LABORATORY AND FIELD EVALUATIONS OF ABATE® AGAINST A BACKSWIMMER, *NOTONECTA UNDULATA* SAY (HEMIPTERA:NOTONECTIDAE) [1]

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INTRODUCTION

The insecticide Abate®[4] (*O,O*-dimethyl phosphorothioate *O,O*-diester with 4,4′-thiodiphenol) came into general use as a mosquito larvicide after its acceptance for this use by the U. S. Department of Agriculture in July 1965 (Barker, 1966). The compound was extensively tested and shown to be highly effective against mosquito larvae (Anonymous, 1966; Brooks *et al.*, 1966; Knapp and Pass, 1966; Moore and Breeland, 1967; and Mulla *et al.*, 1964). Also, the concentration of Abate effective against mosquitoes was effective against midges, Chironomidae (Barker, 1966) (Von Windeguth and Patterson, 1966) and blackflies, Simuliidae (Barker, 1966). Moreover, though Abate is toxic to mosquito larvae, it is comparatively nontoxic to certain fish and other forms of aquatic life including Odonata, copepods, ostracods, amphipods, and protozoans (Von Windeguth and Patterson, 1966).

The authors previously reported on practical tests made in a lake in a recreation area for the control of the backswimmer, *Notonecta undulata* Say. This insect sometimes is trapped in the bathing suits of swimmers and may cause rather severe bites (Fales *et al.*, 1963). Control was obtained by spraying the surface with an oil spray containing pyrethrins and piperonyl butoxide. The present paper reports additional testing of this species with Abate in the laboratory and in the lake.

[1] Presented at the Eastern Branch Meeting of the Entomological Society of America, October 30–31, 1967, Baltimore, Maryland.

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[4] Mention of a proprietary product does not necessarily imply endorsement of this product by the U.S.D.A.

METHODS AND RESULTS

LABORATORY TESTS: 1966.—The backswimmers were obtained from the surface of the lake by quickly swinging an insect net through the water. Then the trapped insects were transported to the laboratory and confined in glass jars containing water from the lake. The insects fed readily on larvae of *Culex pipiens pipiens* L. mosquitoes.

The tests were made by using the WHO beaker method for determining susceptibilities of mosquito larvae (World Health Organization, 1960). In the preliminary tests made the summer of 1966, stock solutions were prepared from a technical sample of Abate (94.5 percent), and acetone instead of alcohol was used as the solvent. Five adult backswimmers were counted out into 50 ml. of distilled water and added to 400-ml. beakers that contained 200 ml. of distilled water and Abate. Replicated tests were made at concentrations of Abate of 0.0025, 0.005, and 0.01 p.p.m. Counts of the dead insects on the bottom of the beaker were made ¾, 1, and 2 days later. After 2 days, kills of 30 percent had occurred at concentrations of 0.0025 and 0.005 p.p.m. and kills of 90 percent at 0.01 p.p.m. A 10 percent mortality occurred in the untreated check. These data indicated that backswimmers could be successfully assayed for susceptibility by this test method (Table 1).

LABORATORY AND FIELD TESTS: 1967.—Because the same lake became heavily infested with backswimmers during the summer of 1967, we were able to repeat the beaker tests of the previous year. Three samplings of backswimmers were therefore brought into the laboratory between July 6 and 12. First, the effect on the backswimmers of the small amount of ace-

TABLE 1.—Suspectibility to Abate of field-collected adult backswimmers, *N. undulata*, in the laboratory, 1966 (two tests).

Dose of Abate in distilled water (p.p.m.)	Percentage kill at indicated day after treatment		
	3/4	1	2
0.0025	10	10	30
0.005	0	0	30
0.01	20	60	90
Untreated	10	10	10

tone used in the solutions was tested by placing the insects in solutions of Abate and in blank solutions containing the same quantities of acetone used previously. The results (Table 2) showed that these concentrations of acetone were toxic to the backswimmers.

TABLE 2.—Results of tests to determine the effect of acetone against backswimmers (two tests).

Dose of Abate in distilled water (p.p.m.)	Concentration of acetone (%)	Percentage kill at indicated day after treatment		
		1	2	4
0.0025	0.125	20	20	50
0.005	0.25	30	50	90
0.01	0.5	60	80	90
0.02	1.0	90	100	100
...	0.125[1]	40	40	40
...	0.25[1]	20	20	20
...	0.5[1]	20	20	20
...	1.0	60	80	90
...	...	10	10	20

[1] Single test.

For the second series of laboratory tests, new stock solutions of Abate were prepared, and acetone was used only in the first solution. Thereafter the dilutions were all made with distilled water so the amount of acetone present was negligible. Also, in this series, water from the lake was used instead of distilled water.

The mortalities obtained after 1 and 2 days were fairly similar to those obtained in 1966 (Table 1). A 100 percent kill did not occur until the fourth day with the 0.02 p.p.m. dose (Table 3). Because of the mortality of the untreated check, mortality counts for this species by this method of assay should apparently be made for only 2 days after treatment.

TABLE 3.—Susceptibility to Abate of field-collected adult backswimmers in the laboratory, 1967 (six tests).

