IMPACT OF NEW INSECT GROWTH REGULATORS AND THEIR FORMULATIONS ON MOSQUITO LARVAL DEVELOPMENT IN IMPOUNDMENT AND FLOODWATER HABITATS[1]

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ABSTRACT. Four insect growth regulators were evaluated in the laboratory and field. In the laboratory, AC-291898 showed excellent activity, inducing 90% mortality in *Culex quinquefasciatus* and *Aedes aegypti* at 0.5–0.7 ppb. The EC formulation of XRD-473 was slightly more active than the technical material with an LC_{90} of 0.84 ppb and 0.92 ppb against *Ae. aegypti* and *Cx. quinquefasciatus*, respectively. In the field, AC-291898 at the rates of 0.005 and 0.01 lb AI/acre caused 85 and 100% inhibition of adult emergence of *Cx. tarsalis* 2 days after treatment. Activity, however, declined at the low rate, while the high rate remained active for more than 7 days. In the same species, XRD-473 induced complete inhibition of adult emergence 2 days after treatment at the rates of 0.01, 0.025 and 0.05 lb AI/acre. At the low rate (0.01 lb AI/acre), activity declined markedly, while the 2 higher rates remained active for one week. In *Cx. peus* larvae, AC-291898 at the rates of 0.005, 0.01 and 0.025 lb AI/acre produced complete inhibition of adult emergence 2 days after treatment, but activity declined at the 2 lower rates 7 days after treatment, while the high rate (0.025 lb AI/acre) remained active for more than one week. Methoprene (4%) pellets were effective against *Cx. tarsalis* for 7 days at the rates of 0.25 lb AI/acre whereas 0.5 lb AI/acre was required to obtain similar results against *Cx. peus* larvae. In irrigated date gardens, complete inhibition of adult emergence of *Psorophora columbiae* in larval and pupal isolates was obtained at the rates of 0.005 and 0.01 lb AI/acre with S-31183 and AC-291898, respectively.

INTRODUCTION

Three insect growth regulators (IGRs), fenoxycarb, S-21149 and S-31183, were reported to exhibit high level of activity against *Culex quinquefasciatus* Say, *Cx. tarsalis* Coquillett, *Aedes aegypti* (Linn.) and *Anopheles quadrimaculatus* Say in the laboratory at exceptionally low rates; their LC_{90} ranging from 0.3 to 2.5 ppb (Mulla et al. 1985, 1986; Estrada and Mulla 1986). In the field, these materials produced excellent control of *Cx. tarsalis*, *Ae. melanimon* Dyar and *Ae. nigromaculis* Ludlow at the rates of 0.005 to 0.05 lb AI/acre, with no apparent ill effects on nontarget organisms (Mulla et al. 1985, 1986). Various formulations of fenoxycarb were reported to be highly effective against *Psorophora columbiae* (Dyar and Knab) in Arkansas ricefields at the rates of 10–20 g/ha (Bassi et al. 1987). This material produced excellent control of organophosphorus resistant and susceptible strains of *Ae. nigromaculis* (Ludlow) in California irrigated pastures at the rate of 20 g/ha (Schaefer et al. 1987).

In general, IGRs have high levels of activity and efficacy against various species of mosquitoes in a variety of habitats. Additionally, they show a good margin of safety to nontarget biota including fish and birds. On the basis of these attributes, IGRs are likely to provide additional tools for mosquito control, supplementing microbial larvicides, pyrethroids and organophosphorus larvicides. The present studies were conducted to evaluate new experimental IGRs and their formulations against mosquito larvae in the laboratory and under field conditions.

