INVESTIGATIONS OF FRUIT FLIES IN HAWAI'I
(Formerly Oriental Fruit Fly Investigations.)

QUARTERLY REPORT
January 1 - March 31, 1952.
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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine
Division of Fruit Insect Investigations

INVESTIGATIONS OF FRUIT FLIES IN HAWAII

COOPERATIVE QUARTERLY REPORT

January 1 through March 31, 1952

With the transfer of Dr. D. W. Clancy to the mainland in January, the Bureau of Entomology and Plant Quarantine concluded its parasite quarantine reception and preliminary evaluation activities. Plans are being developed for a comprehensive publication dealing with all phases of the cooperative oriental fruit fly biological control campaign.

The following summaries of progress during the first quarter of 1952 are based on reports furnished by the various project leaders and cooperating agencies.

Biology-Ecology:—On Oahu, fewer adult oriental fruit flies were captured in eleven 30-day traps operated by the University of Hawaii than during any quarter since June, 1950, when the study was inaugurated. Total catches were 143 cc. of flies per day for the period ending in January, 130 cc. for the period ending in February, and 93 cc. for the period ending in March. The index of fruit availability was unusually low during the first month of the record period, and also during the preceding month. Increases in host availability during the last two months of the record period failed to bring about increased catches. During the previous quarter, the last three months of 1951, the number of flies captured in these traps was considerably higher than the numbers caught during each of the first 3 quarters of 1951.

In Bureau studies, a decline in the number of flies caught in poisoned lure traps located on the rims of Opaeka'a gulch was noted which seemed to be associated with low host availability.

On Maui, Bureau citronella trap records showed that the seasonal adult population low occurred in January this year rather than December as in the previous winter. The number of flies in Iao Valley increased from 56 flies per trap day in January to 132 in February, to 132 in March. A similar upward trend from 27 flies per trap day in January to 139 flies per trap day was recorded at Wailuku. At Pauwela and Hailu pronounced increases in the number of flies occurred from January to February, which were followed by slight reductions in March. Evidence was obtained that insecticides applied to adjacent pineapple fields may have prevented normal seasonal increases at the last two trapping stations.
On Hawaii, adult flies continued to be exceptionally abundant in the extensive Puna coast area, even though they were somewhat less abundant than during the previous quarter. At Kapaa, the January citronella trap index was 121 flies per trap day, the February index 451, and the March index 309. The February index was the third highest for this trapping site during 18 months of trapping operations. Adult populations in the Hilo area increased markedly during February and then declined to what may be considered normal levels during March. A similar trend was noted at Chekua. At Kainalu on the Kona coast, elevation 1700 feet, the number of flies per trap day declined from 14 in January to 6 in March.

Data obtained by the University of Hawaii indicated that the number of oriental fruit fly larvae per infested guava on Oahu had declined to an all time low of 0.8 in January. This was followed by a rise to 4.4 in February and then by a decline to 3.0 in March. Dissections of guavas collected at widely scattered localities on Oahu during the first quarter of 1952 showed that 34.2 per cent of them were infested by the oriental fruit fly. In six gulches in the Waialua area of Oahu, infestations, as determined by the Bureau with the holding box technique, ranged from 0 to 54.6 larvae per pound, with an average of about 7. Approximately 50 per cent of the individual fruits are infested when there are 10 larvae per pound. Only 4 of 46 samples gave negative results. From 40 to 70 per cent of the mangoes in eight samples from an isolated tree in Honolulu were infested and the number of larvae per infested fruit ranged from 8 to 60.

Fruit collections made by the Bureau on Maui during the quarter consisted of 78 lots containing 2,971 individual fruits, weighing 62,137 grams. These produced 6,705 fruit fly puparia, equivalent to 0.9 per pound. The emergences included 1,320 oriental fruit flies and 2,095 Mediterranean fruit flies, practically all of the latter coming from loquat growing at elevations above 1700 feet. Infestations averaged about 8 oriental fruit fly larvae per pound of guava, 50 per pound of mango, 13.5 per pound of avocado, and 0.9 per pound of tangerines. One of the heaviest infestations, 378.6 larvae per pound, was recorded for downy myrtle, a new host record. The University of Hawaii, with the fruit dissection method, found 30 per cent of the guavas collected during a 3-day period in March to be infested.

On Hawaii, the infestation indices for guava collected at Kapaa and Hilo, were 31.4 and 28.6 larvae per pound, respectively. These represent an increase in infestations in comparison with the previous quarter. With winter conditions prevailing at higher elevations, infestations along the Mauna Loa Truck Trail were at a seasonal low. The University of Hawaii recorded infestations in 38 per cent of 440 guavas collected at various locations on Hawaii during a 3-day period in March.

