with WD-40 silicon aerosol spray lubricant after each trap-night, and keeping the apparatus as clean and dry as possible between uses.

In addition to being essentially waterproof, this trap has several other advantages over the standard CDC light trap. The failure rate is almost negligible; during an intensive census of sand flies and mosquitoes in central Panama, 4 of these traps were used for 304 trap-nights with no trap failures (1 trap-night=1 trap in 1 night; 4 traps set in one night=4 trap-nights). Because the entrance port is narrow, if the trap does fail during a trap-night, most of the catch is retained. During normal operation the catch remains alive and in excellent condition for both systematic and serologic uses.

When the trap is retrieved from the field the intake port at the bottom is first plugged with a piece of foam rubber or similar material, before turning off the trap motor. In our studies, the insects collected were killed by placing the holding cages in a freezer or an ice chest with dry ice.

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THE EFFECT OF *BACILLUS THURINGIENSIS ISRAELENSIS* (SEROTYPE H-14) ON *AEDES SQUAMIGER* AT THE BOLSA CHICA MARSH, ORANGE COUNTY, CALIFORNIA

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Depressions in Bolsa Chica Marsh where brackish water may be found during the winter rainy season support large populations of *Aedes squamiger* (Coq.). Because of the synchronous development of this species, large numbers of adults emerge over a short period and often create havoc in the adjacent residential areas. The marsh is also a migratory bird refuge and, therefore, insecticide usage is minimized to avoid any detrimental effects on bird populations. Because of the safety of *Bacillus thuringiensis israelensis* (serotype H-14) to wildlife, this study was conducted to evaluate the effect of the bacillus against *Ae. squamiger* in the Bolsa Chica area. The information accrued from this study was to provide a basis for potential use of *B. thuringiensis* in this and other mosquito habitats in Orange County, California.

DESCRIPTION OF THE STUDY SITE. The ponds that provided the habitat for *Ae. squamiger* were located in Rattlesnake Slough in Bolsa Chica Marsh, Orange County, California and are produced by rain-water runoff. The slough is situated within a 265 ha area that is protected as a state Ecological Reserve as part of more than 400 ha of marshland located along the coast 9.7 km (6 miles) southeast of Long Beach, CA. Soil type is a mixture of coastal sand and heavy chino clay. During heavy rainfall the network of roads and dikes impedes runoff that creates temporary ponds where *Ae. squamiger* can develop. Vegetation in the study area predominantly consisted of pickleweed (*Salicornia virginica*), saltmarsh grass (*Distichlis spicata*), cord grass (*Spartina foliosa*), and several other grasses (*Bromus* spp.).

BACTIMOS WP (FIELD STUDY). Twelve sites were selected from eight large ponds where *Ae. squamiger* larvae were observed. The large ponds were subdivided into test plots and each subdivision was delineated by flagged posts and twine. Each of these test ponds was separated by an untreated area that served as a buffer zone.

Linear measurements were made and acreages were calculated for each pond. Water depth was found to range from 15 to 61 cm with an average depth of 30 cm. Application rates of Bactimos WP (50% ai, 3500 AA units) were 2, 3, and 4 oz per acre. Each pond was sprayed with a mixture of water and respective dosage of *B.t.i.* with a hand sprayer. Each treatment rate was tested in three replicates and had been selected on the basis of several preliminary experiments. Three ponds without *B.t.i.* application served as controls.

Ten larval samples were taken with a standard dipper (350 ml) in each pond including the controls before spraying the ponds with *B.t.i.* Third and 4th stage larvae of *Ae. squamiger* were also collected before spraying for later placement in sentinel traps and for laboratory bioassays.

After the ponds were treated with *B.t.i.*, three sentinel traps (1 liter plastic containers with three 1" (2.5 cm) diam screened portals around the container and one on the lid) containing 20 larvae in each trap were placed in each of the 12 study plots. Sampling of ponds with a dipper and observations of sentinel traps were made after 24 and 48 hr of *B.t.i.* treatment.

