EFFECTS OF ORGANOPHOSPHORUS, CARBAMATE, AND ORGANOCHLORINE INSECTICIDES ON *LEPTOCONOPS KERTESZI* (KIEFFER)[1] (DIPTERA; CERATOPOGONIDAE)

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ABSTRACT. Tests with 16 organophosphorus, 6 carbamate and 2 organochlorine insecticides on *Leptoconops kerteszi* (Kieffer) revealed a wide spectrum of toxicity to this insect, ranging from the extremely high activity of methyl Dursban® (LC_{50} 0.039 μg/cm²) to the low activity of carbaryl (LC_{50} 130 μg/cm²). Because of low mammalian toxicity, methyl Dursban® holds promise for spot treatment against gnat populations in parks and other recreational areas.

INTRODUCTION. The black gnat *Leptoconops kerteszi* (Kieffer) is an important biting pest of man and animals in many areas of the western United States (Smith and Lowe, 1948; Rees and Smith, 1950; Foulk, 1966). This insect has been a pest problem in recent years along the Santa Ana River near Riverside, California. A sequence of floods from 1966 through 1969 created extensive breeding grounds favorable for gnat development. Overlapping generations of 25 to 28 days in duration occur during the summer over an area in excess of 600 acres. Human attack rates averaging 300 females per minute as measured by the sampling method developed by Foulk and Sjogren (1967) have been common, and a peak attack rate of 1,813 gnats per minute was recorded in August, 1968.

As a result of the severe annoyance experienced by residents living near the river and persons entering the riverbottom for recreational purposes, the Northwest Mosquito Abatement District was requested to develop a control program. Early trials indicated that organophosphorus insecticides at rates of 0.1 to 0.2 lb./acre, when applied in excess of 100 gallons of water per acre, were effective in controlling the larval stages. A high volume of spray was required in order to permit distribution of the insecticide in the top inch of sand where the larvae occur. Since the area is essentially an unstable bog, which cannot support sufficient vehicle weight to carry the necessary gallonage, larval control measures applied with ground equipment were considered unfeasible. Subsequent trials with ultra low volume aerial applications during periods of heavy dew failed to give significant levels of control.

An investigation conducted during the summer of 1969 by Legner *et al.* (1970) indicated that urea applied at the rate of 119 lbs./acre of nitrogen produced 52 percent control. Based on this information, an integrated control program was undertaken during 1970 in which urea was applied to the accessible larval breeding grounds and organophosphorus materials were applied by air to the dry sandy sites where adult insects congregate.

Field evaluations of adulticidal materials applied in cottonseed oil using 800067 spray systems nozzles indicated that ULV applications were not satisfactory when applied against adult populations during periods of peak flight activity. The best results were obtained when applications were made at daybreak to the nocturnal resting areas, prior to adult insect emergence from beneath the surface grains of sand. The gnats came in contact with spray deposits during preflight activity, when the insects normally walked 12 to 18 inches over the sand, warming up in preparation for flight. Efforts to critically evaluate the toxicity

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of different materials on adult field populations were inconclusive because of changing meteorological conditions which markedly influenced adult insect activity and affected the influx of adults from adjacent untreated areas. It was therefore considered necessary to conduct an extensive insecticide screening program in the laboratory, the results of which are reported here.

In addition to its practical importance, the study was significant because it involves development of a procedure for bioassay of insecticides on a minute insect not previously studied toxicologically.

Materials and Methods. This study was performed during July-August, 1970 on adults collected from the Santa Ana River bottom near Pleasant Knolls golf course, approximately 5 miles west of Riverside, California. The insects were obtained between 9 and 10 a.m. and tested within two hours. The collection was made with a "D-Vac" suction machine modified as per Foulk and Sjogren (1967). A hole was cut in the end of the collecting bag and a one-half gallon ice cream carton, with its bottom replaced with a fine-mesh organza, was inserted. When an adequate number of insects had been collected, the carton was removed and transported to the laboratory in a cold chest.

In the laboratory, the insects were brought to room temperature (74 ° F), and a fluorescent lamp was placed at the screened end of the carton to induce activity and flight. Small groups of active insects were then removed with an aspirator for testing, special care being taken to avoid aspirating insects which might have been damaged during collection and handling.

