FIELD OBSERVATIONS WITH ABATE AND BROMOPHOS: THEIR EFFECT ON MOSQUITOES AND AQUATIC ARTHROPODS IN A WISCONSIN PARK

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Larvicides are valuable tools in a mosquito control program. They should neither leave objectionable residues nor have adverse effects on non-target organisms in the treated area. Abate (o, o-dimethyl phosphorothioate o, o diester with 4, 4'thiodiphenol) is known to be a very effective larvicide (McDuffie and Weidhaas, 1967; and Moore and Breeland, 1967), and its effect upon other arthropods has been studied by von Windeguth and Patterson (1966), Fales *et al.* (1968) and Mulla and Khasawinah (1969). Von Windeguth and Patterson (1966) found no noticeable mortality of Odonata, *Chaoborus,* copepods, ostracods, or fairy shrimp from field applications of 0.25 pound of technical Abate per acre. Fales *et al.* (1968) eradicated a large population of *Chaoborus* spp. in a lake treated with Abate at a rate of 0.39 lb. per acre. This concentration also proved toxic to nearly all other insects in the lake. Mulla and Khasawinah (1969) found Abate to be quite variable in its effect upon chironomid midges. Depending upon the species, they obtained 30 to 100 percent control with an emulsifiable concentrate applied at 0.05 lb. per acre. Bromophos (o, o-dimethyl o-(2,5-dichloro-4-bromophenyl) thionophosphate) is a newer material and has not been widely tested on aquatic arthropods other than mosquitoes.

Mosquito breeding sites in Wisconsin are often in or near the vicinity of permanent bodies of water in which the aquatic fauna is of value as an ingredient in the food chain. Before the widespread use of larvicides is encouraged to supplement a mosquito control program, it is essential to know the effects these materials produce on local species of non-target organisms.

Field tests were conducted to determine the effect of Bromophos and Abate on mosquitoes and local non-target organisms in temporary pools at Point Beach State Forest, which is located along the shoreline of Lake Michigan about five miles north of Two Rivers, Wisconsin. This area is underlain with limestone. Ground water enters the three prominent sloughs in this state forest by seepage from swamps at higher elevations away from the shore of Lake Michigan (Wiedman, 1915) and is supplemented by precipitation. The temporary pools contain varying amounts of decaying vegetation, and the average pH is 7.4. The forest is composed of a mixture of hardwoods and conifers and shades 80 to 90 percent of the area.

The nuisance mosquitoes at this state forest are primarily members of the genus *Aedes*. *Aedes stimulans* (Walker) is the predominant biting species, but *A. punctor* (Kirby), *A. abserratus* (Felt and Young), *A. sticticus* (Meigen), and *A. vexans* (Meigen) are also sources of annoyance at certain times during the summer.

METHODS. Mosquito breeding areas which appeared to be comparable biologically were selected for the tests. The pools were sampled prior to treatment, and a comparable nearby area was left untreated to serve as a control. The treated areas varied from 500 to 1500 sq. ft. depending upon the size and shape of the mosquito breeding site. Each area was measured individually and treated as a

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separate unit. The amount of insecticide was calculated on the basis of active ingredient per surface acre regardless of the depth of the water, which ranged from a few inches to 1.5 feet. Four pound emulsifiable concentrates were applied with a hand operated compressed air sprayer using approximately 20 gallons of water per acre. Bromophos was applied at 0.10 lb. per surface acre, and Abate at 0.03 lb. Population evaluations were made visually and by sampling with a 4½-inch white dipper. The population estimations for the June treatment were based upon 30 random dipper samples throughout the temporary pools. The estimations for the July treatment were based upon 40 random dipper samples and upon aquatic net samples. Some larvae and pupae were collected and reared to adults, while others were preserved in alcohol for identification. The Crustacea were identified only to order. Treatments were applied on June 21 and July 9, 1968. Populations were sampled prior to treatment and on the days indicated after treatment.

RESULTS AND DISCUSSION. Results of the treatments are summarized in Tables 1 and 2. Both materials were effective mosquito larvicides at the rates employed but neither killed mosquito pupae. In the June test, larvae of *Limnephilus indivisus* Walker (Trichoptera) were eradicated with Abate; however, they were not present in the Bromophos treated area (Table 1). Larvae and pupae of *Mochlonyx*

TABLE 1.—The effect of Abate and Bromophos on aquatic arthropods inhabiting temporary pools.

Organism	Pretreatment population 6–20–68	Percent reduction 6–25–68
	ABATE 0.03 lb./acre Applied June 21, 1968	
Culicidae:Diptera		
Aedes stimulans		
larvae	7/Dip	100
pupae	2/Dip	0
Aedes vexans		
larvae	1/Dip	100
pupae	$<$1/Dip	0
Aedes sticticus		
larvae	1/Dip	100
pupae	$<$1/Dip	0
Limnephilidae:Odonata		
Limnephilus sp.—larvae	1/sq. ft.	100
Isopoda	2/Dip	0
Amphipoda	2/Dip	0
	BROMOPHOS 0.10 lb./acre Applied June 21, 1968	
Culicidae:Diptera		
Aedes stimulans		
larvae	3/Dip	100
pupae	1/Dip	0
Aedes cinereus		
larvae	$<$1/Dip	100
pupae	$<$1/Dip	0
Aedes canadensis		
larvae	$<$1/Dip	100
pupae	$<$1/Dip	0
Chaoboridae:Diptera		
Mochlonyx cinctipes		
larvae	1/Dip	0
pupae	1/Dip	0
Isopoda	2/Dip	0
Amphipoda	2/Dip	0

Table 2.—The effect of Abate and Bromophos on aquatic arthropods inhabiting temporary pools.