In studies undertaken jointly by the Bureau and the University of California Agricultural Experiment Station, one continuous year of climate simulation for each of six mainland sites was completed during the quarter. With the advent of winter conditions in the Oceanside, Fresno, and Riverside, California, and Charleston, South Carolina, cabinets, the emergence of adult flies from puparia was completely inhibited and adult longevity was reduced. The mean temperatures during the winter period were below the threshold for pre-imaginal development which has been found to be approximately 55° F.
Of the six mainland simulation sites, the Fort Pierce climate possessed the most ideal conditions for oriental fruit fly development, four generations being obtained during one year of cabinet operation. The principal effect of a brief period of freezing and cool weather at Ft. Pierce was to reduce the rate of pre-imaginal development and to inhibit fly emergence temporarily.

Sub-freezing conditions in the Vincennes, Indiana, cabinet ultimately destroyed all parent and progeny stocks, including cold-trapped puparia.

A melon fly female lived for 462 days under the cool conditions prevailing at the 7030 feet ecological station on Haleakala volcano on Maui. When this fly was 447 days old, 2 1/2 months after the last male died, it was taken to a controlled temperature room where it laid 40 eggs, 55% of which were fertile. The female fly survived frequent temperatures below 37° F. and a low temperature of 31° F. Under similar conditions oriental fruit fly females were still alive and laid fertile eggs after 9 months.

One puparium cold-trapped in soil at the 5100 feet ecological station on the Nauna Loe Truck Trail produced an adult oriental fruit fly after 71 days in the pupal stage. When the pupal stage was extended to from 40 to 50 days by exposure to cool conditions, about 20 to 50 percent of the puparia produced adult flies. These results suggest that the pupal stage may be a critical one as far as the oriental fruit fly's ability to survive normal short periods of cold weather which are characteristic of many subtropical mainland areas.

An account of studies of the field ecology of the melon fly made by the University of Hawaii is included in the Biology-Ecology section of this report. This contains many interesting observations on the habits of the melon fly. Both sexes are involved in the outward movement of flies from breeding centers. Honey dew from insects such as aphids, the corn leaf-hopper, whiteflies and possibly Drosophila, constitutes an important food for the melon fly. Exudates from the glands of certain plants, particularly those of the castor bean plant, appear to be another important food source. The feces of birds are also frequently fed upon by the fly, and, on one occasion, a few flies were observed to feed on a decomposing dead toad. Since the hatchability of eggs from field flies was always as high as those from laboratory stocks, it was concluded that the greater mortality of eggs in tomatoes and cucumbers in the field is due to factors associated with the environment at egg deposition sites.

Biological Control:--Parasite evaluation studies conducted by the University of Hawaii have revealed a steady downward trend in the parasitization of the oriental fruit fly infesting guava on Oahu from 92% in December 1951, to 53% in March, 1952. This was accompanied by an increase in the general level of individual fruit infestation. A similar downward trend occurred a year ago but it was not as pronounced as the recent decline. A decrease in egg mortality and its effect on the parasite/fly balance is suggested as a possible reason for the current decline.
On Hawaii, parasitization averaged 62.2% in infestations in 22 guava samples and 64.3% in 13 samples from Maui. Replacement of Oryia vandenboschi Fullaway by O. cephalus Fullaway has continued on Hawaii, 80 per cent of the recent parasite recoveries consisting of the latter species. All of the parasites recovered on Maui were O. cephalus with the exception of 3 O. longicaudatus, and O. vandenboschi failed to appear for the first time since its original establishment on that island.

Seven species of parasites are still being propagated in the insectary of the Territorial Board of Agriculture and Forestry. In March the total production was 59,371 parasites, 45,095 of which were liberated at various locations in the Hawaiian Islands.

During the period from September, 1951, to April, 1952, the Territorial Board of Agriculture and Forestry made a special study to find out how many of the introduced parasites have become established. Reearings from fruit collections obtained from Kauai, Oahu, Maui and Hawaii have indicated that a number of additional species are now established. Thirteen different parasites, most of which have been introductions within the past 3 or 4 years, were reared from oriental fruit fly material collected on Oahu.

