Literature Cited

Ainsley, R. W. 1976. Laboratory colonization of the malaria vector *Anopheles culicifacies.* Mosq. News 36:256–258.

Davidson, G. 1957. Insecticide resistance in *Anopheles sundaicus.* Nature 180:1333–1335.

Davidson, G. and A. R. Zahar. 1973. The practical implications of resistance of malaria vectors to insecticides. Bull. W.H.O. 49:475–483.

Sakai, R. K., R. H. Baker and S. Javed. 1979. Genetic linkage analyses of dieldrin resistance in *Anopheles culicifacies.* Trans. Roy Soc. Trop. Med. Hyg. 73:445–450.

EFFECTS OF A NEW INSECT GROWTH REGULATOR, UC-62644, ON TARGET CHIRONOMIDAE AND SOME NONTARGET AQUATIC INVERTEBRATES[1]

ARSHAD ALI AND BRUCE H. STANLEY[2]

University of Florida, IFAS, Agricultural Research and Education Center, P.O. Box 909,
Sanford, FL 32771

ABSTRACT. A new IGR, UC-62644, was bioassayed in the laboratory against 4th-instar larvae of *Glyptotendipes paripes* and *Chironomus decorus.* A 25% WP of this IGR was tested against midges in experimental ponds at 25, 50 and 100 g AI/ha (5.5–22.0 ppb), and in a golf course pond at 100 g AI/ha or 16.0 ppb. Impact of UC-62644 on nontarget invertebrates in the midge habitats was also studied.

The IGR caused 90% mortality of *G. paripes* and *C. decorus* at 3.1–5.7 ppb. In experimental ponds, the WP produced an excellent control of midges. Even the lowest dose induced 99% inhibition of total midge emergence, and control lasted for more than 4 wk. In the golf pond, 56–98% of the total emergence was suppressed for 4 wk. The treatments also caused significant mortality of midge larvae.

In experimental ponds, Rotifera, *Cyclops* spp., *Daphnia* spp., *Chaoborus* sp., *Baetis* sp., corixids, notonectids, and coleopterous larvae and adults were affected but most of these nontarget invertebrates recovered within 2–3 wk after treatment except for *Cyclops* spp. and possibly corixids and beetles. Rotifers, ostracods, and oligochaetes in golf pond were not affected but *Cyclops* spp. and *Hyalella azteca* (Saussure) were sensitive to the IGR.

UC-62644 is the most effective IGR thus far tested against chironomid midges and has moderate and temporary adverse effects on the nontarget aquatic invertebrates.

INTRODUCTION

In the past decade a number of insect growth regulators (IGRs) have been evaluated against aquatic chironomid midges (Ali and Mulla 1977a,b; Ali et al. 1978, Ali and Lord 1980a, Mulla and Darwazeh 1975, Mulla et al. 1974, 1976). These nonbiting midges pose a variety of nuisance and economic problems in many parts of the United States and abroad (Ali 1980).

Among the various IGRs tested against a number of chironomid species, methoprene, diflubenzuron, and Bay SIR-8514 have shown the most activity under laboratory and field conditions (Ali and Lord 1980a, Mulla and Darwazeh 1975, Mulla et al. 1974, 1976). These compounds are especially useful in areas where conventional chemicals are either ineffective due to build up of resistance

---

[1] Florida Agricultural Experiment Stations Journal Series No. 3020.

[2] Present Address: Department of Entomology, New York State Agricultural Experiment Station, Cornell University, Geneva, New York.

by midge larvae or undesirable due to high costs and high levels of toxicity to nontarget organisms (Mulla et al. 1974, 1975, Pelsue et al. 1974). Reported here are laboratory and field evaluations of a new IGR tested against a few nuisance chironomids of Florida. The impact of this IGR on some nontarget invertebrates associated with the midge habitats was also assessed.

