Effects of Plastic Bags as Refuse Containers on Fly Populations

J. K. Ikeda, W. H. Watanabe, G. Toyama and L. Shimoda
HAWAII STATE DEPARTMENT OF HEALTH

A major source of domestic fly breeding in Hawaii, as in most urban communities, has been in garbage improperly kept in containers (Schoof, et al., 1954; Siverly and Schoof, 1955a, 1955b; Wilton, 1961; Ecke, et al., 1965; Ecke and Linsdale, 1967; and Brown, et al., 1970). In these studies although the extent of fly production from garbage cans was found to vary, they all found that the flies infesting the study areas were produced primarily in the contents of the garbage containers. As an example of the importance of garbage as a breeding medium for domestic flies, Siverly and Schoof (1955a, b) have found as many as 70,000 flies produced in one cubic foot of this material. More recently Peters (1968) stated that one pint (a pound) of moist solid wastes of either plant or animal origin is capable of producing upwards of 4,000 flies.

In most of the cases the flies were observed ovipositing on wet food scraps (organic materials in the refuse container). The larvae matured and migrated through holes or over the top of the cans to pupate under more favorable conditions in the dry soil near or under the can.

Numerous authors (Schoof, et al., 1954; Magy and Black, 1962; Ecke, et al., 1965; Ecke and Linsdale, 1967; Walsh, et al., 1968; and Campbell and Black, 1960) have reported on the migration of the maggots, especially *Phaenicia cuprina* (Wied.), from infested garbage containers. Previous fly population surveys in Hawaii (Wilton, 1961) revealed that the dominant fly produced in garbage cans was the copper-green blow fly, *Phaenicia cuprina* (Wied.), which is similar to the findings of other authors previously cited.

This study was conducted to evaluate the effects of using exposed plastic garbage bags collected once-a-week on fly densities and breeding during a 5-week pilot project conducted by the City and County of Honolulu in the rural areas of Nanakuli to Makaha.

In normal practice, all residential areas on the island of Oahu have their refuse collected twice-a-week by the Refuse Division, City and County of Honolulu. Householders place their garbage cans at the curb collection site on the set day of collection and retrieve the containers after collection. For this pilot test, the areas between Nanakuli and Makaha on the Leeward coastal plains on Oahu were selected by the Refuse Division of the City and County of Honolulu to serve as the experimental area for the once-

FIG. 1. *Typical garbage bag collection area along Farrington Highway, Waianae, Oahu, during the survey period in* 1971.

a-week collections using plastic garbage bags. (Fig. 1). The test project was conducted for 5 weeks (from 1 February to 2 April 1971) and the Vector Control Branch, Hawaii State Department of Health was asked to assess the changes that might occur in the fly population densities and to determine if the changes would be beneficial or adverse in terms of fly production.

Materials and Methods

Liquid bait fly traps (Fig. 2) were used to collect the adult flies that emerged from the garbage containers. The bait was a mixture of one pound granular sugar, one-half ounce of active dry Brewers Yeast, six ounces of deactivated dry Brewers Yeast, one-half pound of Alco Fly Fighter[1] (0.93% DDVP) and one gallon of water. The bait was placed in a one-pint mason jar with the cover perforated in the center through which a cloth wick was inserted. The filled jars were then placed on a white circular 15" paper plate and placed on the ground near the garbage container. The area around the trap was treated with 10% Sevin dust to prevent the dead flies from being carried away by foraging

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FIG. 2. *The liquid fly bait trap placed on a paper plate at one of the sampling stations.*

ants.

A total of 70 sampling sites was randomly selected by initially providing 35 random 2000′ × 2000′ grid units in the entire area between Nanakuli to Makaha. Each of the grid units selected required geographical units containing residential dwellings or commercial establishments interspersed with areas overgrown with weeds and brush. Within each of the 35 grid units, two sampling stations were set up and these totaled 54 stations

affected by once-a-week collection of plastic bags and 16 stations with normal twice-a-week garbage can collection. The 54 stations were considered as the affected group and the 16 stations as the control group.

