persal of the parasitoid corroborates, in part, the findings of Anderson and Kaya (1973) that the greatest incidence of parasitism occurs in the upper strata of the forest.

The question of whether the artificially placed egg masses were parasitized by the released parasitoids or by parasitoids from natural elm spanworm infestations to W and S of the release point cannot be overlooked. We believe the latter did not occur for two reasons: (1) at Quaddick, parasitization occurred only within 20 ft in a lateral direction from the release point. Egg masses placed 40–160 ft laterally from the release point were unparasitized. (2) Bigelow Hollow was closer to the natural elm spanworm infestations, and the rate of parasitism there should have been higher than in Quaddick if naturally dispersing adults had been responsible for parasitization.

Our data show that *O. clisiocampae* was introduced successfully into forest areas. This parasitoid overwinters in Connecticut and is easy to rear in the laboratory (unpublished data), the limiting factor being the availability of host eggs. It inhabits primarily the upper strata of the forest where most host eggs are deposited, and it is capable of parasitizing almost all host eggs. We believe therefore that this parasitoid can be manipulated for management of populations of the elm spanworm.

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Bait Units for Collection of House Flies[1,2]

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Lurtox™[4] is a proteinaceous attractant for *Musca domestica* L. and other synanthropic Diptera (Mulla et al. 1973; Willson and Mulla 1973a) and is easily mixed with commercial poison sugar baits. The mixture of Lurtox and dichlorvos sugar bait (50:50 by wt) can be administered in measurable quantities into compact bait units where dead flies can be easily recovered for counting and for other studies. While developing Lurtox for control of *Hippelates* eye gnats,[5] Mulla et al. (1973) found that moisture was essential for the emanation of the volatile attractants contained in the bait. Therefore, if the prevalent humidity level is not sufficient to activate the attractant, the bait unit designed for use with the bait mixture should include a moisture source.

A variety of bait unit designs have been used in our studies on fly behavior to baits (Willson and Mulla 1973a, b). Two designs that have proved very effective are described here. In addition, need for a moisture source and effect of unit size are investigated in regard to the use of the bait mixture in suspended bait units for collection of house flies.

The 2 suspended bait units used most were a small 275-ml cup unit (Fig. 1) and a larger 1.5-liter can unit (Fig. 2). The former unit was used primarily for comparing bait formulations in matched-pair field tests, and the larger can unit was used for sampling fly populations on a periodic survey schedule. Within the 275-ml cup unit is a 160-ml (5-oz) disposable cup, containing a plaster base for a bait substrate. This plaster substrate absorbs water from a source in the base of the larger cup and provides the necessary moisture to activate the attractant, Lurtox. The plaster is exposed to the water by removing the plastic bottom of the smaller cup after the plaster has set. The larger 1.5-liter unit (46-oz juice can) holds a 500-ml plastic container (16-oz cup used for packaging liver) partly filled with moist vermiculite, which serves as the bait substrate. An 11-cm disk of filter paper was placed over the moist vermiculite to prevent mixing the dead flies and vermiculite; thereby facilitating fly removal.

Two variables in the bait unit design that affected fly collection were availability of moisture and size of the units. To determine the importance of the moisture, wet and dry vermiculite substrates were compared in two 24-hr matched pair tests of 6 replicates each, using the 1.5-liter can unit. The bait mixture dosage (50:50 by wt of attractant and 1% dichlorvos sugar bait) was kept constant in all units at 4 g/unit. Units were hung from the end of the suspended cage rows on the poultry ranch. To determine the effect of unit size, 2 similar tests were conducted in which the 1.5-liter can unit was compared with a smaller 450-ml can unit (9-oz can commonly used for dog food). The 450-ml can unit was selected for this experiment in place of the 275-ml cup unit to standardize the cylindrical design. Moist vermiculite was

[1] Diptera: Muscidae.
[2] This investigation was supported (in part) by NIH Training Grant no. ES00084 from the National Institute of Environmental Health Sciences. Manuscript from a thesis submitted by the 1st author in partial fulfillment for the Ph.D. degree, University of California. Received for publication Oct. 12, 1972.
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[4] Registered trade name applied for by McGlaughlin, Gormley & King Co., Minneapolis, Minn.
[5] Diptera: Chloropidae.