MATERIALS AND METHODS

LABORATORY STUDIES. The IGR bioassayed was a Union Carbide material, UC-62644. This IGR was a benzoyl urea compound similar to diflubenzuron [1-(4-chlorophenyl)-3 (2,6-difluorobenzoyl)-urea], and Bay SIR-8514 [1-(4-trifluoro-methoxyphenyl)-3-(2-chlorobenzoyl)-urea]. The growth regulator was tested against 4th-instar field populations of *Glyptotendipes paripes* Edwards and *Chironomus decorus* Johannsen. Technical grade material of the test compound was utilized to prepare 1% stock solution in acetone and further dilutions in acetone were made as needed.

For the purpose of bioassay, 1200 ml clear styrene plastic rearing units containing midge larvae, sterilized sand, tap water, and a continuous air flow were used (Ali and Lord 1980a). Twenty 4th-instars of a species were placed in each rearing unit and after 1–2 hr of acclimatizing, the required amount of the IGR was added to each unit. The rearing units were maintained under 14-h light/10-h dark, and 27 ± 2°C room temperature. For larval food, 0.1 g of ground Dog Kisses® (The Hartz Mountain Corp.) was added to each unit every 3 days. The IGR was tested on 3 different occasions against each species. Each time, 4–5 triplicated concentrations of the IGR were tested while 3 untreated checks containing one ml of acetone were also run. Dead larvae, pupae and living or dead adults were counted and removed daily. The experiment was continued until complete mortality in each unit had occurred or surviving larvae had pupated and emerged as adults. Average cumulative (larval, pupal and adult) corrected percent mortality at different concentrations of the IGR was subjected to log-probit regression analysis to determine the LC_{50} and LC_{90} levels against the 2 midge species.

FIELD STUDIES. *Target Midges: Experimental Ponds.* The IGR was evaluated against natural midge populations in artificial earthen ponds at Sanford, FL. These 4 × 6 m and 45–50 cm deep ponds have a continuous water supply from an underground artesian source. The water level in each pond is maintained constant by a float valve.

On August 19, 1980, a 25% WP of UC-62644 was applied to the ponds in a completely randomized design. The method of application of WP was the same as in Ali and Lord (1980a). Three replicated rates of the WP, 25, 50, and 100 g AI/ha were employed and 3 ponds were left untreated as checks.

Prior to and at intervals after treatments, chironomid larval density and one night's emergence of adults from the treated and check ponds were assessed. A 15 × 15 cm scoop sampler was used to collect 2 random mud samples from each pond. Midge larvae were separated from the mud by the procedures of Mulla et al. (1971). Adult emergence was sampled by employing 30-cm high metal cone submerged emergence traps (Mulla et al. 1974). A minimum of one or 2 traps was left overnight in each pond.

Golf Course Ponds. UC-62644 (25% WP) was applied at 100 g AI/ha on July 18, 1980, to one of the three 1-ha, ca. 50 cm deep ponds on the golf course of the City of Cocoa Beach, FL, and one pond was utilized as control. The WP was applied from a motor boat to the pond surface with a stainless steel pressurized sprayer. The toxicant was discharged in the water disturbed by the propeller and several swaths were made to achieve a uniform distribution of the IGR in the pond.

Ten Ekman dredge mud samples were randomly collected from each golf pond and 6 emergence traps in each pond were also employed to sample adult emergence prior to and after the treatment.

Nontarget Invertebrates: Experimental Ponds. The zooplankton and nektonic invertebrates in experimental ponds were sampled immediately prior to and at intervals after treatments by employing a 50 cm long and 20 cm diam mouth nylon net of 125 μm pore, and also by using a 400 ml dipper. The net was mounted on a metal sled. On each occasion, 2 plankton sled samples and a composite of 5 dips were collected and preserved in formaldehyde. The sampling methods have been described elsewhere (Ali and Lord 1980b).

Golf Course Ponds. The zooplankton in the 2 golf ponds was sampled by towing the plankton net behind a boat. On each visit, 4 samples were obtained from 4 randomly predetermined locations, 2 along the length and 2 across the width of each pond, and preserved as in Ali (1981).

In the laboratory, midge larval samples were analyzed and the larvae were identified and counted. The zooplankton and nektonic samples were also processed, identified and counted as in Ali and Mulla (1978). The posttreatment reduction of midge larvae, inhibition of emergence of adults and the reduction of nontarget invertebrates were calculated as described by Mulla et al. (1971).