The fly species selected as the indicator species of garbage container breeding were *Phaenicia cuprina* and *P. sericata* (Meigen). They were grouped together as *Phaenicia* spp.

The dead flies within the paper plates were retrieved twice-a-week from the sampling stations and placed in individually labelled paper packages and brought back to the laboratory for identification and counting. The entire catch was placed on a gridded glass plate and the flies counted. Weekly catches were recorded and subjected to statistical analysis for comparison between the control and affected groups.

A one-week presurvey count was taken to determine the pretest fly population levels. Post survey counts were continued for three weeks after the termination of the experiment to monitor the fly populations. All the counts were subjected to an analysis of variance (Snedecor, 1962).

Selection of the sample stations was not based on the criterion used by many of the California authors since we selected sites randomly, including residential, commercial and other types of sites.

The period of the experiment extended from 1 February 1971 to 2 April 1971, a total time period of nine weeks; apportioned as follows: 1) one week for the initiation of the project by the City and County during which the bags were given to each residence followed by 2) five weeks of bags, 3) one week in which the City and County of Honolulu resumed collection of garbage cans on a once-a-week basis and 4) two weeks for the post operational counts with the City and County returning to routine twice weekly collection. The pre-survey period was not counted as part of the experimental period.

To initiate the study, a letter was hand-delivered to each participating sample station by one of two inspectors of the Vector Control Branch assigned to do the field work. This letter informed the participants concerning the purpose of the survey and other significant facts. Questions were also answered verbally to satisfy curiosity, allay fears and to establish satisfactory cooperation and rapport.

Results

Our trapping efforts resulted in large catches of dipterous species. These are listed in Table 1. The trappings also produced a few non-dipterous species including rove beetles (Coleoptera: Staphylinidae), souring beetles (Coleoptera: Nitidulidae: *Carpophilus* spp.), false blister beetles (Coleoptera: Oedemeridae: *Anaca bicolor*) and ham beetles (Coleoptera: Cleridae: *Necrobia* spp.). It was thought that high populations of *Musca domestica* (L.) would occur in several areas located close to animal

TABLE 1. *List of the Species of Flies Caught in the Baited Fly Traps*

Family	*Species*
Calliphoridae	*Phaenicia cuprina* (Wied)[1]
	Chrysomya megacephala (Fab.)
	Chrysomya rufifaces (Macquart)
	Calliphora vomitora (Linn.)
	Phormia regina (Meigen)
	Rhinia testacea Robineau-Desvoidy
Muscidae	*Musca domestica* L.
	Musca sorbens Wied.
	Synthesiomyia nudiseta (Van der Wulp)
	Ophyra chalcogaster (Wied.)
	Orthellia caesarion (Meigen)
	Muscina stabulans (Fallen)
Anthomyiidae	*Fannia pusio* (Wied.)
	Atherigona orientalis Schiner
	Anthomyia bisetosa (Meigen)
Sarcophagidae	*Sarcophagula occidua* (Fabricius)
	Helicobia morionella (Aldrich)
	Boettcherisca peregrina (Robineau-Desvoidy)
	Ravinia lherminieri (Robineau-Desvoidy)
	Parasarcophaga ruficornis (Fab.)
	Bercaea haemorrhoidalis (Fallen)
	Parasarcophaga argyrostoma (Robineau-Desvoidy)
	Seniorwhitea orientaloides (Senior-White)
	Parasarcophaga misera (Walker)
Syrphidae	*Eristalis arvorum* (Fab.)
	Volucella obesa (Fab.)
	Volucella tamaulipana Townsend
	Volucella tricincta Bigot
	Volucella dracaena Curran
Otitidae	*Physiphora aenea* (Fab.)
	Notogramma stigma (Fab.)
Trypetidae	*Dacus cucurbitae* Coquillett
Tachinidae	*Lixophaga* sp.
Drosophilidae	*Drosophila* spp.
Phoridae	*Megaselia scalaris* (Loew)
Statiomyidae	*Hermetia illucens* (Linn.) —

[1]*Phaenicia cuprina* (Wied.) does not imply that no *P. sericata* (Meigen) was present but because of the difficulty in separating large numbers of flies, the predominant species, *P. cuprina*, was so used.

farms, but this assumption did not materialize. Certain other species such as *Chrysomya rufifaces* (Macquart) and *Muscina stabulans* (Fallen) exhibited marked fluctuation during the period of the study.

