of mayfly, one species of diving beetle, and bluegill sunfish suffered adverse effects. Hurlbert *et al.* (1970) and Porter and Gojmerac (1969) reported toxicity to several species of aquatic insects and ducklings but no effect to *Gambusia,* Amphipoda, Ostracoda, Isopoda, and Copepoda.

Buzicky [2] in extensive preflood tests with a granular formulation of Dursban demonstrated that it was highly effective against *Ae. vexans* larvae and that very little mortality occurred to caged crayfish, fathead minnows, or frogs. Abate is shown in the literature (Mulla, 1966; Von Windeguth and Patterson, 1966; Laws *et al.,* 1967; Gaines *et al.,* 1967; Moore and Breeland, 1967; Laws *et al.,* 1968; Porter and Gojmerac, 1969) to have little effect on nontarget organisms.

The purposes of our studies were (1) to determine the relative effectiveness of both Abate and Dursban against floodwater *Aedes* (primarily *Ae. canadensis, Ae. sticticus,* and *Ae. vexans*), (2) to compare the effectiveness of prehatch and posthatch treatments, (3) to compare the relative residual effectiveness of the insecticides, and (4) to determine their effects on naturally occurring nontarget organisms.

METHODS AND MATERIALS

POSTHATCH TESTS. Four sites known to produce suitable larval populations after inundation from early spring rains were selected for conducting field bioassays. These test pools (Colliers Slough 7, 8a, 8b, and Mitchell Hollow 1) ranged in size from approximately 1/16 to 1 ac and consisted mainly of woodland habitats containing either *Ae. sticticus* exclusively or mixed populations of *Ae. sticticus* and *Ae. canadensis* in a 1:1 ratio. The granular insecticides were applied with a hand-operated rotary grass seeder. Two sites were treated with a 1-percent clay granular formulation of Dursban at the rate of 0.10 lb of active ingredient per acre (0.10 lb a.i./ac), and one site was treated at the rate of 0.05 lb a.i./ac. The remaining site was treated with a 1-percent sand granule formulation of Abate at the rate of 0.10 lb a.i./ac. The effectiveness of these treatments was evaluated on the basis of reduction in larval densities from the pretreatment count when compared with controls. The standard dipper technique was used to sample populations of both larval mosquitoes and nontarget organisms concurrently before and after treatment.

Residual effectiveness of the insecticides

[2] A. W. Buzicky. 1968. Dursban prehatch trials. Unpublished report. Metropolitan Mosquito Control District, St. Paul, Minnesota.

in the field was determined from laboratory bioassays of field-collected larvae tested in water from treated pools. Twenty-five third or fourth instar *Ae. sticticus* or *Ae. canadensis* larvae were placed in each of three plastic bowls that contained 250 ml of this treated water. Three control vessels were included that contained untreated water from the pools from which the test larvae were collected. One bioassay of *Ae. vexans* larvae and one bioassay of *Culiseta inornata* larvae were also included when these species became available. Mortality was recorded after 24 h. Bioassays were conducted following sequential inundation of the test plots until mortality ceased or became negligible. As many as five flooding and drying periods occurred during these tests.

PREHATCH TESTS. The insecticide was applied 10–14 days before test plots were flooded. Test sites were selected on the basis of egg densities in soil samples and expected larval production. Five prehatch tests were conducted on plots ranging in size from 0.35 ac to 5.5 ac. Three of the five plots were flooded artificially, while the remaining two were inundated naturally from lake water. The three artificially flooded plots (approximately 0.35 ac each) were located in McFarland Bottom, Florence, Alabama, adjacent to Pickwick Reservoir but not directly connected to it. Flooding of these plots normally occurs after heavy spring rains. In late June either Dursban emulsifiable concentrate (EC), Dursban 1 percent clay granule, or Abate 1 percent sand granule was applied to one of the three plots 10 days before flooding, which was produced by pumping water from Pickwick Reservoir into the three test plots and a designated control plot simultaneously. The plots were flooded and allowed to dry three times during these tests, producing three distinct broods of mosquitoes.