Physiology—Investigations of the cholinesterase of the oriental fruit fly, the melon fly and the Mediterranean fruit fly have indicated that it is very similar in its basic properties in all three flies. Four compounds structurally related to 1 phenyl-3-methyl-pyrazyl-(5)-dimethyl-carbamate (compound G-22008) were studied in preliminary investigations of in vitro anticholinesterase activity. Compound G-23611, in which the isopropyl group replaced the phenyl group, had about the same degree of anticholinesterase activity as G-22008 but it was slower in its action. Compounds G-23642 and G-23224, with straight chain groups on the one position of the pyrazyl ring, were less effective than compound G-23611. Compound G-19258, with only the dimethyl carbamate group in common with the other compounds, was still less effective. Paraoxon was more effective and somewhat more rapid in its action than G-22008.

Phytone, a papain digest of soy, was found to be an adequate substitute for soy hydrolysate to insure maximum fertility of oriental fruit fly eggs and this material is now a regular component of the adult diet in the oriental fruit fly rearing room.

Chemical Control:—Oriental fruit fly adults with access to protein hydrolysate during the first 14 days after their emergence, retained the tolerance to topical applications of DDT which they acquired for the next 10 days when no protein was available.

In residual toxicity tests American Cyanamid compounds 4124, 3456 and 4049 (malathion) were from 10 to 30 times as toxic to the oriental fruit fly as DDT when deposited in xylene solutions. When topical applications were made, malathion was 100 times as toxic as DDT at the LD-50 level whereas 4124 and 3456 were only about 10 times as effective. The LD-50 for malathion as a residual insecticide was 10 times that for parathion when the deposits were 24 hours old. At a deposit level above the LD-50 level (about 1.9 mg. per square centimeter), malathion emulsifiable retained most of its effectiveness for six days. In a comparative test, parathion lost most of its effectiveness during a six-day period.
In other screening tests, emulsifiable JH 711 (stereoisomer of aldrin) was 3 times as toxic to the oriental fruit fly as aldrin while JH 269 (stereoisomer of dieldrin) was slightly more toxic than JH 711. In residual tests with wettable powders, dieldrin was most effective followed closely by JH 711, then JH 269, with aldrin the least effective. R-242 and Geigy miticide 338 were comparatively non-toxic to the oriental fruit fly, the first in residual tests, and the second in topical applications.

Four applications of low concentration DDT and aldrin Tifa fogs at two-week intervals failed to control the oriental fruit fly in large banana plots. The continuous movement of flies into the treated area was probably the most important factor contributing to the poor results, but the application interval and concentrations used may have been partly responsible.

In large guava plots 4 ounces of parathion per acre in a sugar-protein bait spray formula was superior to 4 ounces of lindane in a comparable formulation. Infestations averaged 14.4 larvae per pound in the lindane areas and 3.3 per pound in the parathion areas two weeks after each of the first two sprays. In banana plots, a similar bait spray was not able to compete successfully with ripe bananas as an attractant for the ovipositing females. In incidental tests, the parathion-protein-sugar bait spray was much more attractive to the melon fly than one containing only parathion and sugar.

The large-scale test on Oahu of a poisoned lure containing methyl eugenol and G-22008, which eliminates the male population and markedly reduces the fertility of the females, was terminated after two and one-half years. In the gulch protected by poisoned lure stations, the infestation in the last guava crop was only 4.4 larvae per pound, or 70 per cent less than the average infestation of 14.8 larvae per pound in untreated gulches. To further evaluate this promising control method two new tests were inaugurated on Hawaii, one covering an area comprising 5 square miles on the Hamakua coast, and another covering 15 acres of isolated guava near Kilauea volcano. In all, more than 200 bait stations have been established to protect these two areas.

Tests were made with six different insecticides applied to nine different surfaces to provide Plant Quarantine officials with a basis for recommending a residual insecticide for treating the interior surfaces of fruit packing plants. One month after treatment, 75 per cent DDT wettable powder residues were 100 per cent effective on all surfaces. DDT and Dilan emulsifiables were never completely effective on all surfaces while methoxychlor was the least effective of all materials. Chlordane and lindane were completely effective when the deposits were fresh and they remained highly toxic on porous materials such as cane and plywood. These two materials were of no value after one week, however, when applied to aluminum, galvanized iron, and plastic screen, and they were not much better when applied to glass, painted plywood, or galvanized wire screen.
No increase in resistance to DDT was noted in the twelfth and thirteenth generations of the residual and aerosol strains of the oriental fruit fly. The aerosol strain was discontinued and a new strain that is being treated before the flies attain sexual maturity was started. The latter has already shown indications of resistance to DDT after only one generation. The DDT residual resistant strain showed much less resistance when treated topically than it did when exposed to DDT residues. This has suggested that the resistance, in part at least, may be the result of behavior differences.