Organism	Pretreatment population 7–6–68	Percent reduction 7–11–68
ABATE 0.03 lb./acre Applied July 9, 1968		
Culicidae:Diptera		
Culex territans		
larvae	1/Dip	100
pupae	1/Dip	0
Libellulidae:Odonata		
early instar naiads	3/sq. ft.	100
Lestidae: Odonata		
Lestes dryas—naiads	1/sq. ft.	0
Limnephilidae:Trichoptera		
Limnephilus indivisus—larvae	2/sq. ft.	50
Cladocera	4/Dip	100
Isopoda	2/Dip	0
Amphipoda	2/Dip	0
Copepoda	1/Dip	0
Ostracoda	1/Dip	0
BROMOPHOS 0.10 lb./acre Applied July 9, 1968		
Culicidae:Diptera		
Culex territans		
larvae	1/Dip	100
pupae	1/Dip	0
Lestidae:Odonata		
Lestes dryas—naiads	1/sq. ft.	100
Limnephilidae:Trichoptera		
Limnephilus indivisus—larvae	2/sq. ft.	50
Isopoda	3/Dip	0
Amphipods	3/Dip	0
Ostracoda	1/Dip	0
Copepoda	1/Dip	0

cinctipes (Coquillett) (Chaoboridae) were not affected by the Bromophos treatment. A heavy rain 6 days after treatment flooded the pools, and first and second instar *Aedes* larvae were noted a few days later in these pools.

In the July test Abate was toxic to early instar libellulid naiads (Odonata) but did not harm mature naiads of *Lestes dryas* Kirby (Table 2). Cladocera were eradicated in the pool treated with Abate but were not present in the pool treated with Bromophos (Table 2). Bromophos killed all mature naiads of *Lestes dryas*. Both materials had reduced populations of *Limnephilus indivisus* by 50 percent 2 days after treatment. Additional dead larvae were found 9 days post-treatment although some living pupae were present. The other arthropod populations remained unchanged from the previous post-treatment sampling. No sudden changes in the arthropod population in the control pools were observed during the tests.

Summary. Bromophos at 0.10 lb./acre was toxic to the trichopteran, *Limnephilus indivisus,* and the odonate, *Lestes dryas.* Abate at 0.03 lb./acre was toxic to early instar naiads of a libellulid, to *Limnephilus indivisus* and to Cladocera. Neither Abate nor Bromophos were toxic to mosquito pupae, Amphipoda, Isopoda, Ostracoda, and Copepoda. Bromophos was not toxic to the larvae and pupae of *Mochlonyx cinctipes.*

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THE EFFECT OF PHOTOPERIOD ON TRANSMISSION EFFICIENCY OF JAPANESE ENCEPHALITIS VIRUS BY *CULEX TRITAENIORHYNCHUS SUMMOROSUS* DYAR [1]

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INTRODUCTION. *Culex tritaeniorhynchus summorosus* Dyar (CTS) has been implicated as the vector of Japanese encephalitis virus (JEV) by Wang *et al.* (1962) and Hurlbut (1964). Furthermore, Hurlbut (1964) reported that CTS is involved in a "pig-mosquito cycle" which precedes and coincides with late summer encephalitis epidemics in Taiwan. To the present time, these outbreaks in both porcine and human populations have been attributed only to a rapid increase in CTS populations (Hurlbut, 1964).

Hurlbut (1964) and Hayashi *et al.* (1966) emphasize the necessity of more investigations into the ecology of vector species of JEV. Such a pursuance might explain what factors favor CTS population explosions and what factors may favor JEV transmission. In this respect, Eldridge (1963) has shown that long photoperiods induce feeding by *Culex tritaeniorhynchus* Giles mosquitoes but that short photoperiods depress feeding activity. This paper deals with the effect of daylength on JEV transmission by CTS.

MATERIALS AND METHODS. Newborn white Swiss mice were infected by an intracerebral injection of 0.02 ml mouse brain suspension containing JEV-Nakayama virus. Each mouse was incubated for 2 days and then offered to about 5-day-old adult female CTS mosquitoes for 4 hours. The viremia was determined in these mice before and after they were offered to mosquitoes. Bioassay of mouse blood was performed by logarithmically diluting the blood with PBS and 0.5 percent bovine albumin and injecting 0.03 ml. of one dilution, i.e., into each of six litter-mates 21–23 days old. All mice offered to mosquitoes had 10^{-3} to 10^{-4} log dilution virus titer.

Engorged females were divided into

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