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Malathion Leakage from Fruit Fly Male-Annihilation Traps on Kauai, Hawaii

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The male-annihilation technique for tephritid fruit flies utilizes a chemical attractant (or "parapheromone") mixed with a toxicant to reduce male populations and thereby control the population by preventing mating (Cunningham 1989). In a large scale pilot test covering 900 ha on the island of Kauai, Hawaii, the U.S. Department of Agriculture- Agricultural Research Service (USDA-ARS) is deploying thousands of traps containing a mixture of methyl eugenol or cue-lure and malathion to control the Oriental fruit fly, *Bactrocera dorsalis* (Hendel) and the melon fly, *B. cucurbitae* (Coquillett), respectively. If this test is successful, the technology may be used on a much larger scale by other agencies to cover greater areas of Kauai and other Hawaiian islands as part of a statewide eradication program.

Malathion causes detrimental side effects on non-target arthropods in many situations (see references in Asquith & Messing 1990), and because of the unique status and vulnerable condition of the Hawaiian fauna (Howarth 1990), monitoring of the male-annihilation traps was initiated. The present study reports the results of rainwater leachate, soil, and ground-dwelling arthropod samples taken from beneath fruit fly male-annihilation traps in the field.

MATERIALS AND METHODS

Each of the 3,000 traps deployed by USDA-ARS in the Kauai male-annihilation project consists of an inverted 5.2 L white plastic bucket with a 3.8 cm x 1.9 cm cotton wick suspended from a wire punched through the upper surface. The hole in the upper surface through which the wire passes is caulked with silicone sealant (Dow Corning Corp., Midlands, MI). Wicks are loaded with 8 mL of an 80% methyl eugenol/ 20% technical grade malathion mixture, and replaced monthly. Traps are hung from trees and shrubs at a height of about one meter above the ground.

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The concave upper surface of the inverted buckets has a volume of ca. 160 mL. It was observed that rainwater tended to collect in this concavity, where it leaked through the central hole onto the cotton wick, and then down to the ground. We tested to see if this leachate contained significant amounts of malathion. To collect water samples, 7.5 L plastic basins were set on the ground beneath USDA-ARS traps and the leachate was collected over a 24-72 hr period (depending on amount of rainfall). Identical traps were set up with no toxicant and leachate was collected beneath these to use as a control. For the first trial, conducted September 12, 1991, we borrowed standard USDA-ARS traps and set them up on the grounds of the Kauai Research Station in Kapa'a, Kauai, suspended from a wooden beam at a uniform height of 1.5 m and perfectly level. There were four treatment traps (with toxicant) and four controls. Because no rain fell for several days, we poured 160 mL of tap water directly over each trap to provide the leachate. In two subsequent trials, conducted December 7, 1991 (six treatments and three controls) and January 15,1992 (five treatments and two controls), we collected natural rainwater leachate from beneath traps already deployed by USDA-ARS in the field as part of their male-annihilation program at the Moloa'a agricultural area on the north shore of Kauai (see Vargas et al. 1990 for complete site description).

To collect soil samples, a cylindrical plug measuring 8 cm diam x 6 cm deep (≈ 0.5 L of soil) was taken directly beneath male-annihilation traps. Samples were taken 48 hr after fresh wicks were loaded. Identical samples of the same soil type were taken at the same time 5-7 m away from the traps to use as a control. (Pre- and post-treatment soil samples from any given trap could not be taken, because sampling destroys the soil structure at the focal point of impact directly beneath the trap). An initial trial (four treatments and four controls) was conducted on September 12, 1991 using borrowed traps set up at the Kauai Research Station; a second trial (six treatments and three controls) on January 15, 1992 examined soil from beneath field traps deployed by USDA-ARS as part of their program at Moloa'a.

Malathion extractions from water samples were performed using minor modifications of standard EPA methods (EPA 1980). Samples were placed in separatory funnels with 3 g NaCl, then extracted three times with a total of 25-200 mL methylene chloride and collected in a flask with (or percolated through a bed of) anhydrous sodium sulfate to remove traces of water. In some cases samples were centrifuged to obtain separation of organic and aqueous layers. Samples were rotary evaporated to dryness, transferred with acetone to a 10 mL volumetric flask, and analyzed by gas chromatography with flame photometric detection. Three 50 mL volumes of water spiked with malathion standard at 10 ppm were extracted to determine extraction efficiency; recovery was approximately 90%.