RESULTS AND DISCUSSION

EFFECTS ON MIDGES. *Laboratory.* Table 1 shows the effectiveness of UC-62644 against *G. paripes* and *C. decorus.* The IGR was highly active against both midge species as shown by the LC_{90} values of 3.1 ppb for *G. paripes* and 5.7 ppb for *C. decorus.* A comparison of activity of UC-62644 with diflubenzuron and Bay SIR-8514, tested previously against the same species (Ali and Lord 1980a), showed UC-62644 to be the most active IGR against *G. paripes,* while against *C. decorus,* it had similar activity as diflubenzuron but was 3–4 times as active as Bay SIR-8514 (Table 1).

Experimental Ponds. The effects of 25% WP of UC-62644 on chironomid emergence from experimental ponds are shown in Table 2. The IGR was highly effective against Tanytarsini, *Polypedilum* sp. and other Chironomini. Among these groups, the former 2 were slightly more sensitive to the IGR. All 3 treatment rates produced excellent control of midges for more than 4 wk. Although the rates of 50 and 100 g AI/ha produced slightly better and longer lasting control of Chironomini, the total control of midges produced by the lowest rate (25 g AI/ha) was not significantly different ($P>0.05$) from the highest rate of 100 g AI/ha when tested by analysis of variance.

Golf Course Ponds. The treatment of

Table 1. Susceptibility of 4th-instar midges exposed continuously to 3 insect growth regulators (IGRs) in the laboratory.

	Lethal concentration in ppb					
	Glyptotendipes paripes[a]			*Chironomous decorus*[b]		
IGRs	LC_{50}	LC_{90}	Slope	LC_{50}	LC_{90}	Slope
UC-62644	1.4	3.1	3.95	2.1	5.7	2.92
Diflubenzuron[c]	1.8	4.1	3.58	1.9	6.0	2.56
Bay SIR-8514[c]	2.6	7.6	2.75	6.4	22.0	2.39

[a] Field populations taken from Lake Monroe, Sanford, Seminole-Volusia Co., FL (1979–80).

[b] Field populations taken from the Florida Power and Light water cooling reservoir, DeBary, Volusia Co., FL (1979–80).

[c] Data obtained from Ali and Lord (1980), J. Econ. Entomol. 73:243–9.

Table 2. Effects of the IGR, UC-62644 (25% WP), on chironomid midge emergence from experimental ponds at Sanford, FL, (1980).

	Mean no. (± SD) adult emergence/m² pre-, and posttreatment (days)									
Genus/Tribe	Pretreat	3	7	14	28	Pretreat	3	7	14	28
		25 g AI/ha or 5.5 ppb					*50 g AI/ha or 11.0 ppb*			
Tanytarsini[a]	528 ± 237	2 ± 2 (99)[d]	3 ± 4 (99)	7 ± 8 (99)	28 ± 17 (96)	752 ± 410	2 ± 4 (99)	2 ± 2 (99)	4 ± 6 (99)	9 ± 10 (99)
Polypedilum sp.	284 ± 155	2 ± 4 (99)	0 (100)	4 ± 6 (99)	39 ± 37 (95)	194 ± 86	0 (100)	0 (100)	2 ± 4 (99)	14 ± 17 (98)
Chironomini[b, c]	30 ± 31	5 ± 6 (86)	1 ± 2 (97)	4 ± 6 (81)	11 ± 9 (35)	6 ± 8	0 (100)	0 (100)	4 ± 6 (3)	6 ± 4 (0)
Total	842 ± 264	9 ± 4 (99)	4 ± 3 (99)	15 ± 10 (99)	78 ± 35 (94)	952 ± 485	2 ± 4 (99)	2 ± 2 (99)	10 ± 9 (99)	29 ± 22 (98)
		100 g AI/ha or 22.0 ppb						*Check*		
Tanytarsini[a]	428 ± 338	4 ± 8 (99)	0 (100)	0 (100)	4 ± 8 (99)	192 ± 139	158 ± 78	516 ± 188	284 ± 161	276 ± 170
Polypedilum sp.	156 ± 77	0 (100)	0 (100)	0 (100)	8 ± 11 (98)	40 ± 41	47 ± 39	84 ± 53	170 ± 162	119 ± 219
Chironomini[b, c]	110 ± 87	6 ± 7 (95)	2 ± 4 (98)	0 (100)	0 (100)	16 ± 15	18 ± 12	16 ± 6	11 ± 6	9 ± 10
Total	694 ± 255	10 ± 9 (98)	2 ± 4 (99)	0 (100)	12 ± 10 (99)	248 ± 134	223 ± 70	616 ± 226	456 ± 117	404 ± 326

