EFFECT OF *BACILLUS THURINGIENSIS ISRAELENSIS* (H-14) ON THE ISOPOD *ASELLUS FORBESI* AND SPRING *AEDES* MOSQUITOES IN MICHIGAN

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Spring *Aedes* mosquitoes [including *Aedes stimulans* (Walker), *Aedes fitchii* (Felt and Young), *Aedes excrucians* (Walker), *Aedes intrudens* Dyar, *Aedes sticticus* (Meigen), *Aedes provocans* (Walker) and *canadensis* (Theobald) comprise an important complex of pest mosquitoes in Saginaw County, MI (R. G. Knepper, unpublished data). Typically, larvae of these species hatch in March in pools of water formed by melted snow or by flooding, and adults emerge in May in large numbers that persist into the summer months. The Saginaw County Mosquito Abatement Commission (SCMAC), located in the east-central lower peninsula of Michigan, annually treats about 10,000 ha of spring pools during one week of April to control larvae of these species. For this purpose, the SCMAC uses Vectobac-G®, a 0.2% (by weight) corn-cob granular formulation of *Bacillus thuringiensis* var. *israelensis* (H-14) (B.t.i), applied aerially or by ground crews.

The Shiawassee National Wildlife Refuge is a 7,039 ha federal and state conservation area located immediately to the southwest of the city of Saginaw. In part, the refuge consists of hardwood bottomlands that flood in spring because of several rivers which flow through the refuge. Large numbers of pools in these flooded bottomlands, as well as snow-melt pools in more elevated areas, form considerable habitat for spring *Aedes* larvae. Prevailing southwest winds carry adult spring mosquitoes from the refuge into the city, creating pest mosquito conditions. In 1987, officials of the SCMAC requested permission from the U.S. Fish and Wildlife Service (USFWS) to include about 400 ha of flooded refuge habitat in the spring *Aedes* control program. Biologists of the USFWS expressed concern that *B.t.i.* may affect nontarget aquatic invertebrates that are important spring-time food sources for managed waterfowl on the refuge. Because flooded bottomlands are an important component of wood duck [*Aix sponsa* (Linn.)] habitat (Sousa and Farmer 1983), the USFWS stipulated that a study should be conducted to determine whether *B.t.i.* would affect the isopods in spring pools. Isopods comprise an important protein source for nesting female wood ducks (Drobney and Fredrickson 1979, Drobney 1980). This note reports results of the study we conducted to examine this question.

Fifteen pools in the refuge were chosen for study in April 1987, with 5 pools in each of 3 wooded areas. Pools in 2 woods were designated for treatment, while the pools in the third woods were left untreated as controls. At the time of the study, water temperatures ranged from 6 to 19°C, pool depth ranged from 4 to 18 cm and pool surface area ranged from 460 to 930 m^2. For sampling purposes, each pool was divided into 4 parallel transects spanning the entire pool, with 3 sampling stations per transect, so that samples would be collected near the edges and in the middle of each pool. At each station, 4 dips (350-ml mosquito dipper) were taken for a total of 48 dips per pool per day. Also at each station, a scoop of leaf detritus was collected from the bottom of the pool using a 30-cm diam "D-ring" benthic aquatic net (2-mm^2 mesh openings), for a total of 12 benthic samples per pool per day. Mosquito larvae and isopods were sorted and counted in the field. At the time of the study, larvae were third and fourth instars, and species present were *Ae. canadensis*, *Ae. stimulans* and *Ae. fitchii*. Isopods were identified from males as *Asellus forbesi* Williams using the key of Williams (1976).

Pools were sampled for pretreatment data on 3 consecutive days (days 1–3 of the experiment), then *B.t.i.* was applied (5.6 kg/ha) on day 7 of the experiment; and posttreatment sampling was accomplished on days 10, 14 and 21. Sampling data were summed by day for each pool. Data were transformed with $\log_{10}$ to reduce heterogeneity of variances, and subjected to repeated measures analysis of variance (ANOVA), because each pool was repeatedly sampled over time; and consequently within-pool samples were not independent (Steel and Torrie 1980). This analysis allowed a comparison of treated and nontreated pools as well as a simultaneous comparison among days pre- and posttreatment.