MATERIALS AND METHODS

Four IGRs were evaluated under field conditions: they were XRD-473 EC (5%) lot PM 661 (Dow Chem. Co., Midland, MI); AC-291898 EC (10%) (American Cyanamid Co., Princeton, NJ); S-31183 (0.5 G) lot 50441 (Sumitomo Chem., Osaka, Japan) and methoprene 4% pellets lot 8687 (Zoecon Corp., Professional Pest Management Div., Dallas, TX). Methoprene and S-31183 were evaluated in the laboratory earlier (Mulla et al. 1985, 1986), therefore, only the more recent experimental materials (AC-291898 and XRD-473) were evaluated in the laboratory against 2 mosquito species. Chemical descriptions of these IGRs are:

S-31183: [1-(4′-Phenoxyphenyoxy)-2-(2′-pyridyloxy)-propane]; AC-291898: [1-(3,5-dichloro-2,4-difluorophenyl)-3-(2,6-difluorobenzoyl)-urea]; XRD-473: [N-(C, 5-dichloro-4-(1,1,2,2-tetrafluoro-ethoxy)-phenylamino) carbonyl)-2,6-difluorobenzamide]; Methoprene: [Isopropyl (E,E)-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate].

Laboratory and field evaluation methods utilized during these studies were described elsewhere by Mulla et al. (1986). In brief, these studies were conducted as follows:

Laboratory Evaluation: One-percent stock solutions of technical materials and serial dilutions were prepared in acetone, while distilled

[1] These studies were conducted with the cooperation of Coachella Valley Mosquito Abatement District, Thermal, California, and supported by State of California Special Funds for Mosquito Research.

water was utilized in the preparation of 1% stock suspensions and serial dilutions of the emulsifiable concentrate formulations of AC-291898 and XRD-473. The required amount of the proper strength dilution was added to 10-oz disposable foam salad bowls (Dixi Marathon product, Greenwich, CT) containing 20 4th instar larvae in 200 ml of distilled water. Both materials were evaluated against 4th instar larvae from laboratory colonies of *Aedes aegypti* and *Culex quinquefasciatus*. AC-291898 was also evaluated against 2nd instar larvae of *Cx. quinquefasciatus*.

Each formulation was tested 2–3 times at 4 concentrations, utilizing 3 replicates per concentration. Along with each test, 3 bowls were treated with 1 ml of acetone, and 3 bowls were left untreated as checks. Test organisms were placed in a holding room where temperature was maintained constant at 26 ± 1°C. Mortality readings were taken daily until all organisms died or reached the adult stage. Dead larvae, pupae and adults were counted and removed at each reading. Percent mortality values obtained (up to the adult stage) at each concentration tested were subjected to probit analysis with Compucorp 145 E computer to determine the LC_{50}—LC_{90} values in ppb and the LC_{90} (95%) confidence limits for each formulation.

Experimental Ponds: Tests were conducted at the Aquatic and Vector Control Research Facilities of the University of California, Riverside, located in Riverside and in the Coachella Valley of southern California. These facilities were described elsewhere by Mulla et al. (1982). The ponds at Riverside measured 12 × 24 ft (27 m^2), were free of vegetation, harbored high larval populations of *Cx. peus* Speiser and had water pH of 8.2. The ponds in the Coachella Valley measuring 18 × 18 ft. (30 m^2) were fully vegetated with Bermuda and crab grasses (10–15 cm in length) and average water pH was 9.4. In these ponds, the larval populations consisted mostly of *Cx. tarsalis*. Water depth was kept constant (30 cm) with float valves at both locations.

To treat the ponds, the required amount of emulsifiable concentrate for each rate was mixed with 120 ml of tap water and applied with a polyethylene squeeze bottle. Methoprene pellets (4%) were broadcast by hand from the sides of the ponds towards the center, covering the entire water surface area. Each material was tested at 3–5 different rates in triplicates, and 3 ponds were left untreated as checks. Two methods of evaluation were utilized to assess the effect of IGRs on larval populations and to determine their impact on larval development.

