A Progress Report on INSE

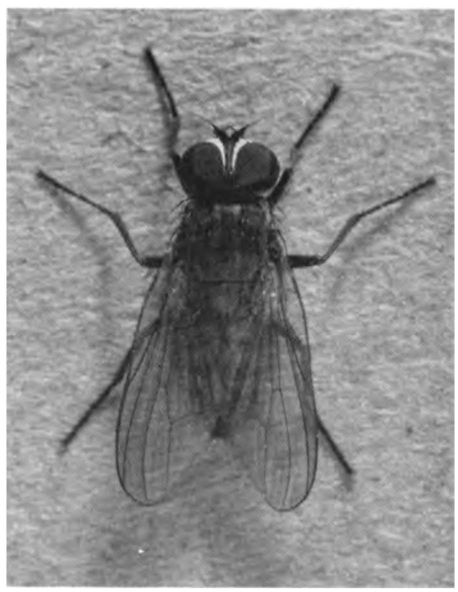
Adult house fly (Musca domestica), top photo. Medium size, about 5/16 inch in length. Dull colored with 4 dark stripes on top of thorax and yellowish pale spots at anterior lateral margins of abdomen. Life cycle from egg to adult averages 8 days in summer. Normally found close to food and egg-laying sources such as poultry manure, wet feed, broken eggs, and decomposed plant material. A warm weather species with dense populations during summer.

Adult little house fly (Fannia canicularis), right photo. Slightly less than medium size, about ¼ inch in length. Dull colored with 3 dark stripes atop thorax and yellowish pale spots at anterior lateral margins of abdomen. Life cycle from egg to adult averages 24 days in spring and fall. Normally found feeding and laying eggs in poultry manure but may use rabbit and dog excrement, damp feed, grass clippings and food residues. Adults more prevalent during spring and fall months.

Adult "coastal fly" (Fannia femoralis), below left. Small size, about 3/16 inch in length, and shiny black in color. Life cycle from egg to adult may take from 10 to 21 days depending on temperature. Chiefly found around poultry manure although food and egg-laying sources may include excrement found in bird and animal nests. Adults more abundant from May through October in northern California while populations are greatest from April to June and from October to December in the south.

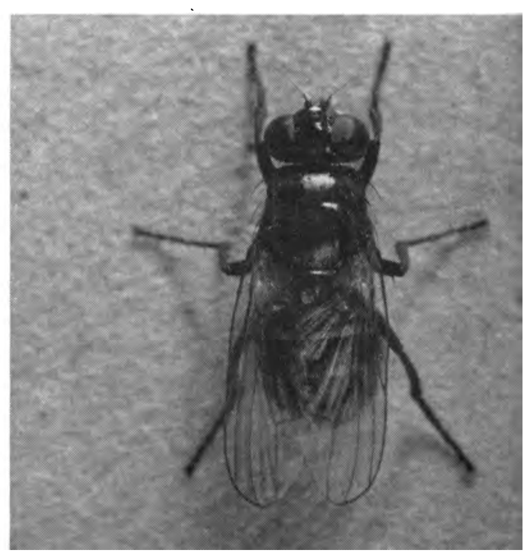
Adult black garbage fly (Ophyra leucostoma), second photo to right. Similar in size to the little house fly but shiny black in color. Life cycle from egg to adult averages 10 days in summer and about 45 days during colder weather. Adults commonly found around decaying food and plant material but occasionally feed and lay eggs in poultry and other animal manures. More dense adult populations found during summer.

Insecticide resistance, resulting in the gradual elimination of compounds originally possessing high toxicity to flies (graph 1), presents a challenge if chemical control of flies is to be maintained. During the last 10 years, a succession of compounds including malathion, ronnel, diazinon, and naled have been used in some areas until high resistance has rendered them ineffective. Resistance to a newly introduced compound is known to develop faster when the fly population is already resistant to related compounds. In one case studied, diazinon resistance rose from 8.18x to 66.50x within two years and naled resistance rose from 3.59x to 11.86x within 16 months.



Proposals for reducing the rate of development of resistance include: (1) manure disposal at frequent intervals to minimize its use as a medium for fly development; (2) screening of poultry houses to exclude flies; (3) proper maintenance of water systems to eliminate water leaks on manure and thus reduce the suitable fly-development areas; (4) resort to chemical treatment only as a supplementary measure to good manure-management operations; (5) avoidance of insecticide treatment of poultry manure as much as possible; and (6) exclusion of sprays from trees in the near vicinity of poultry ranches since trees serve as night resting sites for parasites and predators of noxious flies.