The two plots flooded naturally (1 ac and 5.5 ac) were located on the Hiwassee Reservoir, Murphy, North Carolina. A 1 percent clay granular formulation of Dursban was applied to these plots at a rate of 0.10 lb a.i./ac in late spring, 14 days before inundation. A control plot was established for comparison.

Effectiveness was evaluated by comparing larval densities in treated plots with those in the control plot. The dominant species in all test plots was *Ae. vexans*. However, a second brood of mosquitoes produced in late August in the McFarland Bottom plots had almost equal numbers of *Ae. vexans* and *Ae. atlanticus*. Only one laboratory bioassay could be conducted to verify residual effectiveness of the three treatments in McFarland Bottom; larvae were not available for further testing.

RESULTS AND DISCUSSION

POSTHATCH TESTS. The first portion of Table 1 summarizes the results of the tests in which the insecticides were applied after larval populations were present in the field. In these tests, actual numbers of larvae present before treatment were compared with those present after treatment. The percentage reduction 24 h after treatment ranged from 72 to 99 percent; however, 100 percent reduction was attained 48 h posttreatment in all plots. Dursban and Abate granules applied at the rate of 0.10 lb a.i./ac gave 99 percent reduction in 24 h except in one test with Dursban in which only 72 percent was recorded. This plot contained only late fourth instar *Ae. sticticus* larvae, whereas the other plots contained second and early third instar *Ae. sticticus* and *Ae. canadensis* larvae. Laboratory bioassays of *Ae. sticticus* and *Ae. canadensis* showed them to be equally susceptible to the insecticides used; however, in general, early instars are more susceptible than late instars, which may explain the delay in reaching 100 percent mortality. Dursban applied at the rate of 0.05 lb a.i./ac yielded a 94 percent reduction in 24 h that increased to 100 percent after 48 h.

Results of laboratory bioassays showed that Dursban applied at the rate of 0.10 lb a.i./ac remained 100 percent effective under field conditions from 11 days to at

TABLE 1.—Effectiveness of prehatch and posthatch treatments of Dursban and Abate insecticides against floodwater mosquitoes in the Tennessee Valley.

Treatment	Days aged prior to flooding	Rate of application (lb a.i./ac)	Percentage reduction 24 h [a]	Percentage reduction 48 h	Residual effectiveness of 75 percent or more (days) [b]
Posthatch			From pre-test count		
Dursban granule	0	0.10	72	100	>25
Dursban granule	0	0.10	99	100	>11
Dursban granule	0	0.05	94	100	<2
Abate granule	0	0.10	99	100	<5
Prehatch			From untreated check		
Dursban granule	14	0.10	100	...	..
Dursban granule	14	0.10	80	...	..
Dursban granule	10	0.10	100	100 [c]	>14
Dursban EC	10	0.10	100	100 [c]	<14
Abate granule	10	0.10	...	—15 [c]	<14

[a] 24 hours after the appearance of larvae in control plots.
[b] Based on last laboratory bioassay to yield 75 percent or more mortality on various species of field-collected larvae.
[c] Data from the first hatch only.

least 25 days (Figs. 1 and 2). During this time, the test plots were intermittently flooded two to four times. In one test (Fig. 1), 100 percent mortality of *Ae. sticticus* and *Ae. vexans* larvae was recorded through four floodings and three