1) The Standard Dipper Method: Five dips per pond were taken prior to treatment, 2, 7 days after treatment and every week thereafter until the termination of the test. Percent reduction was calculated according to Mulla's formula (Mulla et al. 1971) in order to take into account the fluctuation of larval numbers in the checks: percent reduction (% R) = 100 (C1/T1 × T2/C2) 100, where C1 = number of larvae in check pretreatment, C2 = number of larvae in check posttreatment, T1 = number of larvae in treated pretreatment and T2 = number of larvae in treated posttreatment.

2) Larval Isolation Method: Forty 4th instar larvae were collected from each treated and check pond and 20 larvae placed in each of 2 floating units per pond at each interval as described by Mulla et al. (1974). Mortality readings were taken every 2–3 days until all isolated organisms had died or reached the adult stage. Dead larvae, pupae and adults were counted and removed at each reading. Pupal skins found in the floating units were considered as surviving adults, while drowned adults on water surface which remained attached to their pupal skins were considered dead adults.

Field Tests: AC-291898 EC (10%) and S-31183 (0.5 G) were evaluated against *Psorophora columbiae* larvae in tail water at O'Rourke date garden located on Avenue 62 and Monroe in the Coachella Valley of southern California. Tests were conducted in duplicate 0.2 acre plots each (808 m^2) in irrigation checks, utilizing one rate of application per check. Two plots were left untreated as control.

The granular formulation S-31183 (0.5 g) was applied with a granule applicator (PCB Spreader Model B, U. S. Borax, Los Angeles, CA). The required amount for each rate of application of AC-291898 EC (10%) was mixed with tap water and applied at the rate of 8 gal of aqueous spray/acre (30 liters/4,047 m^2). The spray was applied with a 1-gal (~4 liters) stainless steel pressurized sprayer equipped with 004-size fan jet nozzle covering the entire plot.

The dipper and larval isolation methods were utilized to assess the effect of the IGRs on the larval population of *Ps. columbiae*. Twenty dips/plot were taken prior to treatment and 2, 4 and 6 days after treatment. Percent reduction calculations were based on the number of larvae and pupae in posttreatment vs. pretreatment counts in each treatment. Twenty-four and 48 hr after treatment, 4th instar larvae and pupae in field water were collected from each plot. Water samples containing the larvae and pupae were placed in buckets lined with 2 plastic bags and transported to the laboratory. In the laboratory, 200 ml of water from each treated and control plot were transferred into 10-oz disposable bowls (in triplicates) and 20 wild larvae and 20 wild pupae from each treatment were placed

separately in each bowl in their respective water. Test organisms were placed in a holding room at the Coachella Valley Mosquito Abatement District where temperature was maintained at 32 ± 1°C. Mortality readings were taken daily as described above and percent inhibition of adult emergence (% EI) was determined. All field data were subjected to statistical analysis using ANOVA and Duncan's Multiple range test $P < 0.05$ via Compucorp 145 E computer.

RESULTS AND DISCUSSION

Both IGRs AC-291898 and XRD-473 exhibited high levels of biological activity against 4th instar larvae of *Cx. quinquefasciatus* and *Ae. aegypti* in the laboratory. The technical grade and emulsifiable concentrate formulations of AC-291898 produced similar results, inducing 90% mortality in both species at a concentration in the range of 0.5–0.7 ppb (Table 1). The emulsifiable concentrate formulation of XRD-473 was a little more active than the technical grade material, causing 90% mortality of both species at concentrations in the range of 0.84–0.94 ppb, while 1.40–1.45 ppb of the technical material was required to render similar results (Table 1). *Aedes aegypti* and *Cx. quinquefasciatus* larvae appeared to be equally susceptible to the technical and emulsifiable concentrate formulations of AC-291898. Both species were less susceptible (ca. 1.5×) to the technical grade of XRD-473.