[a] Mixture of *Tanytarsus* spp. and *Rheotanytarsus* sp.

[b] *Chironomus carus, Goeldichironomous holoprasinus,* and an unidentified species of *Chironomous.*

[c] Includes 0–10% Tanypodinae.

[d] Numbers in parentheses indicate percent inhibition of adult emergence after treatment.

Table 3. Effects of the IGR, UC-62644 (25% WP), applied at 100 g AI/ha (16.0 ppb) on chironomid midge emergence from a golf pond, city of Cocoa Beach, FL, (1980).

	Mean no. (± SD) adult emergence/m² pre-, and posttreatment (days)				
Genus/Species	Pretreat	3	7	14	28
			Treated Pond		
Chironomus carus	117 ± 71	50 ± 36	2 ± 2	4 ± 6	27 ± 20
		(53)[a]	(98)	(98)	(80)
Chironomus sp.	8 ± 8	5 ± 6	0	0	5 ± 5
		(51)	(100)	(100)	(2)
Coelotanypus sp.	7 ± 8	0	0	0	0
		(100)	(100)	(100)	(100)
Total	132 ± 70	55 ± 41	2 ± 2	4 ± 6	32 ± 28
		(56)	(98)	(98)	(78)
			Check Pond		
Chironomus carus	76 ± 41	69 ± 51	65 ± 36	112 ± 82	86 ± 50
Chironomus sp.	11 ± 5	14 ± 11	8 ± 5	6 ± 4	7 ± 8
Coelotanypus sp.	2 ± 4	1 ± 2	2 ± 2	0	3 ± 5
Total	89 ± 50	84 ± 57	75 ± 39	118 ± 80	96 ± 48

[a] Number in parentheses indicate percent inhibition of adult emergence after treatment.

Table 4. Effects of the IGR, UC-62644 (25% WP) on benthic chironomid larvae in experimental ponds, Sanford, and in a golf pond, city of Cocoa Beach, FL, (1980).

	Percent larval reduction posttreatment (days)				
Midge group	Pretreat[a]	3	7	14	28
Experimental Ponds:					
			25 g AI/ha		
Tanytarsini	4714 ± 1210	26	47	59	30
Chironomini[b]	1948 ± 927	15	38	32	42
			50 g AI/ha		
Tanytarsini	5260 ± 1560	11	52	48	46
Chironomini[b]	1740 ± 1106	19	65	34	49
			100 g AI/ha		
Tanytarsini	2400 ± 725	50	69	58	76
Chironomini[b]	2120 ± 1100	32	61	47	64
			Check[a]		
Tanytarsini	1480 ± 1000	2414 ± 719	4920 ± 293	3280 ± 1002	2644 ± 921
Chironomini[b]	926 ± 292	1628 ± 1107	1720 ± 729	1868 ± 527	2120 ± 1210
Golf Ponds:					
			100 g AI/ha		
Chironomini	3600 ± 3103	18	27	59	37
Tanypodinae	340 ± 142	0	39	4	6
			Check[a]		
Chironomini	2616 ± 1212	2792 ± 790	2120 ± 1630	3240 ± 1100	2360 ± 1112
Tanypodinae	112 ± 12	68 ± 7	78 ± 18	92 ± 21	70 ± 21

[a] Mean no. (± SD) larvae/m².

[b] Includes 0–10% Tanypodinae.