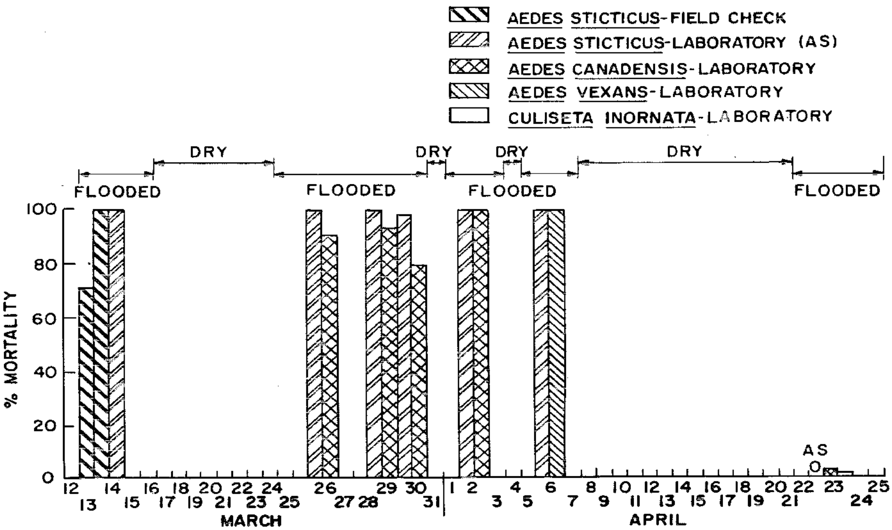

FIG. 1.—Results of field and laboratory bioassays of four species of mosquito larvae exposed to Dursban insecticide applied at the rate of 0.10 lb a.i./ac—Colliers Slough #7.

successive dry periods. Mortality of *Ae. canadensis* larvae in this test ranged from 80 to 100 percent throughout three flooding and drying cycles. Effectiveness after 42 days was negligible for all species tested.

Based on laboratory bioassays, Abate granules applied at the rate of 0.10 lb a.i./ac and Dursban granules applied at the rate of 0.05 lb a.i./ac (Figs. 3 and 4), respectively, demonstrated very little re-