To ascertain stage related activity, the emulsifiable concentrate formulations were evaluated at the LC_{50} and up to 5-fold the LC_{50} levels in the laboratory. Both materials as shown in Table 2 were somewhat equal in overall activity, but XRD-473 was slightly more active, inducing 86, 100 and 100% mortality at rates of 0.5, 1.0 and 2.5 ppb, respectively. AC-291898 yielded 56, 99 and 100% mortality at the same concentrations. Most of the mortality occurred in the adult stage at the lower concentrations, while the bulk of mortality occurred in the pupal and larval stages at the higher concentrations of 1.0–2.5 ppb, respectively (Table 2). As the concentration was increased, mortality trends increased in the reverse order from adult to pupae and to larvae.

Similar trends of stage related mortality were observed for both materials when used against *Cx. tarsalis* larvae in experimental ponds as assessed by the dipper sampling method (data omitted). Marked reduction in larval population occurred only at the high rates, and no marked reduction was observed at the low rates. At the rates of 0.001, 0.0025 and 0.005 lb AI/acre (1.1, 2.8 and 5.6 g/ha), AC-291898 EC (10%) caused no reduction in larval population; however, 67 and 90% reduction occurred 7 days after treatment at the high rates of 0.01 and 0.025 lb AI/acre (11 and 28 g/ha), and no reduction was obtained 14 days after treatment (data omitted). No larval mortality was observed in ponds treated with XRD-473 EC (5%) at the low rate of 0.005 lb AI/acre (5.6 g/ha), but 72, 88 and 93% reductions in the larval populations were obtained 7 days after treatment at the rates of 0.01, 0.025 and 0.05 lb AI/acre (11, 28 and 56 g/ha), respectively. The population recovered 14 days after treatment at the lower 2 rates, while 84% reduction in larvae occurred at the high rate of 0.05 lb AI/acre (data omitted). *Culex peus* larvae were as susceptible as *Cx. tarsalis* to the IGR AC-291898 EC (10%). *Culex peus* larvae

Table 2. Stage-related mortality and overall inhibition of emergence (EI) of *Culex quinquefasciatus* treated with various concentrations of two IGRs in the laboratory.

Concentration (μg/liter)	Cumulative mortality (%) L	P	A	Percent EI[a]
AC-291898 EC (10%)				
0.5	1	3	52	56 b
1.0	9	59	31	99 c
2.5	92	8	0	100 c
Check	2	1	2	5 a
XRD-473 EC (5%)				
0.5	8	10	68	86 b
1.5	35	58	7	100 c
2.5	83	17	0	100 c
Check	7	2	0	9 a

[a] Values in a column followed by the same letter are not significantly different from each other (Duncan's Multiple Range Test $P < 0.05$).

Table 1. Activity of various IGR formulations against 4th instar mosquito larvae in the laboratory.

IGR	Formulation	LC_{50}-LC_{90} (μg/liter) *Ae. aegypti*	C. L.[a]	*Cx. quinquefasciatus*	C. L.[a]
AC-291898	EC (10%)	0.30–0.60	0.5–0.80	0.40–0.70[b]	0.5–0.9
AC-291898	Technical	0.40–0.70	0.6–0.80	0.30–0.50[c]	0.5–0.7
XRD-473	EC (5%)	0.47–0.84	0.8–0.84	0.45–0.92	0.5–1.0
XRD-473	Technical	0.50–1.40	1.3–1.40	0.60–1.45	1.4–1.6

[a] 95% confidence limits are given for LC_{90} values only.
[b] LC_{50}–LC_{90} (0.3–0.6 μg/l) against 2nd instar larvae.
[c] LC_{50}–LC_{90} (0.2–0.4 μg/l) against 2nd instar larvae.

experienced 43, 62 and 79% reductions in the larval populations at the rates of 0.005, 0.01 and 0.025 lb AI/acre (5.6, 11 and 28 g/ha), respectively, 7 days after treatment. Efficacy declined in the treatments of 0.005 and 0.01 lb AI/acre (5.6 and 11 g/ha) 14 days after treatment, while complete control was still obtained at the high rate of 0.025 lb AI/acre (data omitted).