The detection of unequal resistance in the various species of flies also suggests the following practical recommendations concerning the choice of a suitable insecticide: when the coastal fly is the predominant pest species, control may be obtained with ronnel without resort to diazinon or naled; these can be held in reserve until needed. Similarly, ronnel will still control the little house fly in many areas, although the house fly may be resistant to it. Since the little house fly is a problem in the coastal areas in the spring, while the house fly is a problem in the late summer and fall, control of the former may be achieved with ronnel and, if necessary, with diazinon. Thus, naled may be reserved for use in the summer if diazinon no longer gives adequate control of the house fly.



CTICIDE RESISTANCE IN THE FLY COMPLEX

. . . of California Poultry Ranches

G. P. GEORGHIOU · MARILYN K. HAWLEY · E. C. LOOMIS

In an earlier report on house fly resistance to insecticides on poultry ranches (*California Agriculture,* October 1965), it was pointed out that insecticide resistance, i.e., the selection and survival of individual insects possessing physiological mechanisms for degrading certain insecticides, is a dynamic process subject to continuous change depending on, among other factors, past and present chemical control practices in each area. Studies have been continued at Riverside on resistance in certain critical areas of California, and the scope of these investigations has been expanded to include a number of other noxious fly species associated with poultry ranches, in addition to the house fly (*Musca domestica*). These include the little house fly (*Fannia canicularis*), the coastal fly (*Fannia femoralis*), the false stable fly (*Muscina stabulans*), and the black garbage fly (*Ophyra leucostoma*).

Some of the objectives of this study were: (1) to determine the changing pattern of resistance in the house fly following a changeover in chemical control practices; (2) to investigate the presence and extent of resistance, if any, in the other species of flies; and (3) to propose means of delaying resistance and thus prolonging the useful "life" of insecticides.

The resistance pattern in the house fly was studied in 1964, 1965, and 1966 at a poultry ranch in Anaheim and another in Moorpark—both of which had been experiencing fly control difficulties due to resistance. Flies were collected from each ranch in midsummer, reared on artificial media in the laboratory, and their offspring tested for resistance to most of the currently used insecticides by a microdrop technique. The two ranches were different in several important respects.

The Anaheim ranch was a small operation of about 17,000 birds, located in a suburban area and in proximity (1 to 5 miles) to several other poultry and livestock ranches. The flies on this ranch had ample opportunity to intermingle with the surrounding fly populations. From 1960 to 1962, fly control at this ranch was based on weekly or bimonthly applications of malathion. Since 1963, malathion has been replaced by ronnel, dichlorvos, and naled. During 1964 and 1965, diazinon was also used as a larvicide. Although it has not been possible to obtain accurate information on chemical control practices of other ranches in the area (due to changes in management or discontinued operations), control was generally based on the same materials. In the last few years the area's poultry industry has declined as a result of urbanization.

The Moorpark ranch, involving more than a million birds, has relied heavily on chemicals since its establishment in 1962. The following insecticides were used weekly during most of the year: ronnel (1962–64), diazinon (1964–65), naled

HOUSE FLY (Musca domestica) **RESISTANCE TO ORGANOPHOSPHORUS INSECTICIDES IN ANAHEIM AND MOORPARK, 1964, 1965, 1966**

Insecticides	Resistance Levels* (at LD_{95})					
	Anaheim			Moorpark		
	1964	1965	1966	1964	1965	1966
Diazinon	20.70	22.92	17.68	8.18	17.31	66.50
Ronnel	13.50	10.78	11.55	7.60	13.64	26.35
Fenthion	10.50	7.25	6.03	5.38	6.65	10.21
Naled	..	2.90	2.69	..	3.59	11.86
Dichlorvas	..	2.08	2.76	1.71	2.10	4.23
Dimethoate	4.32	4.79	3.49	2.95	3.58	3.06
Zytron	..	..	1.52	..	..	1.79
Ciodrin	..	19.89	12.23	..	17.75	>100.00
Malathion	>100.00	60.00	..	>100.00	>100.00	>100.00
Coumaphos	..	>100.00	>100.00	..	>100.00	>100.00

* Numbers indicate degree of resistance. Level of "normal" or nonresistant flies = 1.