The results of the entire survey are tabulated in Table 2 and depicted in Figure 3. The overall pre-test mean was 210.37 (187.23–227.41) for the pre-survey period while the overall post-test mean was 205.09 (184.31–264.94). The life cycle of the *Phaenicia* spp. observed under the conditions of this test, averaged approximately 10 days from egg to adult. Thus after initiation of the experiment, the fly population density should have

TABLE 2. *Results of Ten Weeks of Trapping Adult* Phaenicia cuprina *(Wied.) in the Leeward Area.*

Time/ Groups	*Pre-Test*[a]	*Week* I[b]	*Week* II[c]	*Week* III[c]	*Week* IV[c]	*Week* V[c]	*Week* VI[c]	*Week* VII[d]	*Week* VIII[d]	*Week* IX[d]
Control										
Mean x	187.23	198.94	210.21	195.64	194.44	148.56	167.19	197.00	176.50	184.31
Range	1—	2—	6—	12—	0—	12—	9—	1—	5—	4—
n=16	738	879	1132	1354	719	724	1037	1092	1166	378
Test (Bag)										
Mean x	227.41	272.31	466.39	578.15	493.76	562.30	595.94	516.00	320.11	264.94
Range	0—	0—	0—	7—	3—	5—	5—	10—	7—	0—
n=54	1592	1486	4426	5604	4392	3435	3655	4745	2584	3029
Overall										
Mean x	210.37	255.54	415.16	542.71	425.34	467.73	580.93	443.09	287.29	205.09
n=70										

[a]Pre-test period = one week prior to start
[b]Residence start collecting garbage in plastic bags
[c]Plastic bags collection by City and County with once-a-week collections
[d]Back to routine collection

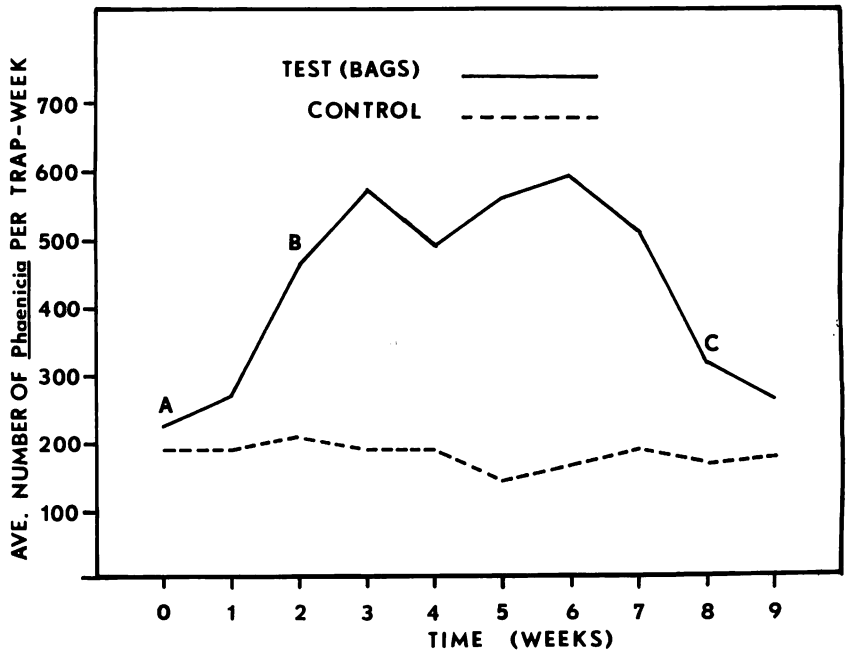

FIG. 3. *Graph of ten weeks of trapping adult* Phaenicia cuprina *(Wied.) in the Leeward area in* 1971. *(A) Pre-test period; (B) Test period using plastic garbage bags and once-a-week collection in effect; (C) Post-test period returning to routine garbage collection procedures.*