In those treatments where larval mortality was incomplete, efficacy of the 2 IGRs was assessed by isolation of surviving larvae of *Cx. tarsalis*. This method further enhanced and confirmed the results obtained by the dipper counts. AC-291898 caused 13 and 85% inhibition of adult emergence (EI) from surviving larvae 2 days after treatment at the rates of 0.0025 and 0.005 lb AI/acre (2.8 and 5.6 g/ha), respectively, and 15 and 38% inhibition 7 days after treatment (Table 3). Complete inhibition of adult emergence was obtained at the high rate of 0.01 lb AI/acre (11 g/ha) for more than 7 days. At the rates of 0.005 and 0.01 lb AI/acre (5.6 and 11 g/ha), XRD-473 produced 57 and 100% inhibition of adult emergence 2 days after treatment and 14 and 55% inhibitions 7 days after treatment. Complete inhibition of adult emergence was obtained for more than 7 days at the high rates of 0.025 and 0.05 lb AI/acre (28 and 56 g/ha).

Activity of AC-291898 against *Cx. peus* as assessed by larval isolation appeared to be slightly higher than against *Cx. tarsalis*. Complete inhibition of adult emergence of *Cx. peus* was obtained 2 days after treatment at the rates of 0.005, 0.01 and 0.025 lb AI/acre (5.6, 11 and 28 g/ha). Activity declined 7 days after treatment at the low rates (0.005 and 0.01 lb AI/acre), but the high rate of 0.025 lb AI/acre (28 g/ha) remained active for more than 7 days (Table 3).

According to the data presented, activities of the IGRs AC-291898 and XRD-473 declined rapidly at the low rates of 0.005 to 0.01 lb AI/acre, while the high rates of 0.025 lb AI/acre and above remained active for more than 7 days. In addition, the high rates acted more rapidly by inducing mortality in the larval stages. Both materials appeared equally effective and could be used for the control of *Culex* mosquitoes in fresh water habitats at rates in the range of 0.01–0.05 lb AI/acre (11–28 g/ha). However, higher rates in the range of 0.05–0.1 lb AI/acre (56–112 g/ha) will be needed in polluted water as recently reported by Mulla and Darwazeh (1988).

Larval populations in the check ponds and in ponds treated with methoprene (4%) pellets remained constant. No reduction in the populations were observed in methoprene treatments as assessed by the dipper method (data omitted). However, excellent initial activity was indicated against *Cx. tarsalis* and *Cx. peus* in experimental ponds as assessed by the larval isolation method (Table 4). Methoprene pellets (4%), when applied to ponds in the Coachella Valley, yielded 95% and complete inhibition of adult emergence

Table 3. Efficacy of IGRs against *Culex* larvae in experimental ponds as assessed by the larval isolation technique.

IGR and formulations	Rate lb/acre	(%) Mortality in larval isolate after treatment (days) 2 L	P	A	Percent[a] EI	7 L	P	A	Percent[a] EI
		Cx. tarsalis, Coachella Valley							
AC-291898 EC (10%)	0.0025	5	0	8	13 a	15	0	0	15 a
	0.005	10	53	22	85 b	38	0	0	38 a
	0.010	30	52	18	100 c	No larvae*			100 b
	Check	7	9	0	16 a	10	6	0	16 a
XRD-473 EC (5%)	0.005	11	22	24	57 b	6	4	4	14 a
	0.010	31	60	5	100 c	25	20	10	55 b
	0.025	74	26	0	100 c	No larvae*			100 c
	0.05	100	0	0	100 c	No larvae*			100 c
	Check	10	1	0	11 a	3	4	0	7 a
		Cx. peus, Riverside							
AC-291898 EC (10%)	0.005	73	27	0	100 b	18	28	0	46 b
	0.010	93	7	0	100 b	63	5	0	68 c
	0.025	100	0	0	100 b	No larvae*			100 d
	Check	11	5	0	16 a	15	9	0	24 a

[a] Values in a column followed by the same letter are not significantly different from each other (Duncan's Multiple Range Test $P < 0.05$).

