RESIDUAL EFFECTIVENESS OF INSECTICIDE-TREATED SCREENS FOR CONTROL OF BITING MIDGES, *CULICOIDES FURENS* (POEY) (DIPTERA: CERATOPOGONIDAE)[1]

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ABSTRACT. The effectiveness of insecticide residues (malathion, propoxur, dichlorvos, stirofos and dimethoate) on commercial screen for the control of biting midges was determined by exposing the insects to treated screens in the laboratory. Residues were much less effective on new fiberglass screen than on aluminum screen. The most effective and long-lasting chemicals on aluminum screen were malathion and propoxur.

INTRODUCTION. Along the Atlantic and Gulf Coasts of the United States, biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae) are major pests of residents and tourists. These biting gnats occur from March through October in North Carolina with each of the 3 major pest species, *C. furens* (Poey), *C. melleus* (Coq.) and *C. hollensis* (Melander & Brues) reaching high population levels at one or more times during this period (Kline and Axtell 1975, 1976). These gnats are attracted to light at night and due to their small size easily penetrate conventional 16x18 mesh window screening used to exclude mosquitoes and flies from dwellings. As a result, *C. furens* and *C. melleus* often attack humans indoors during the evening when the lights are on. *C. furens* is generally a greater indoor pest than *C. melleus* due to its wider distribution and greater abundance. *C. hollensis* is much less of a problem indoors due to it being mostly a day time biter and its flight activity ceasing soon after sunset (within 1 hr.).

Control of biting midges is extremely different and the available methods are generally unsatisfactory. Approaches to control have been reviewed by Linley and Davis (1971). Substantial reduction of the sand fly annoyance within dwellings and screened porches has been achieved by treating the screens with insecticides (Hull and Shields 1939; Trapido 1947; Jamnback 1961, 1963; Linley and Davis 1971). The insecticides were applied to the screens as solutions in various organic solvents (alcohol, acetone, kerosene, naphtha, lubricating oil). We tested 4 insecticides formulated as emulsifiable concentrates (EC) and 1 as a wettable powder (WP) which are mixed with water to apply to the screens. Our tests were with *Culicoides furens* (Poey) while previous reports were mostly based on tests with other species.

MATERIALS AND METHODS. The insecticides, formulations and sources were as follows:

malathion: (Cythion®), 4 lb/gal (57%) EC, diethyl mercaptosuccinate, S-ester with O, O-dimethyl phosphorodithioate. American Cyanamid Co.

dichlorvos: (Vapona®), 2 lb/gal (22.8%) EC, 2, 2-dichlorovinyl dimethyl phosphate. Shell Chemical Co.

stirofos: (Gardona®) 2 lb/gal (24%) EC, 2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate. Shell Chemical Co.

dimethoate: (Cygon®), 2.67 lb/gal

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EC, O,O-dimethyl S-(methylcarbamoylmethyl) phosphorodithioate. American Cyanamid Co.

propoxur: (Bayon®, Bayer 39007), 70% WP, O-isopropoxyphenyl methylcarbamate. Chemagro Corp.

Discs (9 cm diam.) of screen were immersed for 30 seconds in the desired concentration of insecticide which was prepared by mixing with water and agitating thoroughly immediately before the treatment period. Insecticide concentrations were expressed as percent active ingredient calculated on a weight basis. The treated screens were hung beneath the eaves of a house (adjacent to the sound at Atlantic Beach, NC during the months of May and August) to dry and weather.

The sand flies were exposed to the treated screen in an arrangement described by Jamnback (1961). This consisted of 2 paper pint-size freezer containers with the open tops abutting and taped together with a disc of screen separating the two. The bottom of one of the containers was replaced with transparent plastic to allow light to enter. The bottom of the opposite container was intact to create partial darkness. Sand flies were introduced by means of an aspirating tube into the darker half of the apparatus through a small hole in the side near the bottom of the container. The hole was then covered with tape. The gnats quickly moved the length of the dark side, through the treated screen and into the light chamber where they remained and mortality was determined by counts at 1-hr intervals for 5 hrs post-exposure. Lighting was standardized by keeping the testing apparatus indoors (ca. 20° C) at a uniform distance below fluorescent light fixtures. There were 15 to 100 (usually about 30) gnats per chamber. Tests to compare aluminum to fiberglass screen consisted of 4 replicates per treatment. Other tests consisted of 6 replicates per treatment. Controls were untreated screens. All of the sand flies were unfed adult female *C. furens* which were collected into a large cage in the field with a suction-light trap a few hours before the tests. While in the cage the sand flies had access to water.

Both aluminum and fiberglass screening were used in the tests. The aluminum screen (Continental Copper and Steel Industries, Inc., Hanover, Pa.) was standard 16x18 mesh with 83% open space. The fiberglass screen (Chicopee Manufacturing Co., Buford, Ga.) was also 16x18 mesh with 74% open space. The treated screen discs were tested after varying numbers of days of weathering.

RESULTS AND DISCUSSION. In the tests there was usually less than 10% mortality among the biting midges in the control chamber with the untreated screen at 1, 2 and 3 hrs post-exposure. After 4 and 5 hrs post-exposure there was often greater than 10% mortality and the data were not used in this report.