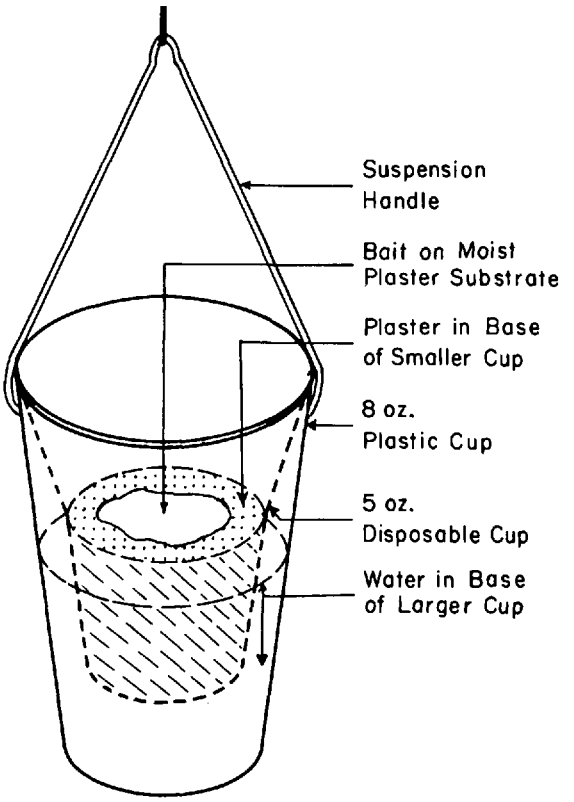

FIG. 1.—The 275-ml (8-oz) cup unit used for bait comparison experiments.

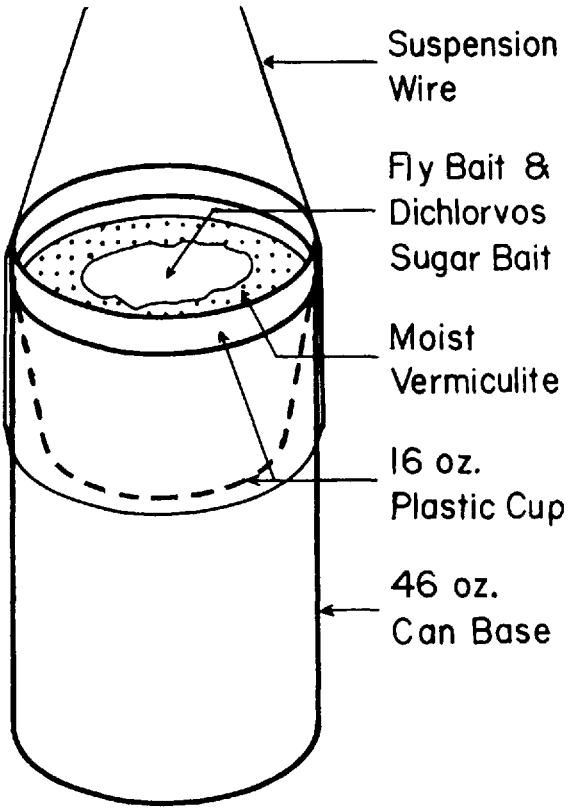

FIG. 2.—The 1.5-liter (46-oz) can unit used for monitoring fly activity.

used as a substrate in both the large and small units. Significance between the mean counts of house flies/treatment was determined by use of the Student's t-test for paired variates.

The number of house flies collected in the units with the moist vermiculite substrate was 2-fold more than that collected in units with dry substrate (Table 1). In experiments comparing dichlorvos sugar bait with and without the attractant, the increase in fly collection was generally about 3-fold (Willson and Mulla 1973a). Thus, the absence of a moist substrate in an area such as inland southern California significantly limits the attractant from achieving its full potential, and bait units designed for use of the bait mixture of Lurtox and sugar-toxicant baits should include a source of moisture.

In the experiments comparing bait units of different size, the larger 1.5-liter can units collected nearly 4 times as many flies as the smaller units (see Table 1). This positive relationship of bait unit size and the number of flies collected may be related to the house fly's response to the surface area of an object. For example, Perez de Talens and Ferretti (1970) showed that the house fly exhibits a landing reaction when an expanding optical pattern is placed before it, and that the reaction is dependent on the dimension and spatial position of the pattern. In similar tests neither a 2-fold increase in the dosage of dichlorvos sugar bait nor a 2-fold increase in the attractant has demonstrated an effect on fly collection as great as that observed in the experiments comparing bait unit size variation (Willson, unpublished data). Thus, the physical size of the bait unit is an important factor to be considered in relation to other baiting parameters.

Recognition of the importance of bait unit size on fly collection allows an investigator to regulate the size of fly samples collected. If one is working with low-density fly population, the larger unit can facilitate collection of larger samples, or the smaller unit can be used to decrease sample size in a situation of high fly density. Thus, any particular size of unit may be adapted to suit an experiment where an optimum sample size is desired.

Table 1.—Influence of substrate moisture and bait unit size on the collection of house flies in suspended bait units.