Adult false stable fly (Muscina stabulans), right photo. Often mistaken for the house fly because of its similarity in size and color. Adults have a distinguishing pale spot atop the posterior end of the thorax. The life cycle from egg to adult is longer than that of the house fly, taking about 14 days during the summer. Adults are attracted to and deposit eggs in various animal excrement including poultry manure and decaying vegetable matter (garbage and grass clippings). More common during summer.

Fly photo enlargements on these pages are in relative scale.

(1965–66), and dichlorvos dry sugar bait (1964–66). The area is not urbanized, and neighboring ranches (about six miles away) also rely heavily on chemical control of flies. Thus, the fly population at the Moorpark ranch was subject to more severe selection for resistance than at Anaheim, and there was little opportunity for dilution with susceptible or less resistant flies from the surrounding area. Both the Anaheim and Moorpark ranches practiced manure cleanup only once or twice a year; thus, the flies were afforded abundant opportunity for reproduction on the premises.

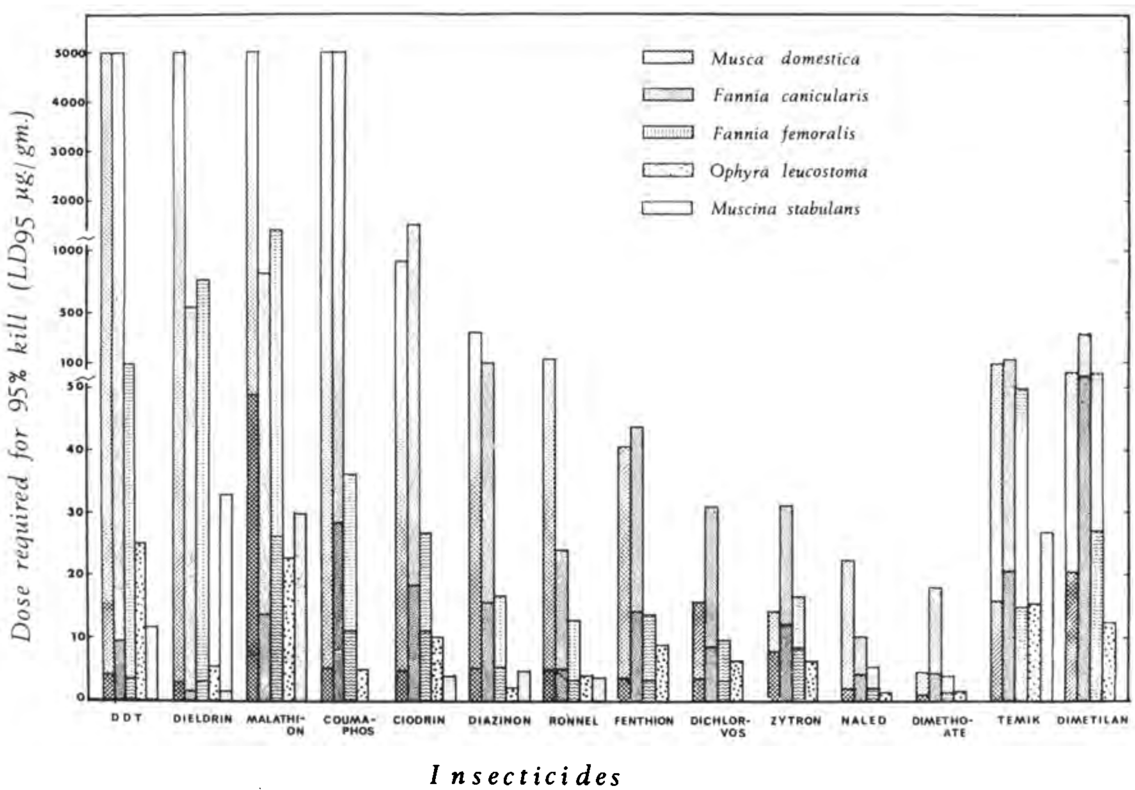
Levels of resistance to various organophosphorus insecticides in the house fly population on the two ranches during 1964, 1965, and 1966 are shown in the table. As indicated, the Anaheim flies were resistant to diazinon, ronnel, Ciodrin, coumaphos, and malathion; they were moderately resistant to fenthion, and had low or insignificant resistance to dimethoate, dichlorvos, naled, and Zytron. Only a small fluctuation in the levels of resistance was noted on this ranch during 1964–66. This phenomenon may be due to insufficient selection pressure on the population over the area as a whole, owing to the varied fly-development sources (poultry, dairy, cattle, etc.)—at each of which independent approach to fly control was pursued.