* 4th-instar larvae were absent in treated plots, therefore, 100% control was obtained.

Table 4. Activity of the IGR methoprene (4%) pellets against *Culex* larvae in fresh water ponds as assessed by the larval isolation technique.

Rate lb AI/acre	(%) Mortality in larval isolates after treatment (days)							
	2				7[a]			
	L	P	A	Percent EI[b]	L	P	A	Percent EI[b]
	Cx. tarsalis, Coachella Valley[c]							
Check	10	8	0	18 a	11	5	0	16 a
0.10	16	79	0	95 b	8	80	5	93 b
0.25	10	90	0	100 c	11	89	0	100 c
0.50	3	97	0	100 c	15	85	0	100 c
	Cx. peus, Riverside[d]							
Check	3	8	0	11 a	3	16	0	19 a
0.10	3	35	9	47 b	10	31	4	45 b
0.25	1	60	20	81 c	4	70	4	78 c
0.50	0	96	4	100 d	5	95	0	100 d

[a] Ponds at both locations were allowed to dry for 2–3 weeks and no effect on the larval population was detected one week after reflooding.

[b] Values in a column followed by the same letter are not significantly different from each other (Duncan's Multiple Range Test $P < 0.05$).

[c] Water temperature 23.3°C minimum, 31°C maximum.

[d] Water temperature 22.7°C minimum, 31°C maximum.

in *Cx. tarsalis* 2 and 7 days after treatment at rates of 0.1, 0.25 and 0.5 lb AI/acre, respectively (0.112, 0.28 and 0.56 kg/ha) (Table 4). The same rates produced 47, 81 and 100% inhibition of adult emergence of *Cx. peus* at the Riverside facility 2 days after treatment, and 45, 78 and 100% inhibition was obtained 7 days after treatment (see Table 4). No residual activity was observed for any of the treatments at either location when the ponds were reflooded after drying for 2 to 3 weeks. Almost all larvae isolated during the reflooding period reached the adult stage normally.

The floodwater mosquitoes *Aedes nigromaculis* and *Ae. melanimon* were reported earlier to be highly susceptible to the IGRs-31183 (0.5 G) at the rate of 0.005 lb AI/acre in irrigated pastures in Inyo and Kings Counties, California (Mulla et al. 1986). Since these IGRs were highly effective against floodwater mosquitoes, S-31183 (0.5 G) and AC-291898 EC (10%) were tested here against the floodwater mosquitoes *Psorophora columbiae* at the rates of 0.005 and 0.01 lb AI/acre (5.6 and 11 g/ha). At the higher rate of 0.01 lb AI/acre (11 g/ha) AC-291898 caused 93 and 100% reductions in the populations 2 and 4 days after treatment, respectively, as assessed by the dipping method (Table 5). At the low rate 0.005 lb AI/acre (5.6 g/ha), 76, 90 and 98% reductions occurred 2, 4 and 6 days after treatment, respectively. Mortality occurred in the larval stages at the high rate, while at the low rate mortality was gradual, occurring in the larval and pupal stages. Most mortality of larvae treated with S-31183 (0.5 g) occurred in prepupal or pupal stages. No reduction in the larval population was observed 2 days after treatment at the low rate of 0.005 lb AI/acre, however, 60% reduction occurred 4 days after treatment. A 73% reduction was observed at 2 and 4 days after treatment at the high rate of 0.01 lb AI/acre (11 g/ha) (see Table 5). The test was terminated 6 days after treatment due to high winds.

Using larval and pupal isolation techniques, AC-291898 EC (10%) produced complete inhibition of emergence in the surviving population at the rate of 0.01 lb AI/acre (11 g/ha) (Table 6). At the low rate of 0.005 lb AI/acre (5.6 g/ha), 91 and 48% inhibition of adult emergence occurred in the larval and pupal isolates, respectively. Mortality in larval isolates occurred in the larval, pupal and adult stages while mortality of pupal isolates occurred in the pupal and adult stages. S-31183 (0.5 g) produced complete inhibition of adult emergence in the larval and pupal isolates at both rates of 0.005 and 0.01 lb AI/acre (5.6 and 11 g/ha). The majority of mortality occurred during the pupal stage (Table 6).