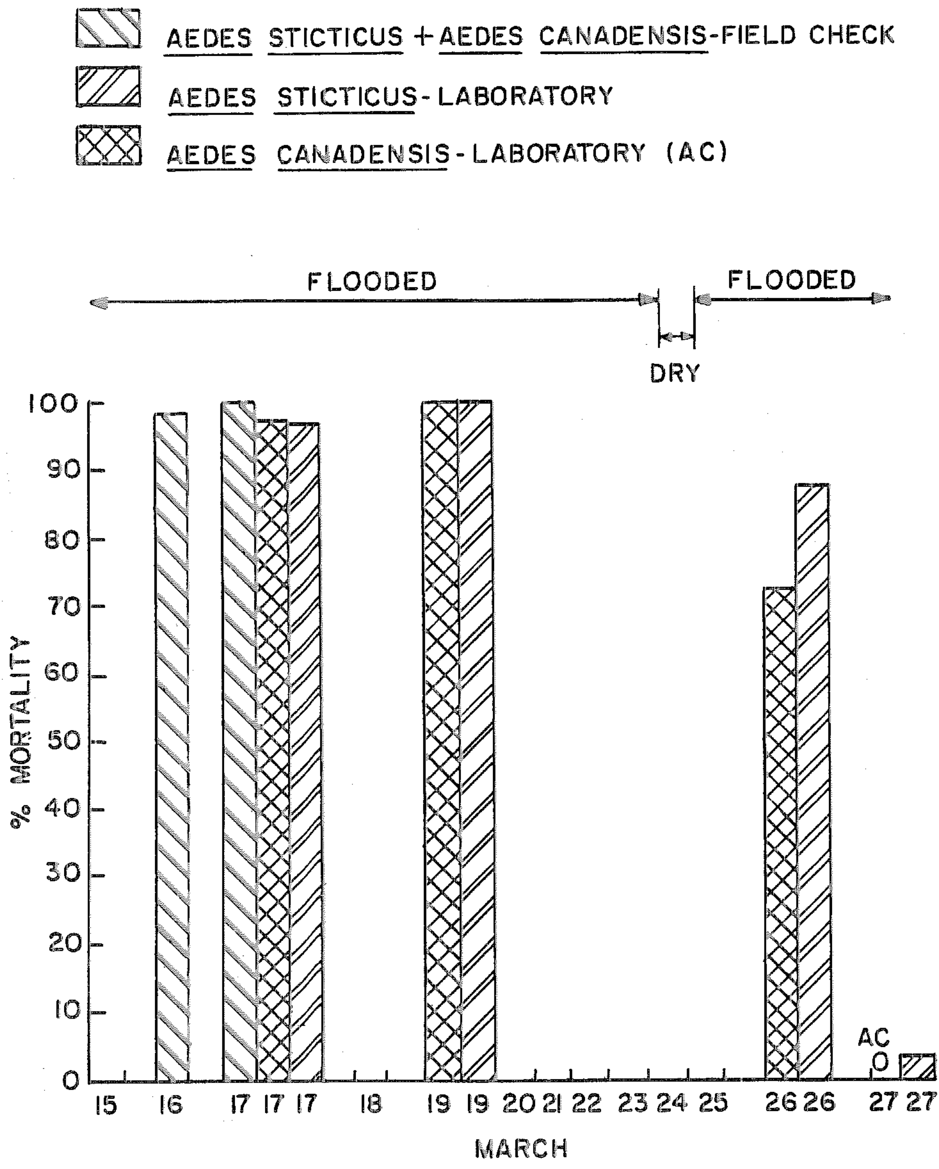

FIG. 2.—Results of field and laboratory bioassays of two species of floodwater mosquito larvae exposed to Dursban insecticide applied at the rate of 0.10 lb a.i./ac—Colliers Slough #8a.

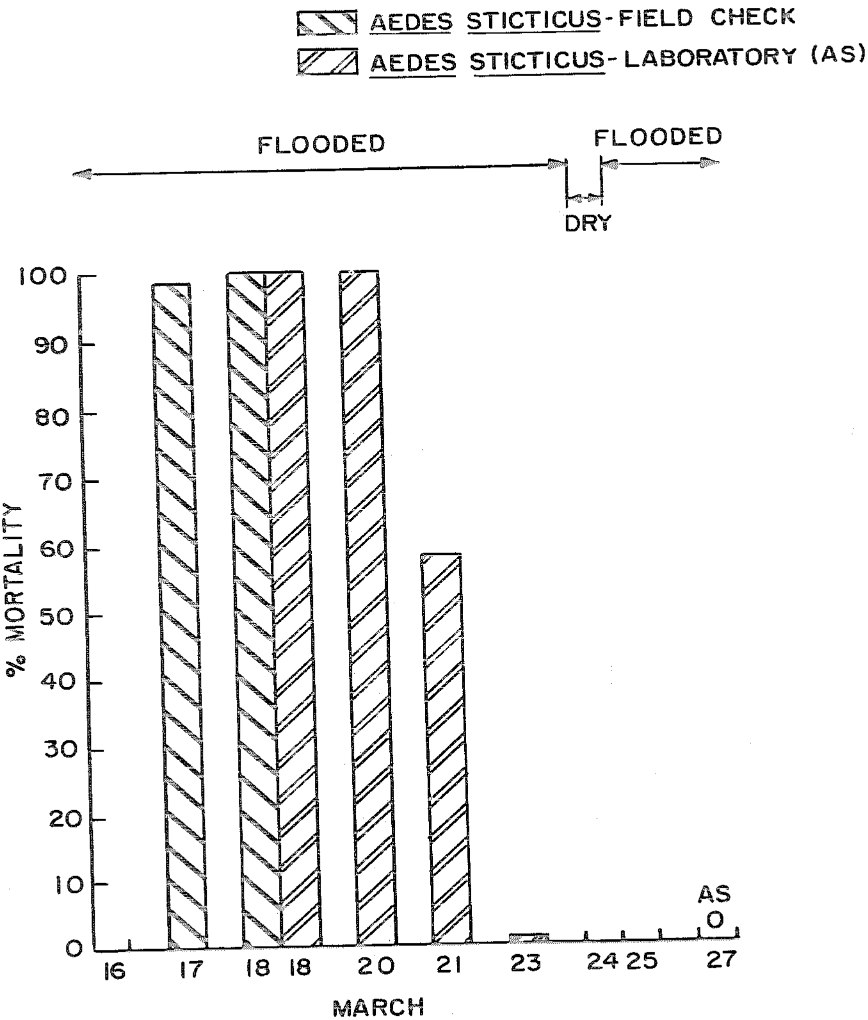

FIG. 3.—Results of field and laboratory bioassays of *Aedes sticticus* larvae exposed to Abate insecticide applied at the rate of 0.10 lb a.i./ac—Mitchell Hollow #1.