FIG. 4. *Torn plastic bag containing food scraps that serve as food for the flies. Note the open can with lid that may have initially punctured the plastic bag andalso the teeth-like puncture marks that could have been made by a dog.*

shown an increase within a week and a half, as was shown in the results (Week II). The length of the larval period, approximately 3–5 days, was short enough so that the maggots migrated from the bags prior to the collection of the bags. Visual observations indicated that the adult flies oviposited in the refuse materials until the bags were filled and tied. In many cases, the bags were filled rapidly and tied properly, but punctures created by animals or objects provided ready entry for the ovipositing adults and exit for the pupating larvae. Animals were noticed ripping the bags open and scattering the contents (Fig. 4). Some of the maggots

were observed to emerge from tiny pin holes subsequently enlarged by the larvae. On several occasions, a large number of larvae were also observed escaping from the tied top portion of the plastic bag when randomly selected bags were brought back to the laboratory to determine modes of escape and approximations of breeding.

For the five weeks during the test as well as for the one week following, the fly counts remained significantly higher in the test group than in the control group. During weeks II and III, the control counts were measurably higher than normal, but it was noted that the two stations causing this abnormality adjoined the Waianae City and County Baseyard where the refuse trucks were parked The trucks that collected the bags apparently contained fly maggots that escaped from the crushed bags during transport. These larvae migrated off the parked truck and pupated in the soil below the truck. Subsequently the trucks were thoroughly cleaned prior to returning to the baseyard. For the duration of the test period, the control remained relatively constant, fluctuating only within the population variation anticipated in normal population deviation. Climatic contions did not appear to hinder the survey since the fly counts followed predictable trends.

The levels of the adult fly catches predictably declined in the last two weeks of the study (Week VIII–IX) due to the return to twice-a-week refuse collection.

Discussion

As was indicated by the results (Table 2 and Fig. 3), the adult fly counts were significantly higher in the treated group than in the control groups. The breeding that occurred within the plastic bags enhanced larval development, because the favorable micro-environment created within the bags provided for rapid development of the maggots. The six significantly higher counts (Weeks II–VII) in the test group was thus directly related to fly breeding in the bags allowed by once-a-week collection, while the declining counts (Weeks VIII–IX) showed the effect of a twice-a-week collection which prevented fly life cycle completion at the collection site.

Our method of adult sampling gave statistically reliable results under the conditions of this study as can be noted in the control group (Table 2 and Fig. 3). The only problem with the trap method used would be to account for bias developed by excessive dead flies which served as a powerful lure which further attracted other flies. However, this bias was minimized by our twice-weekly servicing of trap stations. Our methods differed considerably from those used in California where the workers primarily used larval traps.

Conclusions

The results of this survey indicate that there were statistically significant changes in fly population densities during the 5-week test period of the experiment.

Shortly after inception of the change from twice-a-week collection using covered garbage cans to once-a-week collections utilizing exposed plastic bags, fly counts in the test stations increased significantly as shown in Table 2 and Figure 3 (Week III). Week VI shows another peak which resulted from increased numbers of adult flies previously breeding from the plastic bags. The accessibility of breeding sites coupled with the once-a-week collection schedule maintained a high fly population level in the test area.

After week VI the decrease in adult fly numbers reflects the return to the twice-a-week collections and Figure 3 and Table 2 reflects the constant decrease through to Week IX when adult fly levels returned practically to the base levels existing prior to the experiment.

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