Table 5. Effects of the IGR, UC-62644 (25% WP), applied at different rates, on some zooplankton in experimental ponds, Sanford, FL, (1980).

	Mean no. (± SD) zooplankton/250 liters pre-, and posttreatment (days)							
Taxa	Pretreat	3	7	14	Pretreat	3	7	14
		25 g AI/ha or 5.5 ppb				*50 g AI/ha or 11.0 ppb*		
Rotifera	70 ± 55	116 ± 73 (11)[a]	181 ± 181 (0)	70 ± 59 (0)	53 ± 53	186 ± 186 (0)	260 ± 240 (0)	84 ± 61 (0)
Cyclops spp.	73 ± 73	47 ± 47 (27)	40 ± 40 (94)	15 ± 15 (99)	403 ± 3	50 ± 46 (86)	31 ± 10 (99)	53 ± 37 (99)
Daphnia sp.	16945 ± 12705	16 ± 14 (99)	20407 ± 20193 (23)	12638 ± 7012 (0)	14175 ± 1200	16 ± 16 (99)	2007 ± 1893 (91)	9480 ± 330 (0)
Ostracoda	595 ± 561	763 ± 636 (0)	854 ± 718 (0)	1073 ± 16 (0)	7881 ± 2517	4455 ± 4006 (0)	950 ± 125 (0)	1470 ± 166 (0)
Chaoborus sp. L	510 ± 140	49 ± 6 (65)	60 ± 21 (0)	—	353 ± 172	22 ± 9 (77)	84 ± 76 (0)	—
		100 g AI/ha or 22.0 ppb				*Check*		
Rotifera	140 ± 140	87 ± 81 (67)	46 ± 44 (65)	106 ± 92 (0)	30 ± 21	56 ± 42	28 ± 11	16 ± 14
Cyclops spp.	345 ± 295	0 (100)	1 ± 1 (99)	0 (100)	43 ± 16	38 ± 11	400 ± 112	707 ± 167
Daphnia sp.	19455 ± 13265	1 ± 0 (99)	1818 ± 1815 (94)	1695 ± 1690 (0)	9767 ± 8511	7102 ± 10836	15264 ± 26155	510 ± 495
Ostracoda	2431 ± 2429	670 ± 432 (37)	241 ± 214 (17)	1855 ± 1829 (0)	10211 ± 9930	4499 ± 4044	1220 ± 1074	435 ± 407
Chaoborus sp. L	573 ± 212	2 ± 1 (99)	60 ± 10 (0)	—	809 ± 949	223 ± 260	18 ± 15	—

[a] Numbers in parentheses indicate percent reduction of zooplankton after treatment.
L = larvae.

UC-62644 at 100 g AI/ha in a golf course pond also resulted in good control of midges. The predominant species, *Chironomus carus* Townes, was controlled 53–98% during the 4 wk of evaluation, and an overall 56–98% inhibition of total emergence of midges occurred during the same period (Table 3).

The IGR, in addition to suppressing adult midge emergence, caused considerable mortality of benthic midge larvae in the treated habitats. In experimental ponds, 11–76% of Tanytarsini and 15–65% of Chironomini were eliminated during 4 wk of posttreatment (Table 4). In a golf course pond, Chironomini were reduced 18–59% during the 4 wk of evaluation while tanypodine larvae showed lesser sensitivity to UC-62644.

EFFECTS ON NONTARGET INVERTEBRATES. *Experimental Ponds.* The pre-, and posttreatment population changes of the predominant zooplankton in the treated ponds are shown in Table 5, and are compared with the corresponding changes of the zooplankton in the check ponds. The treatment of 100 g AI/ha of the IGR affected Rotifera but they recovered within 1–2 wk after treatment. *Cyclops* spp. were affected for over 2 wk at all 3 treatment rates. The most predominant zooplankton, *Daphnia* spp., showed extreme sensitivity and were eliminated >99% at all treatment rates but their population completely recovered within 1–2 wk posttreatment. The IGR slightly affected ostracods for one wk at the highest dose. Larvae of *Chaoborus* sp. also showed some sensitivity to the IGR during the week after treatments.