Soil samples were analyzed using the methods of Miles et al. (1990). Soil was passed through a 9 mesh sieve, and moisture content determined by oven drying 10 g of each sample at 110° C. for 24 hr. Moisture content ranged from 22-43%. For each extraction, 50 g of soil was placed in a 1000 ml flask, enough distilled water was added to adjust moisture content to 50%, and 250 mL of 4:1 ethyl acetate/methanol was added and allowed to reflux for 1 hr. The extract was then filtered, rotary evaporated to dryness, transferred with acetone to a 10 mL volumetric, and analyzed by gas chromatography with flame photometric detection. Two 50 g soil samples spiked with 26 ppm malathion standard were extracted to test efficiency; recoveries were over 99%.

To examine effects of leachate on non-target arthropods, six 0.5 L soil samples were taken from beneath USDA-ARS traps deployed at Moloa'a 48 hr after new wicks were loaded, and held in a Berlese funnel with a 25 watt incandescent bulb for 24 hr. Six samples from the same soil type taken at the same time 5-7 m away from the traps were also held in Berlese funnels as a control. Emergent arthropods were sorted and identified to the lowest possible taxonomic level.

RESULTS AND DISCUSSION

Substantial amounts of malathion were recovered in leachate samples collected beneath male-annihilation traps. In the first trial, a recovered sample volume of 35.6 ± 11.0 mL yielded a mean of 3,166 ± 1620 ppm malathion (n=4). Samples from control traps without toxicant yielded a mean of 0.04 ± 0.01 ppm malathion from a volume of 44.1 ± 10.0 mL (n=4), probably as a result of manual contamination during handling.

In the second and third trials, when naturally occuring rainfall was collected beneath traps at Moloa'a, significant amounts of malathion were again recovered. In trial 2, traps with toxicant wicks yielded a volume of 26.3 ± 18.2 mL water containing 169.8 ± 266.1 ppm malathion (n=6), while control samples (20.5 ± 25.5 ml) contained no detectable levels (n=3). In trial 3, traps with toxicant wicks yielded a volume of 54.0 ± 19.8 mL containing 2,454 ± 5,172 ppm malathion (n=5), while control samples (54.5 ± 2.1 mL) contained 0.06 ± 0.04 ppm (n=2) .

Soil samples taken beneath male-annihilation traps yielded lower but still significant levels of toxicant. In the first trial, soil beneath traps with wicks contained 664.1 ± 487.9 ppm malathion (n=4), compared to 0.001 ± 0.001 ppm for controls (n=4). In the second trial, only 1.3 ± 3.0 ppm were found in treatment samples, and no detectable levels in controls.

In soil samples held for 24 hr. in Berlese funnels, 10 taxa accounted for over 95% of the soil fauna recovered: *Pheidole* ants, mites, psychodid flies, collembola, isopods, cydnid bugs, amphipods, millepedes, *Monorum* ants, and centipedes. In only one taxon (amphipods) was the number of individuals from soil beneath malathion traps significantly lower than control soil samples (t = 4.86, df = 8, P < 0.01). Three additional taxa (*Pheidole* , mites, and collembola) had substantially lower numbers of individuals in soil from beneath malathion traps (see Figure 1), but because of extreme variability in population densities among sites these differences were not statistically significant.

The Experimental Use Permit and the Environmental Assessment upon which it was based for the USDA-ARS male-annihilation project on Kauai stated that the toxicant would be deployed in "closed plastic containers" and therefore would not contaminate the environment (Anonymous, 1989). However, the present study clearly shows that the male-annihilation traps are not a closed system, and that significant amounts of malathion are leaking out of the traps. Although the amount of malathion leaking from any one trap was highly variable (reflecting in large part the age of traps and size of the hole on the upper surface, but also factors such as precipitation levels and wind velocity), individual samples yielded amounts as high as 11,700 ppm malathion (in rainwater leachate) and 1,076 ppm (in soil). Berlese funnel samples, although inconclusive, at least suggest that these levels of insecticide may have localized detrimental effects on Hawaiian soil fauna. It should also be noted that some USDA-ARS traps hang directly over intermittent and perennial streams flowing through the Moloa'a area, and these streams are known to harbor a large percentage of the small remaining endemic arthropod fauna found in lowland habitats of Kauai (Asquith and Messing 1993).