BACTIMOS LABORATORY BIOASSAYS

Wettable Powder: The pretreatment-collected *Ae. squamiger* larvae were assayed in the laboratory against Bactimos WP formulation at dosages of 0.01, 0.05, 0.1, 0.5, 1.0, 2.0 and 5.0 ppm. Twenty 3rd and 4th stage larvae were placed in each test cup containing 100 ml of water and respective *B.T.I.* concentration. Four replicates for each concentration and control were run simultaneously. Observations were made 24 and 48 hours after application of *B.t.i.*

Flowable Concentrate (FC): Bactimos flowable concentrate (10% with 1000 AA units) was also evaluated in the laboratory against *Ae. squamiger* larvae. The larvae were collected from the same study area and were subjected to similar bioassay procedures as described earlier. In addition to 3rd and 4th stage larvae, 1st and 2nd instars were also assayed.

The effect of *B.t.i.* on larval populations as determined by dip sampling is presented in Table 1. The results indicated that 56, 86 and 76% mortality was caused at application rates of 2, 3 and 4 oz/acre of *B.t.i.* wettable powder, respectively. It was observed that mortality in the early instars of *Ae. squamiger* was significantly higher than that of later instar larvae at both sampling intervals.

Data from sentinel traps are presented in Table 2. The percentages of mortality were 52, 47 and 87 at the 2, 3 and 4 oz/acre rate, respectively, after 48 hr of treatment. Mortality was significantly higher 48 hr posttreatment than after 24 hr at all the application rates.

Bioassay results (Table 3) from *Ae. squamiger* larval exposure to *B.t.i.* revealed that Bactimos WP (50%) caused 89% mortality at 0.5 ppm after 24 hr posttreatment. Concentrations higher than 0.5 ppm produced very little additional larval mortality. There was no significant difference in mortality between 24 hr and 48 hr posttreatment at this rate. However, a substantially higher mortality was observed after 48 hr at the 0.05 and 0.1 ppm rate than that of 24 hr posttreatment.

The bioassay evaluation of Bactimos FC (10%) on early instars of *Ae. squamiger* produced mortality of 81 and 99%, 48 hr after application at 0.05 and 0.1 ppm respectively, whereas, 72 and 100% mortality occurred in 3rd and 4th instars during the same period at 0.1 and 0.5 ppm rate. Higher mortality was induced earlier

Table 1. The effect of Bactimos (WP (50%) on *Aedes squamiger* larvae as determined by dip sampling at Bolsa Chica Marsh, Orange County, California.

Posttreatment (hours)	Average no. of larvae/dip[b] at various rates (oz/acre) 2	3	4	Control
Pretreatment	4.5	5.6	4.5	1.6
24	3.7	2.1	3.2	2.4
	(18)	(63)	(29)	(0)
48	2.0	0.8	1.1	2.3
	(56)	(86)	(76)	(0)

[a] Samples contained all stages of larvae.
[b] Numbers in parentheses represent percent reduction.

Table 2. The effect of Bactimos (WP 50%) on 3rd and 4th stage larvae[a] of *Aedes squamiger* as determined in sentinel traps at Bolsa Chica Marsh, Orange County, California.

Posttreatment (hours)	Percent mortality at three rates (oz/acre) 2	3	4	Control
24	36	27	69	0
48	52	47	87	2

[a] Twenty larvae in each trap. Three traps per application rate.

Table 3. Bioassay results illustrating the effects of two formulations of *Bacillus thuringiensis* var. *israelensis* on various larval instars of *Aedes squamiger*.