Testing was by exposure to insecticide-treated filter paper in shell vials according to the method employed by Georghiou and Metcalf (1961) in tests with adult mosquitoes. The insecticides used were of technical grade and were dissolved in acetone. Organophosphorus and organochlorine insecticides were tested on cellulose filter-paper discs and carbamates on glass-fiber filter paper (Georghiou and Gidden, 1965). One milliliter volume of the desired concentration of the insecticide was applied to 9-cm. diameter of filter paper, or 2-ml in the case of glass-fiber paper, and after the solvent had evaporated the paper was rolled tightly against the inside walls of a 2.1 x 8.4 cm. shell vial. The insects were anesthetized briefly with CO_2, counted in groups of 20, and aspirated into the vials. Only females were used. The males, which in our samples occurred at a frequency of approximately 1:20, were easily distinguished by their plumose antennae and were removed. Exposure was for one hour, after which the insects were again anesthetized briefly and transferred to holding containers for assessment of mortality 24 hours later. In preliminary tests, adults exposed to CO_2 suffered no mortality when the length of exposure was less than 20 minutes. Two 5-minute exposures one hour apart, as employed in the present study, showed no adverse effects.

Because of the minute size and thigmotactic behavior of the gnats, paper cups of the type used as post-exposure holding containers for mosquitoes were not satisfactory, since the gnats tended to become wedged in the crease around the bottom of the cup. Instead, clear plastic shell vials (3 cm. x 8 cm.) with snap-on plastic caps, were used successfully. A 1-cm. diameter hole was cut into the cap and a piece of fine-mesh organdy was placed under it to allow diffusion of insecticide vapors. Control gnats survived best when held at low temperature and high relative humidity. The post-treatment holding vials therefore were placed in an enamelled dissecting tray, a damp cloth towel was stretched over it, and a second tray was inverted on top. This provided a closed, high humidity container in which minimal mortality (<5 percent) occurred when the gnats were held for as long as 4 days without food at 60° F.

Each insecticide was tested at four or

more concentrations within the range producing 5 percent to 95 percent kill. The tests were replicated at least three times on different days and the results plotted on log-probit paper. Dosage-mortality regression lines were fitted by eye.

RESULTS AND DISCUSSION. The results obtained with 16 organophosphorus, 6 carbamate, and 2 organochlorine insecticides are summarized in Table 1. These

TABLE 1.—Susceptibility of *Leptoconops kerteszi* adults to various insecticides.[1]

	Insecticides	LC_{50} ($\mu g/cm^2$)	LC_{95} ($\mu g/cm^2$)
I	Dursban®, methyl	.039	.096
II	parathion, methyl	.081	.094
III	dieldrin	.12	.27
IV	Dursban®	.14	.31
V	dichlorvos	.17	.25
VI	fenthion	.23	.49
VII	DDT	.27	.61
VIII	phoxim	.40	.61
IX	naled	.54	1.1
X	parathion	.90	.97
XI	Mobam®	1.2	4.7
XII	Bay 62863	1.4	3.1
XIII	Phenthoate®	1.4	3.5
XIV	RE-11775	2.4	3.0
XV	fenitrothion	3.2	6.3
XVI	Akton®	3.2	6.3
XVII	Landrin®	3.6	7.1
XVIII	ronnel	4.4	12.0
XIX	Iodofenphos®	5.0	8.3
XX	propoxur	6.3	51.
XXI	dicapthon	8.6	16.
XXII	malathion	14.5	66.
XXIII	Abate®	45.	160.
XXIV	carbaryl	130.	250.

[1] See Table 2 for chemical identity of trademarked insecticides.

compounds represent a wide spectrum of activity against *Leptoconops,* ranging from extremely high toxicity of methyl Dursban (LC_{50} 0.039 μg./cm^2) to low toxicity of carbaryl (LC_{50} 130 μg./cm^2). In general, most phosphorothioates tested were more toxic to the gnats than the carbamates. Methyl Dursban and methyl parathion were more toxic than their respective ethyl analogs. The considerably lower mammalian toxicity of methyl Dursban (LD_{50} oral, rats, 1000 mg./kg.) suggests that this compound holds promise for spot treatment for the control of gnat populations in parks and recreational areas. In preliminary field trials performed prior to the initiation of this study, the ULV application of a formulation of 0.1 lb./acre of dichlorvos and 0.025 lb./acre of Dursban provided the best control among seven organophosphates and three carbamates tested.