Residues of the insecticides on aluminum screen were much more effective in killing sand flies than the residues on fiberglass screen (Table 1). A slight oily film appeared to be on the surface of the new fiberglass screen and it is possible that this interfered with the adherence of the insecticide. Older, weathered fiberglass screen might give different results. Stirofos and dimethoate were ineffective at 1–5% concentration on both aluminum and fiberglass screen and were not tested further. With aluminum screen, at 5% concentration and 3 hr post-exposure, malathion and dichlorvos gave 98% and 75% sand fly mortality, respectively, while the mortality was only 10% for stirofos and 32% for dimethoate.

Residues of malathion and propoxur retained their effectiveness against sand flies for longer weathering periods than dichlorvos (Table 2). At 8% concentration, malathion gave 94% mortality (3 hr post exposure) after 28 days of weathering while propoxur gave 89%. Malathion and propoxur at 5% concentration gave similar levels of mortality after 5 and 28 days of weathering but the mortalities were not high enough to be practical. Dichlorvos at 8% and 5% gave high

Table 1. Comparison of the mortalities among sand flies (*Culicoides furens*) passing through aluminum or fiberglass screen treated with 4 insecticides and weathered for 2 days.

Chemical	Conc. (% Act. ingred.)	Avg. % Mortality at hrs. post exposure							
		Aluminum screen				Fiberglass screen			
		1		2	3	1		2	3
malathion	8	37	(123)[a]	84	99	5	(89)	16	30
	5	26	(125)	59	98	0	(85)	6	25
	2	10	(112)	52	94	3	(117)	5	18
dimethoate	5	2	(134)	12	32	4	(113)	15	35
	2	1	(96)	12	20	0	(78)	8	17
	1	1	(89)	9	19	2	(95)	12	23
Control		0	(89)	0	0	0	(81)	0	4
dichlorvos	5	6	(102)	29	75	8	(142)	11	16
	2	6	(108)	24	35	3	(162)	9	14
	1	7	(184)	14	26	2	(176)	10	12
stirofos	5	3	(230)	7	10	3	(178)	10	14
	2	1	(249)	7	13	2	(319)	7	11
	1	1	(215)	2	7	1	(309)	4	9
Control		0	(245)	2	4	1	(217)	2	5

[a] Total no. of sand flies is given in parenthesis. There were 4 replicates per treatment.

Table 2. Mortalities among sand flies (*Culicoides furens*) passing through aluminum screen treated with 3 insecticides and weathered for 1–43 days.

Chemical	Conc. (% Act. Ingred.)	Post exposure Time (hrs)	Avg. % Mortality at days treated screens weathered							
			1		5		28		43	
malathion	8%	1	100	(144)[a]	34	(189)	25	(199)	31	(269)
		2	94		80		74		56	
		3	100		93		94		66	
	5%	1	69	(103)	20	(167)	5	(152)	7	(218)
		2	83		41		22		23	
		3	98		84		41		47	
propoxur	8%	1	..		93	(105)	52	(103)		
		2	..		99		78			
		3	..		98		89			
	5%	1	..		62	(96)	24	(168)		
		2	..		73		37			
		3	..		86		45			
	3%	1	..		12	(103)	3	(176)		
		2	..		30		5			
		3	..		52		6			
dichlorvos	8%	1	72	(123)	0	(142)	1	(225)		
		2	98		0		3			
		3	98		7		6			
	5%	1	52	(88)	0	(141)	0	(159)		
		2	84		0		1			
		3	96		1		2			
Control		1	0	(37)	4	(135)	0	(231)	9	(161)
		2	0		8		0		12	
		3	0		10		1		14	

[a] Mortalities are corrected for control mortality by Abbott's formula. Total no. of sand flies is given in parenthesis. There were 6 replicates per treatment, except for 3 for the 1-day control.

levels of mortality initially (screen weathered 1 day) but thereafter was ineffective. This is contrary to the previous report by Linley and Davis (1971) that dichlorvos is long-lasting and effective for sand fly control. However, they used fiberglass screen and a different species (*C. barbosai*).

These data suggest that water-mixed formulations of malathion or propoxur with concentrations of 8% active ingredient when applied to aluminum screening will kill a considerable portion of the *Culicoides* attempting to enter a dwelling for as long as a month. Jamnback (1963) reported similar effectiveness of malathion and propoxur (=Bayer 39007) against *C. sanquisuga*. However, he used solutions in organic solvents while we used water mixtures (emulsifiable concentrate of malathion and wettable powder of propoxur). A disadvantage of the wettable powder is the unsightly white residue left on the screen. For home and resort owners it is more practical to use commercially available emulsifiable concentrates or wettable powders than to prepare the insecticide in organic solvents.

Treated window or porch screens should give significant sand fly control inside. The degree of control will depend upon how long the sand flies rest on the treated screens and how quickly they attempt blood feeding after entering. These factors are not known. However, Jamnback (1961, 1963) discussed the need for rapid kill and considered that mortality should occur within 1 hr after exposure. To achieve that consistently, concentrations of malathion or propoxur greater than 8% and/or more frequent than monthly applications would be required.

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