Among the nontarget insects, nymphal *Baetis* sp. was reduced up to 79% with the 2 higher doses (Table 6). Corixids, notonectids and coleopterous larvae and adults were also sensitive to the growth inhibitor but their numbers in the ponds were too small to determine any definite deleterious effects of the IGR.

Table 6. Effects of the IGR, UC-62644 (25% WP), applied at different rates on some aquatic insects in experimental ponds, Sanford, FL, (1980).

	Mean no. (± SD) insects/5 dips pre-, and posttreatment (days)							
Taxa	Pretreat	3	7	14	Pretreat	3	7	14
	25 g AI/ha or 5.5 ppb				*50 g AI/ha or 11.0 ppb*			
Baetis sp. N	54 ± 27	24 ± 4	21 ± 5	37 ± 7	182 ± 50	49 ± 7	8 ± 1	31 ± 3
		(14)[c]	(0)	(14)		(48)	(68)	(79)
Corixids[a] N	5 ± 1	8 ± 1	3 ± 2	1 ± 1	3 ± 0	6 ± 3	0	1 ± 1
		(20)	(80)	(93)		(0)	(100)	(89)
Coleoptera[b] L	10 ± 3	7 ± 2	6 ± 2	1 ± 1	11 ± 3	4 ± 4	1 ± 1	0
		(0)	(0)	(0)		(40)	(70)	(100)
Coleoptera[b] A	3 ± 1	7 ± 6	1 ± 1	2 ± 0	13 ± 3	2 ± 1	1 ± 1	1 ± 1
		(0)	(0)	(0)		(62)	(71)	(62)
	100 g AI/ha or 22.0 ppb				*Check*			
Baetis sp. N	65 ± 60	21 ± 17	5 ± 2	14 ± 3	191 ± 136	99 ± 88	26 ± 7	152 ± 29
		(38)	(44)	(73)				
Corixids[a] N	5 ± 0	6 ± 1	1 ± 1	1 ± 1	1 ± 1	2 ± 2	3 ± 2	3 ± 2
		(40)	(93)	(93)				
Coleoptera[b] L	18 ± 5	6 ± 2	2 ± 1	2 ± 2	20 ± 8	12 ± 2	6 ± 4	2 ± 1
		(44)	(63)	(0)				
Coleoptera[b] A	26 ± 6	9 ± 5	2 ± 1	4 ± 3	15 ± 6	6 ± 7	4 ± 3	3 ± 1
		(14)	(71)	(23)				

[a] Includes some notonectids.

[b] Mostly Hydroporinae and Hydrophilidae.

[c] Numbers in parentheses indicate percent reduction of nontarget insects after treatment.

N = nymphs; L = Larvae; A = adults.

Table 7. Effects of the IGR, UC-62644 (25% WP), applied at 100 g AI/ha (16.0 ppb) on planktonic, nektonic, and benthic invertebrates in a golf pond, city of Cocoa Beach, FL, (1980).

Invertebrates	Mean no. (± SD) planktonic or nektonic invertebrates/1000 liters or benthic oligochaetes/m² pre-, and posttreatment (days)									
	Pretreat	3	7	14	21	Pretreat	3	7	14	21
	Treated Pond					*Check Pond*				
Planktonic										
Rotifera	420 ± 27	950 ± 112 (0)[b]	510 ± 110 (0)	204 ± 24 (29)	105 ± 24 (0)	185 ± 42	204 ± 14	67 ± 19	127 ± 34	36 ± 16
Cyclops spp.	1100 ± 112	92 ± 14 (96)	48 ± 4 (98)	15 ± 7 (99)	10 ± 2 (99)	129 ± 5	267±4	312±12	185±21	107±16
Nektonic										
Ostracoda	54 ± 12	60 ± 8 (46)	77 ± 27 (0)	31 ± 21 (0)	62 ± 52 (0)	200 ± 67	412 ± 112	129 ± 67	24 ± 4	127 ± 60
Hyalella azteca	5 ± 3	1 ± 1 (87)	1 ± 1 (80)	0 (100)	0 (100)	2 ± 2	3 ± 2	2 ± 2	0	4 ± 4
Benthic										
Oligochaeta[a]	2210 ± 1200	3290 ± 790 (0)	4200 ± 1670 (0)	9200 ± 2405 (0)	4650 ± 1012 (0)	3712 ± 725	4620 ± 2216	6924 ± 1100	3164 ± 1210	7210 ± 3100

[a] Mostly Tubificidae.