Larval stages	Posttreatment (hours)	Mortality (%) of larvae[a] at various concentrations[b] (ppm) of two formulations 0.01	0.05	0.1	0.5	1.0	2.0	5.0	Control
				Wettable powder (50%)					
3rd and 4th	24	4	35	49	89	96	99	99	1
	48	13	71	95	95	98	99	99	3
				Flowable concentrate (10%)					
1st and 2nd	24	8	64	81	98	100	—	—	0
	48	33	81	99	99	—	—	—	5
3rd and 4th	24	5	1	26	99	99	—	—	0
	48	6	16	72	100	100	—	—	0

[a] Twenty larvae in each cup and four replicates per concentration.
[b] PPM expressed in terms of active ingredient (Bactimos 50% WP and 10% FC).

(only after 24 hr) in 1st and 2nd stage larvae than that of later instars. Greater susceptibility to endotoxin of *B.t.i.* in earlier instars has been observed for other mosquito species (Anonymous 1982, Dame et al. 1981, Hembree et al. 1980, Mulla et al. 1980).

From both preliminary data and results discussed here we observed that there was a trend towards higher mortality 48 hr after treatment than that of 24 hr posttreatment. Garcia et al. (1982) found similar phenomena in their studies of *Ae. squamiger* in the San Francisco Bay area. They speculated that larvae were not being killed rapidly because of the cold water temperature which affected the feeding behavior of mosquitoes.

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EVALUATION OF AERIAL APPLICATION OF SCOURGE™ AGAINST ADULT MOSQUITOES IN CALIFORNIA

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SCOURGE™, Penick Corporation's resmethrin synergized at the rate of 1 part with 3 parts piperonyl butoxide, is federally registered for ultra low volume application by portable backpack or truck-mounted equipment and has special local needs (SLN) registration in New Jersey for aerial application. The labelled dosage rate ranges from 0.0035 to 0.007 lb/acre actual resmethrin. The purpose of the evaluations reported here was to obtain data to support: (1) immediate SLN registration in California for aerial application of SCOURGE; and (2) eventual federal registration allowing aerial application.

The protocol was to treat test lines of caged mosquitoes by aerial application beginning at about 0.0035 lb/acre, then double or halve the dosage depending upon results, followed by field plot applications. Using the New Jersey SLN model, 1 part of SCOURGE was mixed with 4 parts of GB 1356, a proprietary petroleum oil mosquito larvicide produced by Witco Chemical Corporation. The combination mixed quickly and well. A sample of the mixture remained stable during 24 days of observation.

The application equipment was modified from that described by Dearman et al. (1965). It consisted of a CO_2 pressurized stainless steel tank feeding liquid into a polyvinylchloride pipe boom, equipped with 4 Spraying Systems nozzles fitted with 800067 flat fan tips directed straight down, taped to an existing aircraft boom. Two aircraft were used, a Grumman AgCat owned by the Butte County Mosquito Abatement District (California), and a Snow AgTractor under contract to the Sacramento County-Yolo County Mosquito Abatement District (California).

Tests were made during August and September, 1983. Each test line consisted of caged (Townzen and Natvig 1973) *Culex pipiens* Linn. atop 3-ft stakes at 33-ft intervals in a single row perpendicular to the flight path. Each test dosage was replicated 2 or 3 times. Field tests were made over plots containing *Aedes nigromaculis* (Ludlow). Wild populations were assessed by counting mosquitoes landing on one or more observers. Simple meteorological data were recorded for each trial. An attempt was made to assess droplet size with oil-sensitive paper (Ciba-Geigy; marketed by Spraying Systems Co.) but apparently few of the droplets were above the threshold of sensitivity of 30 microns, and so the technique was not useful. Untreated plots were not available for comparing most tests, and so the reductions are shown as pretreatment compared with posttreatment numbers.

Table 1 shows the results obtained from applications over test lines. Table 2 summarizes data from 3 field tests. While a dosage of just over 0.0035 lb/acre killed almost all of the caged mosquitoes over the assumed swath, a higher rate (0.006 lb/acre) was needed to adequately control field populations. Our data contrast