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SOLUBILIZED CRYSTAL OF *BACILLUS THURINGIENSIS* SUBSP. *ISRAELENIS*: EFFECT ON ADULT HOUSE FLIES, STABLE FLIES (DIPTERA: MUSCIDAE), AND GREEN LACEWINGS (NEUROPTERA: CHRYSOPIDAE)

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The specificity of the crystalliferous spore-forming entomopathogen *Bacillus thuringiensis* subsp. *israelensis* (H-14) for medically important larval dipterans, and the absence of its effects on non-target organisms, makes it an attractive biological control agent (Colbo and Undeen 1980, Davidson and Sweeney 1983). As with other subspecies of *B. thuringiensis*, most of the research on its pathogenicity to insects, with a few exceptions, has focused on the larval stage. However, it has been demonstrated that adult female *Aedes aegypti* (Linn.) mosquitoes are killed by the solubilized parasporal crystal of *B.t.i.* when the preparation is administered to adults as an enema, (Klowden et al. 1983) and oral ingestion also kills male and female adults of several mosquito species (Klowden and Bulla 1984). In order to determine the susceptibility of other adult insects to the solubilized parasporal crystals of *B.t.i.* we fed the preparation to adult stable flies, *Stomoxys calcitrans* (Linnaeus), adult house flies, *Musca domestica* (Linn.) and adults of the green lacewing, *Chrysoperla carnea* (Stephens).

Solubilized parasporal crystals of *B. thuringiensis* subsp. *israelensis* (H-14) were prepared as described by Klowden and Bulla (1984). Larval stable flies and house flies were reared in Purina larval medium (Ralston Purina Co.) at 27°C. Adult flies were maintained at 27°C and 80% RH with constant access to distilled water, but were denied a reproductive diet. Because the suction probe we used to manipulate mosquitoes (Klowden and Bulla 1984) was not effective with these larger insects, we lightly anesthetized the adult flies and attached them by the thorax to wooden applicator sticks using

molten paraffin wax. When they recovered from the anesthesia, the flies were held under a dissecting microscope and were offered one microliter of several concentrations of the solubilized crystal containing 0.1% sucrose solution as a feeding stimulant. After they ingested the entire drop, the flies were removed from the sticks and incubated with access to 10% sucrose-soaked pads at 27°C for 48 hr. The brief period of restraint during experimental and control feedings and the small amount of paraffin that remained on the flies did not cause demonstrable trauma as evidenced by the negligible mortality in controls.

Larvae of the green lacewing were reared on a diet of pea aphids, (*Acyrtosiphon pisum* (Harris)), corn earworm eggs (*Heliothis zea* (Boddie)) or red flour beetle larvae (*Tribolium confusum* Jacquelin duVal) depending upon availability. After pupation the cocoons were individually placed into test tubes and maintained at 27°C and 80% RH. After emergence, while held by the wings with forceps, adults were offered 1 microliter of *B. thuringiensis* subsp. *israelensis* (H-14) solubilized crystal. After the entire drop was ingested the insects were placed in small cages with cotton pads soaked with 10% sucrose and incubated at 27°C for 48 hr. Controls in all groups were fed identical preparations that were heat inactivated in a boiling water bath for 5 min. Mortality was determined at 48 hr after ingestion of the *B. thuringiensis* subsp. *israelensis* (H-14) preparations.

The results in Table 1 indicate that adult house flies and lacewings were not susceptible to the solubilized parasporal crystals of *B. thuringiensis* subsp. *israelensis* (H-14) at the dosages administered. This contrasts with the re-

Table 1. Effect of solubilized parasporal crystals of *B. thuringiensis* subsp. *israelensis* (H-14) on the survival of house flies, stable flies, and green lacewings at 48 hr. after ingestion.

Species	Dose (μ /insect)	No. tested	% mortality
<i>Musca domestica</i> females	1.3	101	5
	2.6	117	5
	2.6*	82	0
<i>Stomoxys</i> <i>calcitrans</i> females	1.2	83	12
	2.6	94	50
<i>Stomoxys</i> <i>calcitrans</i> males	2.6*	48	10
	1.2	20	5
<i>Chrysoperla</i> <i>carnea</i> males	2.5	155	68
	2.5*	51	3
<i>Chrysoperla</i> <i>carnea</i> females	2.8	11	0
	2.8*	6	0
<i>Chrysoperla</i> <i>carnea</i> females	2.8	12	0
	2.8*	6	0

* Heat-inactivated.

ported non-specific cytotoxicity when these preparations were directly injected into the blood of vertebrates (Thomas and Ellar 1983), and is in agreement with the lack of toxicity to house flies demonstrated by Vankova (1981). However, a significant proportion of stable flies were killed when 2.5–2.6 μg were ingested. Lower dosages of 1.2 μg were not effective.

Although the ingestion of the *B. thuringiensis* subsp. *israelensis* (H-14) toxin by adult insects in the field is now unlikely, the production of entomocidal microbial products by plants or microorganisms that are better able to persist in the environment may someday provide this opportunity. Surveying the susceptibility of various adult insects to the toxin may also provide some information concerning its mode of action. The only adult insects affected thus far are hematophagous, and this may possibly reflect the presence of midgut receptors common to these species.

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THE STATUS OF DEET (*N,N*-DIETHYL-*M*-TOLUAMIDE) AS A REPELLENT FOR *ANOPHELES* *ALBIMANUS*^{1, 2}

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Laboratory tests at the Insects Affecting Man and Animals Research Laboratory (IAMARL) has repeatedly shown that deet (95% *N,N*-diethyl-*m*-toluamide and 5% other diethyl toluamides) has only limited effect in repelling *Anopheles albimanus* Wiedemann (Schreck 1977). Similar observations were made by Arthur Hageman (personal communication) in studies at the S. C. Johnson Biological Research Laboratory, Racine, WI. Using a different test method, Rutledge et al. (1978, 1983) at the

Letterman Army Institute of Research, San Francisco, CA, reported that *An. albimanus* was the least sensitive to deet of up to 7 different species tested.

Anopheles albimanus often occurs in large numbers, is an aggressive feeder and will readily bite humans. Though this mosquito does not pose a problem in the US, it is probably the most important vector of malaria in the Caribbean area and throughout Central America. With a range from the southernmost tips of Florida and of Texas to northern South America, this species continues to threaten the health of people living and traveling in these regions.

This review was prompted by the suggestion that increased military activity in countries with endemic malaria such as El Salvador, Honduras and Nicaragua will mean that large numbers of non-immune people will be exposed to malaria transmission. Published data on personal pro-

¹ This paper reports the results of research only. Mention of a pesticide does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended.

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