[b] Numbers in parentheses indicate percent reduction of nontarget invertebrates after treatment.

Golf Course Ponds. The treatment of UC-62644 in the golf pond did not affect rotifers, ostracods and benthic oligochaetes (Table 7). However, populations of *Cyclops* spp. and *Hyalella azteca* (Saussure) declined after the treatment and both crustacean groups did not recover to pretreatment levels after 3 wk of treatment.

The laboratory and field midge data gathered in this study when compared with the laboratory and field activity of diflubenzuron and Bay SIR-8514 against midges (Ali and Lord 1980a) clearly indicate that UC-62644 possesses superior activity against chironomids than diflubenzuron or Bay SIR-8514, and this new IGR is perhaps the most active growth inhibitor thus far tested against chironomids.

Among the growth regulators previously tested against chironomids, diflubenzuron had shown the greatest activity in laboratory and field studies (Ali and Lord 1980a, Mulla and Darwazeh 1975, Mulla et al. 1974, 1976). In field trials, methoprene at 0.28 kg AI/ha had controlled midges for 1–2 wk (Mulla et al. 1974, 1976), but diflubenzuron at 0.11–0.28 kg AI/ha had yielded midge control for 4–8 wk at the highest dose (Mulla et al. 1976). The studies of Ali and Lord (1980a) in the same experimental ponds as used in the present study had revealed that Bay SIR-8514 at 112 g AI/ha controlled midges for ca. 3 wk but diflubenzuron at comparable rates (28 and 56 g AI/ha) produced better results than Bay SIR-8514.

It is evident from this study that UC-62644 applied at midge control rates would have simultaneous adverse effects on some nontarget aquatic invertebrates, such as *Cyclops* spp., *Daphnia* spp., and *Baetis* sp. Other IGRs, including diflubenzuron and Bay SIR-8514 at rates comparable to the ones used in this study also affect some nontarget organisms (Ali and Lord 1980b, Ali and Mulla 1978, Apperson et al. 1978). However, these adverse effects are usually short-lived as shown here and by the previous studies.

ACKNOWLEDGMENTS

The assistance of Richard D. Baggs and Robert L. Moore during the course of this study is acknowledged. Acknowledgment also is made to Dr. Annelle R. Soponis, Laboratory of Aquatic Entomology, Florida A & M University, Tallahassee, FL, for identification of adult midges.

References Cited

Ali, A. 1980. Nuisance chironomids and their control: a review. Bull. Entomol. Soc. Am. 26:3–16.

Ali, A. 1981. *Bacillus thuringiensis* serovar. *israelensis* (ABG-6108) against chironomids and some nontarget aquatic invertebrates. J. Invertebr. Pathol. 38:264–72.

Ali, A. and J. Lord. 1980a. Experimental insect growth regulators against some nuisance chironomid midges of central Florida. J. Econ. Entomol. 73:243–9.

Ali, A. and J. Lord, 1980b. Impact of experimental insect growth regulators on some nontarget aquatic invertebrates. Mosq. News 40:564–71.

Ali, A. and M. S. Mulla. 1977a. Chemical control of nuisance midges in the Santa Ana River Basin, southern California. J. Econ. Entomol. 70:191–5.

Ali, A. and M. S. Mulla. 1977b. The IGR diflubenzuron and organophosphorus insecticides against nuisance midges in man-made residential-recreational lakes. J. Econ. Entomol. 70:571–7.

Ali, A. and M. S. Mulla. 1978. Impact of the IGR diflubenzuron on invertebrates in a residential-recreational lake. Arch. Environm. Contam. Toxicol. 7:483–91.