In conclusion, the IGRs tested were highly effective against *Cx. tarsalis*, *Cx. peus* and the floodwater mosquito *Ps. columbiae*. S-31183 (0.5 G) showed somewhat higher activity and could be utilized effectively against each species at the rate of 0.005–0.01 lb AI/acre (5.6–11 g/ha). AC-291898 EC (10%) was highly effective against each species at the rate of 0.01 lb AI/acre (11 g/ha). XRD-473 EC (5%) produced excellent control of *Cx. tarsalis* and *Cx. peus* larvae at the same rate, but its activity against floodwater mosquito larvae was not determined.

Methoprene (4%) pellets could produce effective control of *Culex* mosquito species in clear water habitats with rates in the range of 0.25 to 0.5 lb AI/acre (0.28–0.56 kg/ha) depending on water depth and target mosquito species. Additional studies are needed to determine efficacy of XRD-473, and methoprene (4%) pellets against *Ps. columbiae*, *Ae. nigromaculis* and *Ae. melanimon* as prehatch and posthatch treatments in irrigated pastures.

It should be further noted that both AC-291898 and XRD-473 induce high mortality in mosquito larvae at the upper end of effective concentrations or rates. At the low concentrations or rates, larval mortality is low, but most of the mortality occurs in the pupal and adult stages. This phenomenon is corroborated by both laboratory and field experiments. Methoprene, on the other hand, induces mortality primarily in the pupal stage regardless of the dosages employed. Therefore, assessment tech-

Table 5. Activity of IGRs against *Psorophora columbiae* in irrigated date gardens as assessed by the dipping technique.[a] Water temperature 23.3° minimum to 28.8°C maximum.

Pre- and posttreatment (days)	Mean no. larvae and pupae/10 dips at indicated rates (lb/AI acre)								
	0.005			0.01			Check		
	L	P	Percent reduction[a]	L	P	Percent reduction[a]	L	P	Percent reduction[a]
				AC-291898 (10%) EC					
Pretreatment	320	0	— a	105	0	— a	145	0	— a
2	76	0	76 b	7	0	93 c	144	0	1 a
4	30	3	90 b	0	0	100 c	247	15	0 a
6	2	6	98 b	0	0	100 c	0	232	0 a
				S-31183 (0.5 G)					
Pretreatment	65	0	— a	51	0	— a	57	0	— a
2	235	0	0 a	11	3	73 b	51	6	0 a
4	6	20	60 b	7	7	73 b	23	217	0 a

[a] Values horizontally followed by the same letter are not significantly different from each other (Duncan's Multiple Range Test $P < 0.05$).

Table 6. Activity of IGRs as measured by inhibition of emergence (EI) against *Psorophora columbiae* in irrigated date gardens as assessed by larval isolation.

Rate lb AI/acre	Larval isolates				Pupal isolates		
	L	P	A	Percent EI[a]	P	A	Percent EI[a]
				AC-291898 (10%) EC			
0.005	58	23	10	91 b	30	18	48 b
0.010[b]	No larvae			100 c	No pupae		100 c
Check	9	7	0	16 a	7	0	1 a
				S-31183 (0.5 G)			
0.005	0	100	0	100 b	96	4	100 b
0.010	0	100	0	100 b	110	0	100 b
Check	0	0	0	0 a	0	0	0 a

[a] Values in a column followed with same letter are not significantly different from each other (Duncan's Multiple Range Test $P < 0.05$).

[b] Larvae were eliminated in test plots at the rate of 0.01 lb AI/acre, therefore, 100% control was obtained.

niques for efficacy have to rely on isolation of treated larvae.

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