Although the toxicity of DDT and dieldrin to the gnat is now of academic interest only, it should be noted that dieldrin was the third most active and DDT the seventh most active compound tested. The dosage-mortality regression lines obtained did not show any apparent evidence of resistance to these insecticides, despite their presence in the environment for some twenty years.

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TABLE 2.—Chemical identity of trade-marked compounds employed.

I	Dursban® methyl	*O, O*-dimethyl *O*-3, 5, 6-trichloro-2-pyridyl phosphorothioate
IV	Dursban®	*O, O*-diethyl *O*-3, 5, 6-trichloro-2-pyridyl phosphorothioate
XI	Mobam®	4-benzothienyl methylcarbamate
XII	Bay 62863	2, 3-dihydro-2-methylfuran-7-yl methylcarbamate
XIII	Phenthoate®	ethyl mercaptophenylacetate ester with *O, O*-dimethyl phosphorodithioate
XIV	RE-11775	*m-sec*-butylphenyl phenylthio (methyl)carbamate
XVI	Akton®	*O*-(2-chloro-1-(2, 5-dichlorophenyl)vinyl *O, O*-dimethyl phosphorothioate
XVII	Landrin®	3, 4, 5-trimethylphenyl methylcarbamate
XIX	Iodofenphos®	*O*-(2, 5-dichloro-5-iodophenyl) *O, O*-dimethyl phosphorothioate
XXIII	Abate®	*O, O, O', O'*-tetramethyl *O, O'*-thiodi-*p*-phenylene phosphorothioate

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RELATIVE ATTRACTIVENESS OF CO_2 AND A STEER TO TABANIDAE, CULICIDAE, AND *STOMOXYS CALCITRANS* (L.)[1, 2]

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ABSTRACT. Malaise traps baited with CO_2 released at the rate of 3.5 liter/minute, or with a steer, collected 4 times more Tabanidae than unbaited traps. Twelve species of tabanids showed no preference between the two baits; two species showed preference for CO_2. Collections of *Psorophora confinnis* (Lynch Arribálzaga) were increased by a factor of 13 when the traps were baited with CO_2 and by 23 when they were baited with the steer compared with unbaited traps. The numbers of *Stomoxys calcitrans* (L.) collected in traps baited with CO_2, with the steer, or unbaited were 221, 254, and 151, respectively.

The attractancy of CO_2 for Tabanidae is well known (DeFoliart and Morris 1967, Wilson *et al.* 1966). However, CO_2 may not be the only attractant given off by the host; other materials may have attractancy when they are present in conjunction with CO_2. For example, Acree *et al.* (1968) recently showed that L-lactic acid was such an attractant for Culicidae. The present investigation was made at the Livestock Insects Investigations Laboratory at Stoneville, Mississippi, to compare the attractancy of CO_2 and a steer for horse flies and to determine whether an adjunct attractive substance might be present. Data for Culicidae and stable flies, *Stomoxys calcitrans* (L.), are included since these insects were also collected.

MATERIALS AND METHODS. An 8-ft-square wire strand pen was constructed in a small grove of trees adjacent to a grazing pasture on the Delta Branch Experiment Station, Stoneville, Mississippi. Frames (4x8 ft.) covered with ¼-in.-mesh hardware cloth were placed on end around the perimeter of the pen to form an 8-ft.-high barrier. One Malaise trap (Townes 1962) constructed from natural saran screen was placed on each side of the pen (Fig. 1). The bait steer was a 6-year-old Hereford weighing about 1200 pounds.

The CO_2 used as bait was released in the center of the pen at a rate of 3.5 liters/minute from a 50-lb. tank by means of a single-stage regulator, a needle valve, and a compact flowmeter. This rate of

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[1] In cooperation with the Delta Branch of the Mississippi State University Agricultural and Forestry Experiment Station, State College, Mississippi 39762.

[2] Mention of a proprietary product in this paper does not constitute an endorsement of this product by the USDA.