Numbers of isopods and mosquitoes in pre- and posttreatment samples taken from control and treated pools are shown in Fig. 1. In the treated pools, the number of mosquito larvae ranged from 1 to 162 per pool pretreatment, and from 0 to 15 larvae per pool posttreatment. In untreated pools, the number of larvae ranged

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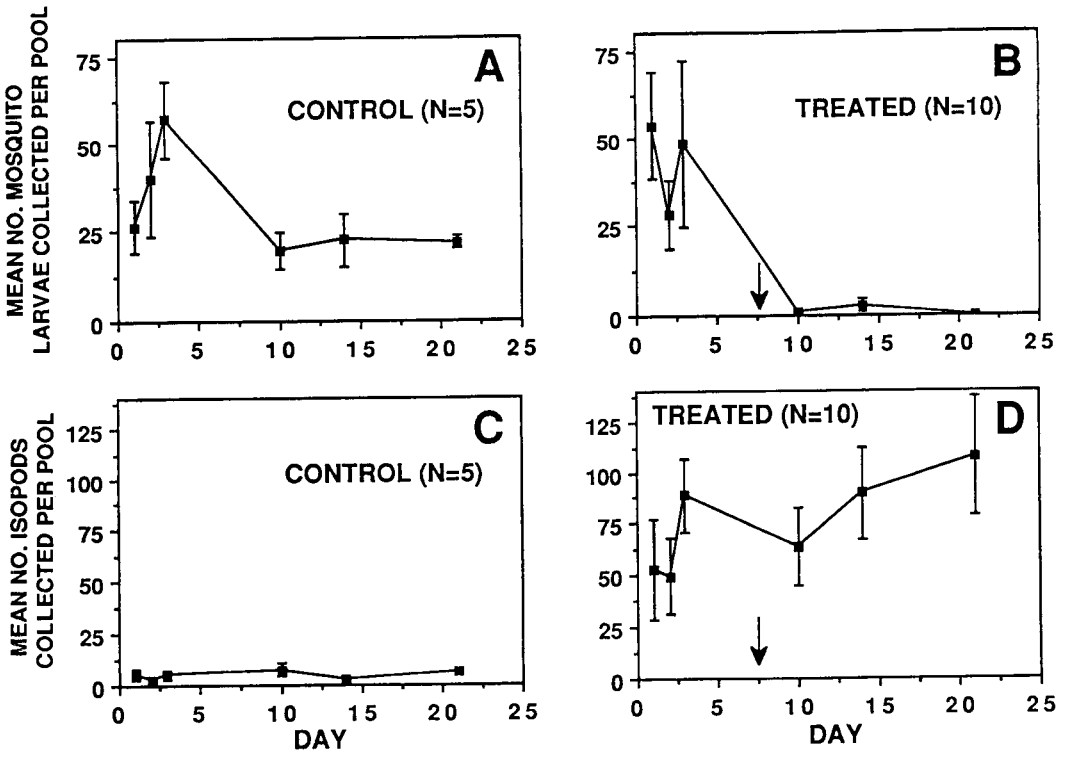

Fig. 1. Mean number (± SE) of mosquito larvae (*Aedes stimulans*, *Ae. canadensis* and *Ae. fitchii*) (48 dips per pool per sampling day) and isopods (*Asellus forbesi*) (12 leaf scoops per pool per sampling day) in spring pools treated (B, D) (n = 10) or not treated (A, C) (n = 5) with Vectobac-G. Arrows indicate day of treatment in treated pools.

from 7 to 101 in the 3 days of pretreatment sampling, and from 4 to 47 in the posttreatment samples. Although the number of larvae decreased in both control and treated pools (Fig. 1, A and B), the decrease in treated pools was much more drastic and dropped from a mean of about 50 larvae before treatment to a mean of near 0 after treatment. The decrease in numbers of larvae in control pools may represent natural mortality in the mosquito populations. The ANOVA showed that there was a highly significant difference between treatments (F = 4.96; df = 1, 13; $P < 0.001$) and among sampling days (F = 18.56; df = 5, 63; $P < 0.001$) in numbers of larvae collected in the pools.

Numbers of isopods were very low in the 5 control pools on all 6 sampling days (Fig. 1C) and were comparatively much higher in the 10 treated pools both before and after treatment (Fig. 1D). Indeed, the ANOVA showed a highly significant difference (F = 4.96, df = 1, 13; $P <$ 0.001) in number of isopods between treatment and control pools. Numbers of isopods actually appeared to increase after treatment in the 10 treated pools (Fig. 1D); however, the ANOVA showed no significant variation among sampling days in this parameter (F = 1.74; df = 5, 63; $P > 0.05$), probably because of large variation in numbers of isopods in samples.

We conclude from our data that isopods in treated pools were not negatively affected by the *B.t.i.* application. These results are similar to other studies indicating that, in general, crustaceans are not adversely affected by *B.t.i.* (e.g., Miura et al. 1980). Consequently, expansion of the spring *Aedes* control program conducted by the SCMAC to the Shiawassee National Wildlife Refuge should be compatible with waterfowl management in the refuge, because isopods would not be reduced in numbers.

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