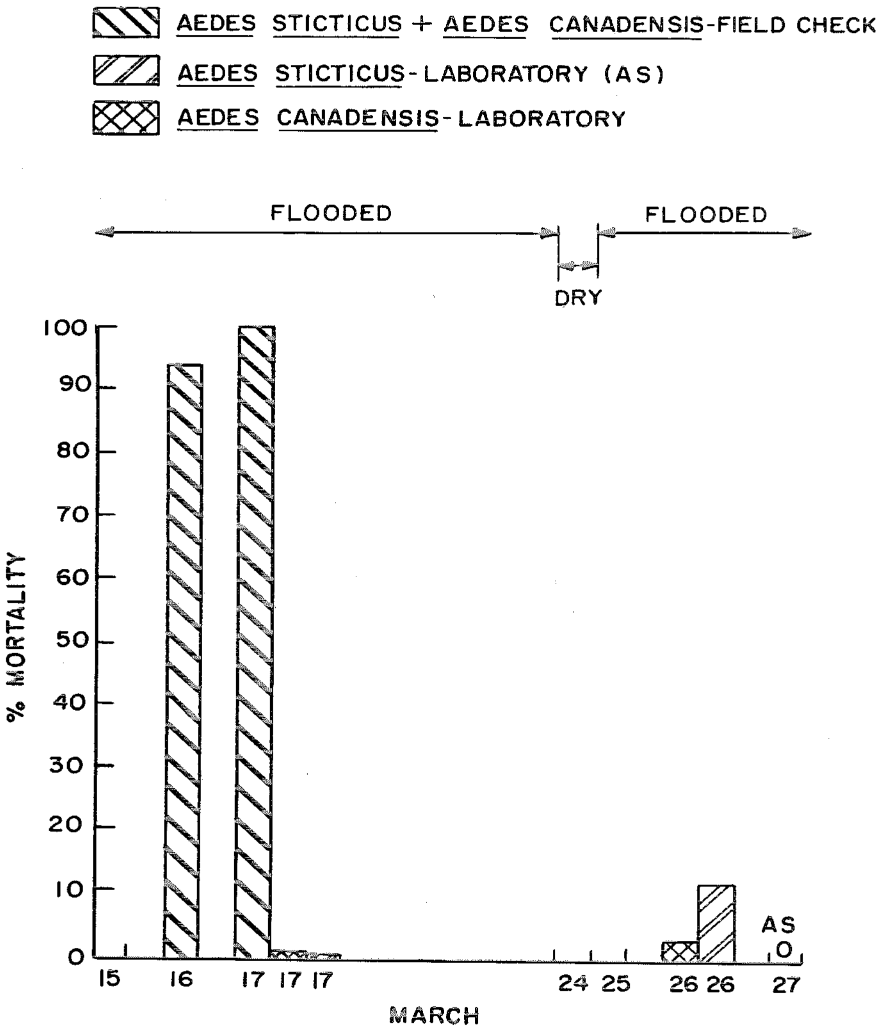

Fig. 4.—Results of field and laboratory bioassays of two species of floodwater mosquito larvae exposed to Dursban insecticide applied at the rate of 0.05 lb a.i./ac—Colliers Slough #8b.

sidual effect. Abate was 100 percent effective against *Ae. sticticus* larvae through the fourth day, but on the fifth day was only 59 percent effective, and by the seventh day was almost completely ineffective. Dursban applied at the rate of 0.05 lb a.i./ac showed no residual effect 2 days after treatment even though 100 percent mortality was recorded in the field plot on the same day. This effect may be explained by the fact that the field application was made to second and early third instar larvae, whereas the laboratory bioassays utilized third and early fourth instar larvae. Also, the concentration of Dursban in the field plot initially may have been high enough to kill the more susceptible early larval stages but was probably much reduced by the second day.

The effect of the various treatments on four orders of naturally occurring nontarget organisms is shown in Table 2. Numbers of specimens of each order were counted by the standard dipper technique both before treatment and 24 h after treatment. The numbers of organisms in each group after 24 h either equalled or exceeded those obtained before treatment except that fewer isopods were found in samples taken after applications of Dursban at both rates. With Abate, however, there were no reductions in numbers of any of the groups observed.