Dose of Abate in lake water (p.p.m.)	Percentage kill at indicated day after treatment		
	1	2	4
0.0025	3	10	47
0.005	27	50	80
0.01	70	87	90
0.02	80	93	100
Untreated	7	7	30

FIELD TEST: 1967.—In August 1967, the owner arranged to empty the lake. We therefore could treat the entire lake with a dose of Abate that should control the backswimmer.

Because the results of the 1967 laboratory tests showed that a dose of 0.02 p.p.m. caused less than 100 percent kill in 48 hours, we decided to use 0.03 p.p.m. for the treatment of the lake. Also, Barker (1966) recommended increasing the dose of Abate in water that had a greater than normal content of organic matter.

The average depth of the 1.3-acre lake was determined by depth measurements to be 4 feet. Commercially available Abate (4E emulsifiable concentrate: 4 pounds per gallon of actual chemical) was used. Thus on August 16, 4 gallons of spray containing 120 ml. of the concentrate per gallon was used to deliver the desired dose of Abate to the lake. The spray was applied to the surface of the lake by hand and portable compressed air sprayers.

The primary purpose of the test was to study the effect of Abate on the backswimmer, but we also attempted to make a quantitative and qualitative analysis of the effect of this material on the associated aquatic organisms. For the quantitative analysis, one sample of the aquatic organisms was collected before application of Abate and two samples were taken, one 24 hours and another 48 hours, after treat-

TABLE 4.—Results of a quantitative sampling of organisms in a lake after treatment with Abate.

		Living Pre-treatment	After treatment: 24 hours Alive	After treatment: 24 hours Dead	After treatment: 48 hours Alive	After treatment: 48 hours Dead
	INSECTA					
COLEOPTERA						
Dytiscidae	*Coptotomus interrogatus* (Fabricius)	0	1	0	0[1]	0
	Graphoderus liberus (Say)	10	1	1	0[1]	1
	Hydroporus carolinus Fall	0	0[1]	0	0[1]	1
	H. tenebrosus LeConte	0	0	0	0	1
	Hydrovatus pustulatus (Melsheimer)	0	0	0	0[1]	1
	Laccophilus fasciatus Aubé	0	0[1]	1	0	0
	L. maculosus (Germar)	0	0[1]	8	0[1]	13
Gyrinidae	*Dineutus assimilis* (Kirby)	0	0[1]	1	0[1]	6
	D. nigrior Roberts	0	0[1]	0	0	6
Haliplidae	*Haliplus fasciatus* Aubé	0	1	6	0	23
	H. triopsis Say	0	1	9	0[1]	44
	Peltodytes muticus (LeConte)	0	0	0	0[1]	2
	P. sexmaculatus Roberts	0	0	0	0	3
Hydrophilidae	*Berosus peregrinus* Herbst	0	0	0	0	1
	B. striatus Say	0	0[1]	2	5	5
	Enochrus nebulosus (Say)	0	0	0	0	1
	Hydrochus scabratus Mulsant	0	0[1]	1	0[1]	2
	Hydrochus sp.	1	0	0	0	4
	Tropisternus blatchleyi Orchymont	0	0[1]	3	0	3
	T. natator Orchymont	2	0[1]	0	0[1]	0
Noteridae	*Hydrocanthusiri color* Say	0	0	1	0	0
DIPTERA						
Chaoboridae	*Chaoborus albatus* Johnson and *Chaoborus* spp.	1	[2]	[2]	0	[3]
HEMIPTERA						
Belostomatidae	*Belostoma flumineum* Say	0	1	0	0[1]	0
Corixidae	*Hesperocorixa interrupta* (Say)	0	1	20	0[1]	307
	H. obliqua (Hungerford)	0	1	11	0	320
	H. vulgaris (Hungerford)	0	0	7	0	13
	Sigara sp.	0	0	67	0	67
Gerridae	*Rheumatobates rileyi* Bergroth	0	0	0	0	2
	Trepobates pictus Herrick-Schaeffer	1	4	19	0	37
Mesoveliidae	*Mesovelia mulsanti* White	0	0	0	0	1
Nepidae	*Ranatra americana* Montandon	1	0[1]	0	0	0
Notonectidae	*Buenoa margaritacea* Torre-Bueno	32	0	61	0	17
	Notonecta irrorata Uhler	1	2	0	0	9
	N. undulata Say	49	0	109	0	83
ODONATA						
Aeschnidae	*Anax junius* (Drury)	0	0[1]	0	0	1
Libellulidae	*Plathemis lydia* Drury	0	0[1]	3	0[1]	17
	ARACHNOIDEA					
ACARINA						
Hydrachnidae	*Hydrachna* spp.	1	29	0	11	0
	MOLLUSCA					
GASTROPODA						
Physidae	*Physa gyrina* Say	0	0	3	0	7
Planorbidae	*Helisoma anceps* Menke	0	0	12	0	12

[1] Not found alive in quantitative sampling, however, this species was found alive in the qualitative sampling.
[2] Estimated millions dead and moribund.
[3] Estimated millions dead.

ment. These samples were obtained by pulling a standard aerial insect net as rapidly as possible through the water alongside the H-shaped dock at a depth of about one foot. The volume of water sampled was calculated to be 542 cubic feet per sample.