Ali, A., M. S. Mulla, A. R. Pfuntner and L. L. Luna. 1978. Pestiferous midges and their control in a shallow residential-recreational lake in southern California. Mosq. News 38:528–35.

Apperson, C. S., C. S. Schaefer, A. E. Colwell, G. H. Werner, N. L. Anderson, E. F. Dupras, Jr. and D. L. Longanecker. 1978. Effects of diflubenzuron on *Chaoborus astictopus* and nontarget organisms and persistence of diflubenzuron in lentic habitats. J. Econ. Entomol, 71:521–7.

Mulla, M. S. and H. A. Darwazeh. 1975. Evaluation of insect growth regulators against chironomids in experimental ponds. Proc. Pap. Calif. Mosq. Contr. Assoc. 43:164–8.

Mulla, M. S., D. R. Barnard and R. L. Norland.

1975. Chironomid midges and their control in Spring Valley Lake, California. Mosq. News 35:389–95.

Mulla, M. S., W. L. Kramer and D. R. Barnard. 1976. Insect growth regulators for the control of chironomid midges in residential-recreational lakes. J. Econ. Entomol. 69:285–91.

Mulla, M. S., R. L. Norland, T. Ikeshoji and W. L. Kramer. 1974. Insect growth regulators for the control of aquatic midges. J. Econ. Entomol. 67:167–70.

Mulla, M. S., R. L. Norland, D. M. Fanara, H. A. Darwazeh and D. W. McKean. 1971. Control of chironomid midges in recreational lakes. J. Econ. Entomol. 65:300–7.

Pelsue, F. W., G. C. McFarland and C. Beesley. 1974. Field evaluation of two insect growth regulators against chironomid midges in water spreading basins. J. Econ. Entomol. 42:157–63.

AN ANNOTATED LIST OF THE MOSQUITOES OF NEBRASKA

STEELE R. LUNT[1] AND WILLIAM F. RAPP, JR.[2]

ABSTRACT. In 1944 Tate and Gates listed 33 species of mosquitoes in Nebraska. By 1976 there were published records of an additional 16 species. Four of the 49 species could not be verified and have been deleted from the list. Presented here is an annotated list of the 45 species of mosquitoes known to occur in Nebraska.

The first comprehensive publication on the mosquitoes of Nebraska (Tate and Gates 1944) listed 33 species. Since that time additional species added to the list are: *Aedes fitchii* (Felt and Young), *Ae. sollicitans* (Walker), and *Culiseta melanura* (Coquillett) (Olson and Keegan 1944a, 1944b); *Psorophora cyanescens* (Coquillett) and *Ps. howardii* Coquillett (Keener 1951); *Anopheles barberi* Coquillett, *Culex territans* Walker, and *Ps. discolor* (Coquillett) (Rapp 1956); *Ps. horrida* (Dyar and Knab) (Rapp 1958); *Ae. canadensis* (Theobald) and *An. franciscanus* McCracken (Rapp 1959); *Ae. melanimon* Dyar (Nebraska State Health Department Mosquito Light Trap Summary for 1960); *Ae. increpitus* Dyar and *Ps. longipalpus* Randolph and O'Neill (Rapp and Harmston 1961); *Ae. hendersoni* Cockerell (Lunt 1969) and *Orthopodomyia alba* Baker (Lunt and Peters 1976).

Nebraska has considerable variation in climatic, topographic and biological conditions which provide suitable habitats for a fairly rich variety of mosquito species. The altitude ranges from 1780 m near the Wyoming border to 275 m in the extreme southeastern region of the state. Variable weather conditions are the result of movement of warm, moist air from the Gulf of Mexico; hot, dry air from the southwest; cool, dry air from the north Pacific Ocean; and very cold, dry air from the north polar region. The average number of days the temperature is above freezing is over 170 in the southeast and less than 120 in the northwest. Precipitation varies somewhat in amount and distribution, but generally averages less than 38 cm in the west and over 91 cm in the

---

[1] Department of Biology, University of Nebraska at Omaha, Omaha, NE 68182

[2] Nebraska State Health Department, Division of Housing and Environmental Health, P.O. Box 95007, Lincoln, NE 68509.