PREHATCH TESTS. The results of all prehatch tests are presented in Table 1. Effectiveness was evaluated by comparing population densities of mosquito larvae in treated plots with densities in control plots and is expressed as percentage reduction. Test and control plots were selected on the basis of having comparable egg densities and species composition. Table 3 illustrates the population density and species composition of the two treatment areas. Variation in species composition and density of eggs among test plots in a treatment area were insignificant. *Ae. vexans* was by far the dominant species. All plots were treated at the rate of 0.10 lb a.i./ac.

Dursban clay granules applied 14 days

TABLE 2.—Population densities[a] of various nontarget organisms occurring in four field plots before treatment and 24 h after treatment.

	Colliers Slough 7		Colliers Slough 8a		Colliers Slough 8b		Mitchell Hollow 1		Control	
	Dursban (0.10 lb a.i./ac)		Dursban (0.10 lb a.i./ac)		Dursban (0.05 lb a.i./ac)		Abate (0.10 lb a.i./ac)			
	Pre[b]	Post[c]	Pre[b]	Post[c]	Pre[b]	Post[c]	Pre[b]	Post[c]	Pre[b]	Post[c]
Isopoda	0.0	0.0	0.31	0.07	0.36	0.03	0.00	0.13	0.50	0.50
Ostracoda	0.0	0.0	0.66	0.87	0.60	0.83	0.93	1.20	0.20	1.90
Salientia	0.3	1.0	0.08	1.53	0.11	0.20	0.00	0.00	0.00	0.00
Tricladida	0.2	0.2	0.17	0.97	0.17	0.30	0.00	3.73	0.20	1.10

[a] Average number of organisms per dipper sample.
[b] Pretreatment.
[c] Posttreatment.

Table 3.—Species composition of mosquito eggs extracted from soil samples from prehatch test and control plots on Hiwassee River, Murphy, North Carolina, and in McFarland Bottom, Florence, Alabama.

	Average No. eggs/Soil sample			
	Hiwassee River		McFarland Bottom	
Species	Treatment	Control	Treatment	Control
Aedes atlanticus	....	....	0.08	0.21
Aedes sticticus	....	....	0.27	0.23
Aedes trivittatus	....	....	0.36	0.16
Aedes vexans	5.50	2.54	8.73	11.35
Psorophora ciliata	....	....	0.00	0.07
Psorophora confinnis	....	....	0.03	0.00
Psorophora ferox	....	....	0.70	0.58
Psorophora varipes	....	....	0.14	0.00

before flooding gave from 80 percent to 100 percent control after 24 h, based on a comparison with the data for the control plots. Dursban granules and Dursban EC applied 10 days before flooding gave 100 percent control after 48 h, while Abate granules were ineffective. The area in which Dursban granules were dispersed 14 days before flooding was subject to river flooding and water flow, whereas the other areas were isolated from river flow and subsequent dilution. Dilution of pesticide concentration and removal by water flow may have been responsible for the lessened effectiveness in one of the Dursban tests. Figure 5 shows the relative effectiveness of the McFarland Bottom prehatch tests in which three separate broods of mosquitoes were produced. Granular Dursban applied at the rate of 0.10 lb a.i./ac was 100 percent effective for a minimum of 30 days in controlling *Ae. vexans* larvae, while Dursban EC was effective for at least 14 days. Granular Dursban was 100 percent effective through two broods, Dursban EC was effective through one brood, and granular Abate was ineffective when applied before flooding.

A laboratory bioassay, conducted 14 days after application of test materials, in which *Ae. atlanticus* larvae were exposed to water from treated plots gave the following results: 90 percent mortality with water from the plot treated with Dursban granules; 2 percent mortality with water from the plot treated with Dursban EC; and no mortality with water from the plot treated with Abate granules.