Smaller exploratory samples taken earlier in the summer had provided numerous specimens and had indicated that the population of insects was sufficient for such analysis. The later pretreatment catch was so small that the population had probably peaked earlier and was now on the wane. However, the number of specimens collected 24 and 48 hours after treatment (Table 4) was much higher, which suggested that the organisms present before treatment, mostly free-swimming forms usually found in open water, were either agile enough to escape the net or were to be found at greater depths in the lake.

To obtain information on the effect of Abate on aquatic organisms that normally live in the littoral zone, we also made pre- and post-treatment qualitative collections with an aquatic dip net along the shore. On each occasion, sampling was continued for 2 hours, but the insects collected were recorded simply as living or dead and were not counted. Table 5 lists the additional species collected along the shore that were not found in the quantitative sampling on the surface of the lake. However, if living specimens of a species were collected on the shore when only dead of that species were found in the lake, a footnote has been placed appropriately in Table 4.

CONCLUSIONS

The laboratory tests indicated that a larger dose of Abate is required to kill backswimmers than to control mosquito larvae. However, the sampling at the center of the lake and around the shore showed that the 0.03 p.p.m. dose of Abate caused complete kill of backswimmers. No mosquitoes were found in any collections made from the lake.

Despite the scarcity of nontarget insects collected in both the quantitative and qualitative pretreatment samples, valuable information was obtained from the extensive list of living insects collected after treatment. Thirty-one species were collected alive 24 hours after treatment and 21 species after 48 hours. The 21 included, among the Coleoptera, 8 species of Dytiscidae, 2 of Gyrinidae, 1 species of Dryopidae, 2 of Haliplidae, and 4 of Hydrophilidae; among the Hemiptera, one species each of the families Belostomatidae, Corixidae, and Naucoridae; and one species of Odonata belonging to the family Libellulidae. No Diptera or Collembola were found alive.

An outstanding result was the effect of the treatment on the larvae of the midge *Chaoborus*. Millions of dead and moribund larvae covered the lake one day after treatment, and all were judged dead the second day. Von Windeguth and Patterson (1966) reported no noticeable mortality of *Chaoborus* after treatment with technical Abate at a rate of 0.25 pound per acre, but the treatment reported here was at the rate of 0.39 pound per acre.

Aquatic mites belonging to the genus *Hydrachna* survived. Also, the painted turtle (Emyidae) and the water snake (Colubridae) survived. The lake contained no fish. Dead snails belonging to two families (Physidae and Planorbidae) were found; however, since no snails were found in the pre-treatment sampling, possible survival is not known.

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TABLE 5.—Additional organisms found in qualitative sampling around shore of lake.

		Living Pre-treatment	After treatment: 24 hours Alive	24 hours Dead	48 hours Alive	48 hours Dead
	INSECTA					
COLEOPTERA						
Dryopidae	*Helichus lithophilus* (Germar)	..	..	..	×	..
Dytiscidae	*Cybister fimbriolatus* (Say)	×	×	..	..	..
	Hydroporus clypealis Sharp	×	..	..	..	..
	H. niger Say	×	..	..	×	..
	Hygrotus nubilus (LeConte)	×	..	..	×	..
	Ilybius fraterculus LeConte	×	×	..	×	..
	Thermonectus basillaris (Harris)	..	×	..	..	..
Gyrinidae	*Gyrinus affinis* Aubé	×	..	..	×	..
Haliplidae	*Peltodytes shermani* Roberts	..	×	..	..	..
Hydrophilidae	*Berosus infuscatus* LeConte	..	..	..	×	..
	Helochares maculicollis Mulsant	×	×	..	..	..
	Hydrochara obtusata (Say)	×	×	..	..	×
	Tropisternus lateralis nimbatus (Say)	×	×	..	..	×
COLLEMBOLA						
Poduridae	*Podura aquatica* Linnaeus	×	.	×	..	..
HEMIPTERA						
Gerridae	*Gerris marginatus* Say	×	×	..	..	..
Hydrometridae	*Hydrometra martini* Kirkaldy	×	..	..	..	..
Naucoridae	*Pelocoris femoratus* Palisot-Beauvois	×	..	..	×	×
ODONATA						
Coenagrionidae	*Enallagma* sp.	×	..	×	..	×
	Ischnura sp.	×	×	×	..	×
Libellulidae	*Perithemis tenera* Say	×	..	×	..	..
	Tramea carolina Linnaeus	×	..	..	..	..
	AMPHIBA					
CAUDATA						
Salamandridae	*Triturus viridescens viridescens* (Rafinesque)	×	×	..	×	..
SALIENTIA						
Ranidae	*Rana clamitans* Latreille	×	×	..	×	..
	REPTILIA					
CHELONIA						
Emyidae	*Chrysemys picta* (Schneider)	×	..	..	×	..
SQUAMATA						
Colubridae	*Natrix sipedon* (Linnaeus)	×	×	..	..	..

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