In olfactometer screening tests, 99 materials were tested for attractiveness to the oriental fruit fly and 45 for attractiveness to the Mediterranean fruit fly. As oriental fruit fly attractants, benzyl alcohol and castoreum appeared to be worthy of more extensive tests. For the Mediterranean fruit fly isobornyl propionate and cetyl alcohol were definitely promising.

Good progress on the work to develop a highly effective proteinaceous bait from soybean meal has been made but attempts to preserve the bait and prevent deterioration have not been successful. A shallow culture soy meal bait was as much as 12 times as effective as the standard lure in trapping female oriental fruit flies.

Several wine yeasts obtained from the University of Hawaii and 15 yeast cultures obtained from the Pineapple Research Institute were tested as substitutes for Fleischman's yeast in the standard bait but none was consistently better. Shallow soy meal cultures with bacterium 14 were superior to soy hydrolysate or soy flour cultures with the same bacterium. Nine yeasts, 3 fungi and 4 bacteria were isolated from anthracnose lesions on papaya which were observed to be exceptionally attractive to flies.

In general, the Mediterranean fruit fly has responded to most baits more readily than the oriental fruit fly but it has favored the proteinaceous lure over the standard fermenting lure much less than the oriental fruit fly.

Commodity Treatments:—In fumigant screening studies, forty-four materials were tested on naked eggs and larvae of the oriental fruit fly. Only one material, allyl isothiocyanate, killed both stages at a low dosage. Four materials (1,2-dibromo pentane, bromo trichloro ethane, dibromo dichloro methane, and 2-chloro allyl alcohol) killed 95% of the larvae at dosages of less than 6 milligrams per liter but were ineffective against eggs.

Additional tests were made with ethylene dibromide to determine the relationship of fruit load in a fumigation chamber to fruit fly mortality. With a given dosage there was some evidence that mortality is depressed as the fruit load increases.

In a large chamber test to study the effect of packing material on fruit fly mortality, 450 pounds of infested papayas and 1,811 pounds of pineapple were fumigated with 3/4 pounds of ethylene dibromide per 1000 cubic feet for 3 hours at 70° F. Fruit fly mortality was complete in the papayas which were wrapped in corrugated paper sleeves and packed in field boxes. There was no detectable effect of the treatment on the flavor, appearance, or keeping qualities of the papayas or the non-infested pineapples.
wrapped in a similar manner. In all tests conducted with papayas wrapped in corrugated paper thus far, at a dosage of 3/4 pound for 3 hours, only 20 puparia have been recovered from an estimated re-treatment population of 187,077 eggs and larvae. Since none of these puparia produced adult flies, this might be interpreted as complete mortality.

The development of new commodity treatments to destroy fruit flies has had a very pronounced effect on the export of fresh fruits and vegetables from Hawaii. Exports have increased from 3,240 pounds during fiscal year 1949, when only the vapor heat treatment was available, to more than 2 1/2 million pounds to date for the fiscal year 1952 when methyl bromide and ethylene dibromide treatments were available. About 80 per cent of the exports during the past year have been treated with ethylene dibromide.

Twenty-six additional experiments were made to determine the effect of ethylene dibromide on Mediterranean fruit fly infestations in oranges. The tests were conducted in 5 gallon cans and steel drums at dosages of 1/16 to 3/4 lb. per 1000 cubic feet for two hours at 70° F. The fruit load in the 5 gallon cans was 3/4 of the free air space and from 30 to 40 per cent of the chamber volume in the steel drums. Last survivors were recorded at the 1/16 pound dosage.

L. D. Christenson, Entomologist in Charge
Investigations of Fruit Flies in Hawaii.
## PERSONNEL CHART

### ORIENTAL FRUIT FLY INVESTIGATIONS

**March 31, 1952**

**HEADQUARTERS, HONOLULU**

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### COMMODITY TREATMENTS PROJECT - HONOLULU

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### BIOLOGY-BIOLOGY PROJECT - HONOLULU

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<td>Domingo Pagey</td>
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### Hilo, Hawaii

- Clifford G. Iona      Entomologist
- Shizuko Haeda        Biol. Aid
- Dorothy H. Niimoto   Biol. Aid
- Hitoshi Kanemoto     L/A Sc.Aid(WAE)
- Robert T. Tanamoto   L/A Sc.Aid(WAE)
- Edward T. Hineno     L/A Sc.Aid(WAE)

### PHYSIOLOGY - HONOLULU

- Robert K. S. Lee      Biol. Aid

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* Bolded names indicate promotions effective 3/2/52.
* Underlined names indicate appointments effective 3/2/52.
* Italics indicate promotions effective 3/5/52.

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