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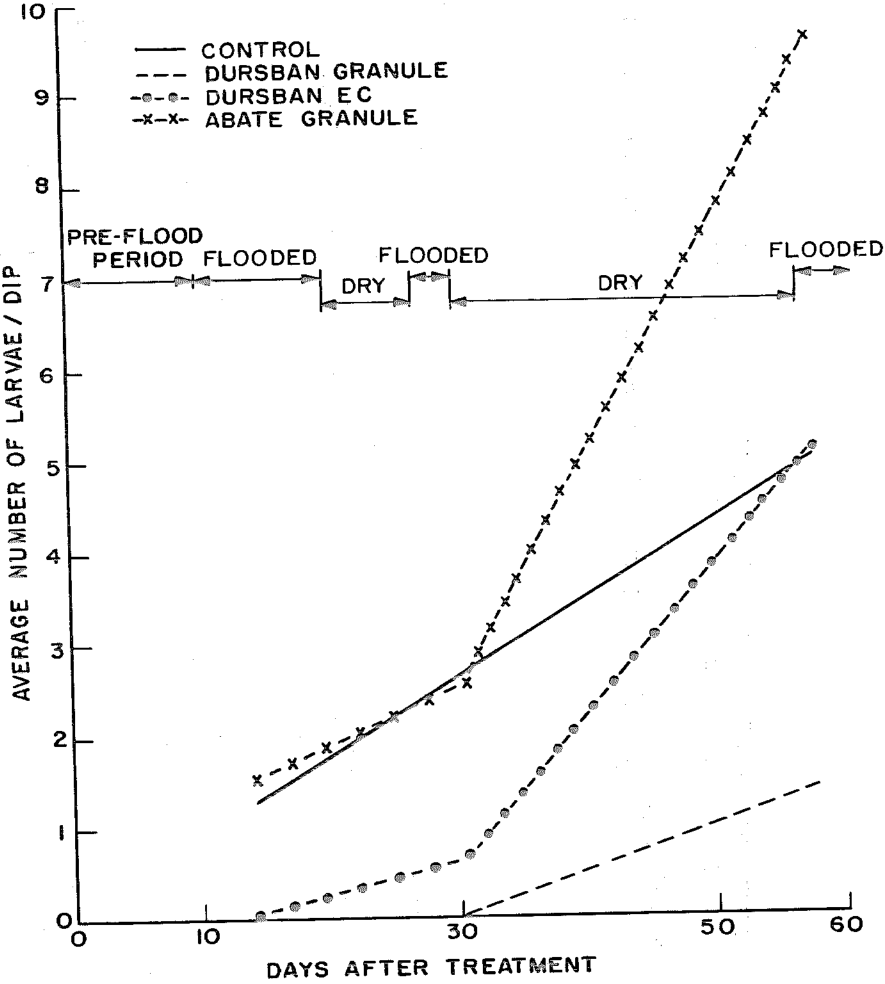

FIG. 5.—Relative effectiveness of three preflood insecticidal treatments against three mixed populations of floodwater mosquitoes composed mainly of *Aedes vexans*.

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THE SALIVARY GLAND CHROMOSOMES OF *ANOPHELES WALKERI* THEOBALD

J. B. KITZMILLER,[1] DENNIS JOSLYN [1] AND R. D. KREUTZER [2]

INTRODUCTION

The salivary gland chromosomes of previously mapped Nearctic anophelines have revealed genetic relationships among members of the subgenus *Anopheles* (Kitzmiller *et al.*, 1967). Similarities are usually confined primarily to the centromere regions of the autosomes and to the free ends, while inversion events are responsible for the variations in banding patterns in the center of the arms. The unique banding patterns of the X chromosomes within the subgenus may be used to distinguish one species from another.

This paper describes the salivary gland chromosomes of *Anopheles walkeri* Theobald and proposes preliminary chromosomal affinities with *A. quadrimaculatus* and *A. atropos,* two closely related species. (Klassen *et al.*, 1965; Kreutzer *et al.*, 1969). *Anopheles walkeri* is distributed in southeastern Canada and eastern United States westward to Louisiana and Minnesota. Extremes in its range to the west include Nebraska and to the south Vera Cruz, Mexico. The slides were prepared from specimens collected in the Everglades National Park, Florida, by the technique described by French, *et al.* (1962). A typical complement is shown in Figure 1. The map (Figure 2) was produced from standard photographic enlargements of the complement with finer details obtained through direct observation at 1000X with a Zeiss photomicroscope. Further details concerning the relationships among *A. walkeri, A. quadrimaculatus* and *A. atropos* will be reported elsewhere.

[1] Department of Zoology, University of Illinois, Urbana, Illinois 61801.
[2] Department of Biology, Youngstown State University, Youngstown, Ohio 44503.