Variable and test	Mean no. of house flies/unit	
Moisture	*Wet*	*Dry*
1	64.7	20.0
2	262.3	123.5*
Size	*1.5 liter unit*	*450 ml unit*
1	144.5	39.2*
2	205.8	51.0*

[a] Significant levels indicated by: + = $P<0.10$; * = $P<0.05$.

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Mortality of Red Flour Beetle Adults[1] Fed Insecticide-Treated Indian Meal Moths[2,3]

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The red flour beetle, *Tribolium castaneum* (Herbst), and the Indian meal moth, *Plodia interpunctella* (Hübner), are important pests of stored products (USDA 1965). Recent studies at the Savannah, Ga., Stored-Product Insects Research and Development Laboratory showed that the red flour beetle feeds on dead or moribund adults of the Indian meal moth (G. L. LeCato and B. R. Flaherty, unpublished). They have shown also that such feeding increased progeny production and rate of development and thus led to larger populations of the red flour beetle.

We initiated the present study to determine whether such feeding might reduce populations of the red flour beetle if the ingested Indian meal moth adults had been treated with insecticides. If certain insecticides should serve as secondary toxicants for the red flour beetle, it might imply that these insecticides could accumulate in an insect food chain contrary to research reported by van Halteren (1971).

Materials and Methods

Indian meal moth adults (0.25–6 h old) were collected from stock cultures reared in 3.78-liter jars on a diet described by Boles and Marzke (1966). The moths were anesthetized by the flow of CO_2 through a Büchner funnel for periods not exceeding 5 min (Young and McDonald 1970). Individual moths were held with a Telvac® vacuum needle, while 0.5 μl of an acetone solution of either pyrethrins, malathion, dichlorvos, methoxychlor, chlordane, dieldrin, or heptachlor (20 mg/ml) was applied with an automatic microapplicator to the thorax of each moth. Although some of these insecticides are not approved for control of stored-product insects, we used representative insecticides of three classes of compounds to establish their effect as secondary toxicants for the red flour beetle. A concn of 20 mg/ml of each insecticide applied to Indian meal moths was used, because preliminary tests showed that lower dosages of these insecticides, such as might be recommended for field use, failed to kill red flour beetles that fed on these moths. Control moths were treated with 0.5 μl of acetone, allowed to revive, and then killed by freezing. A control was used for each insecticide treatment.

Twenty-four h after insecticide application, groups of 20 moths each were placed in 0.24-liter jars containing either 10 g flour beetle medium (47.5% cornmeal + 47.5% wheat flour + 5% brewer's yeast), 10 g coarse cracked corn, or no food. Ten 14- to 21-day-old red flour beetle adults were added to each jar. Each jar was capped with 40-mesh screening secured with a screw-type ring. All insects were held at 27±0.5°C, 65±5% RH, and 12-h light-dark cycles. Counts of dead red flour beetle adults were taken after 3 days and at the end of each week for 2 consecutive weeks. The treatment combinations were replicated 5 times for each insecticide.

Results and Discussion

Highest mortality after 14 days occurred in red flour beetles that ate Indian meal moths treated with heptachlor, dieldrin, malathion, and chlordane (Table 1). Dichlorvos, pyrethrins, and methoxychlor caused significant mortality only when red flour beetles had no food except insecticide-treated Indian meal moths. There was no significant difference in the mortality of red flour beetles exposed to insecticide-treated Indian meal moths placed on either cracked corn (substandard diet for the red flour beetle) (Inouye and Lerner 1965) or on flour beetle medium (standard diet for the red flour beetle) (Harein and Soderstrom 1966). Nevertheless, the beetles were observed to feed more voraciously on the moths placed on cracked corn. It is possible that some beetles were killed by contact with the moths. Such contact, however, was related in part to the feeding activity of the red flour beetles.

The following factors indicate that feeding, not vapor action, was the more important factor in causing red flour beetle mortality: (1) the treated moths were held 24 h before they were introduced as food for the beetles, (2) the beetles and treated moths were held in ventilated containers, and (3) moths treated with dichlorvos, a very volatile insecticide, did not kill the beetles placed on cracked corn or on flour beetle medium but dichlorvos did kill the beetles that had no food except Indian meal moths.

Because of ther residual toxicity, chlorinated hydrocarbons were the most effective as secondary toxicants for the red flour beetle. Possible benefits of these compounds as secondary toxicants for the red flour beetle in no way justify their use on stored products, since the compounds are very residual, and our findings imply that they might become incorporated in an insect-food chain. Most chlorinated hydrocarbons are not used for control of stored-product insects. Dichlorvos and pyrethrins, insecticides that are commonly used for control of stored-product insects, were ineffectual as sec-

[1] Coleoptera: Tenebrionidae.
[2] Lepidoptera: Phycitidae.
[3] Mention of a proprietary product does not imply endorsement by the USDA. Received for publication Dec. 13, 1972.
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