The levels of malathion found in our samples were not meant to provide an estimate of the average or expected leakage from the 3,000 USDA-ARS traps currently deployed at Moloa'a. The traps used in our study were not chosen at random. Rather, to provide a worst case scenario we used traps that were low to the ground, level, and somewhat protected from the wind. Undoubtedly, many of the deployed traps are hanging at enough of an angle, or are shaken enough by wind so that rainwater does not accumulate on the upper concave surface and leaching is not severe. In addition, rain would normally dilute the leachate as it reaches the soil surface and would not likely be found in as high a concentration as it was in our collecting pans. However, it must be recognized that even a small percentage of 3,000 traps would still provide numerous point sources for malathion contamination in the Moloa'a area. There would be even more cause for concern if the method were used on a wider scale as part of a statewide fruit fly eradication program. Also, although the quantification of methyl eugenol levels was not attempted for all samples in this study,

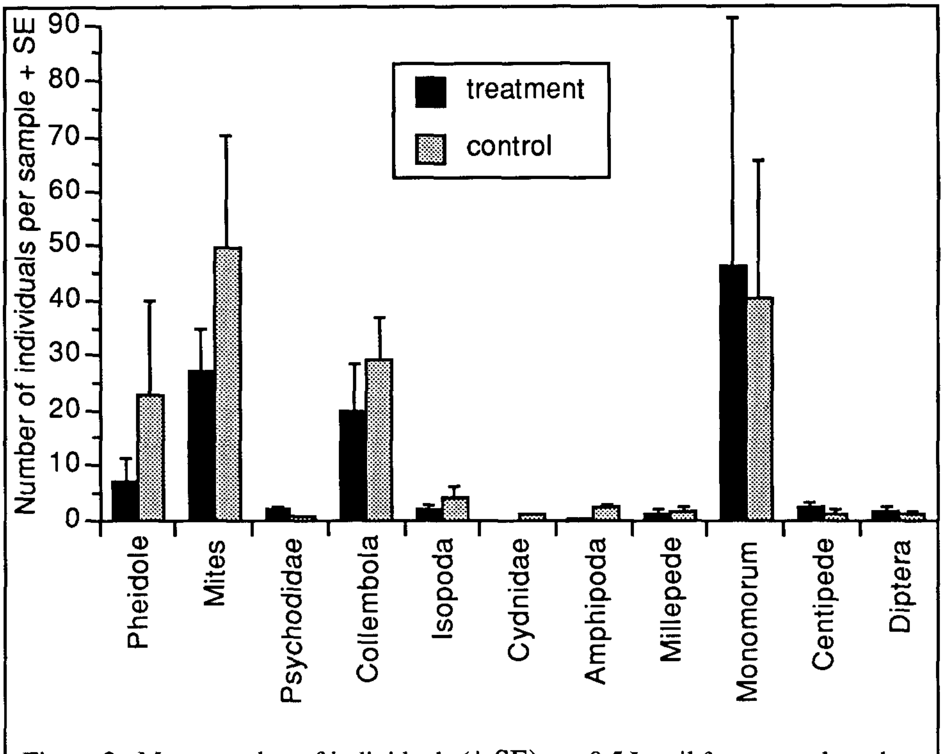

Figure 2. Mean number of individuals (± SE) per 0.5 L soil from samples taken beneath male-annihilation traps (treatment) and samples from 5-7 m away (control).

at least one rainwater leachate sample was analyzed and yielded methyl eugenol in significant concentrations. As a potential carcinogen (Miller et al. 1983), this chemical should be monitored closely in all future fruit fly control programs.

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