At the Moorpark ranch, resistance to all compounds (except dimethoate) was higher than at Anaheim. The higher resistance to the latter insecticide is attributed to its use on dairies in Anaheim, while almost none was used in the vicinity of poultry. Although resistance in 1964 was lower at Moorpark than at Anaheim, a sharp increase was noted at Moorpark during 1965 and 1966 as new materials such as diazinon and naled replaced the older malathion and ronnel treatments. Of particular concern was the marked increase in resistance to diazinon after its introduction as a routine weekly larvicidal treatment in the summer of 1964. Also significant was the development of resistance to naled from 3.59x before use (1964) to 11.86x after use as an adulticide in 1965 (weekly applications on outside porches only), and as a general residual insecticide in 1966. The considerable loss in effectiveness of naled is especially noteworthy since this was the only residual insecticide registered for use in poultry houses to which house flies had not developed resistance. The changing pattern of resistance, as observed at Moorpark, was considered an excellent illustration of the general course of events to be expected in ecologically isolated ranches relying entirely on present-day insecticides for fly control.

Other species

The high level of resistance of the house fly to many insecticides raises the important question as to whether other species of noxious flies on poultry ranches are also resistant to the same insecticides, and to the same extent. If this were so, the established levels of resistance of the house fly could be used to choose an insecticide that would be expected to give control of all the species regardless of which is predominant at any given time. This possibility, however, appears unlikely because of the many biological and behavioral differences among the species: although their larvae live mainly in animal manure and the adults frequent the same general environment, a number of basic differences among species exist, as, for example, number of generations per year, flight habits, and preferred resting sites of adults. Such differences influence the extent of exposure to insecticides and thus the degree of resistance to them.

To obtain answers to this problem, populations of the various species collected from Blythe (Riverside County), Anaheim (Orange County), Moorpark (Ventura County), Sebastopol (Sonoma County), and Bowman (Placer County) were reared in the laboratory and tested (using the microdrop technique). These collections yielded adequate numbers of the house fly, the little house fly, and the coastal fly, which enabled us to determine their levels of susceptibility and resistance to two organochlorine, 10 organophosphorus, and two carbamate insecticides. Only small numbers of the black garbage fly (from Blythe) and of the



Graph 1. Levels of susceptibility and resistance to several insecticides in various species of flies, determined by application of insecticide microdrops to individual flies. Lower, shaded portion of bars indicates level of susceptibility of normal, nonresistant, flies.

false stable fly (from Anaheim) were obtained, and information on resistance in these species is still incomplete. The Blythe and Bowman populations were generally susceptible, or only mildly resistant, to most organophosphorus compounds, and the results obtained were therefore used to establish directly, or by extrapolation, the base line susceptibility levels of the species. The Anaheim, Moorpark, and Sebastopol populations showed various levels of resistance to many of the compounds tested. Resistance varied, moreover, not only with the compound, but with the species. In general, the house fly developed highest resistance to most compounds, followed by the little house fly, and lastly by the coastal fly (which was generally susceptible to most compounds except DDT, dieldrin, and malathion). Distinct differences in the ability of each species to develop resistance to each compound were observed. Thus, while the coastal fly was found to be more susceptible to most organophosphates than the little house fly, it was significantly more resistant to the organophosphate, malathion. The house fly was more resistant to diazinon, ronnel, and naled, but less resistant to fenthion, dichlorvos, Zytron, and dimethoate than the little house fly. The maximum and minimum susceptibility values obtained on each species for each of the insecticides tested are shown in graph 1. Resistance, as illustrated, represents the maximum level achieved by each species anywhere in the study areas. The data thus show the relative tendency for each species to develop resistance under conditions of great reliance on chemical control.

Since certain insecticides can be used in combination with sugar as dry baits, this investigation was extended to cover the relative toxicity of such baits to susceptible and resistant strains of the three species. The resistant strains had all originated from the Moorpark ranch. Male and female flies were confined for 24 hours in screen-covered petri dish halves containing 0.25 gram of sugar impregnated with 0.1% of the test insecticide by weight. The results, as given for diazinon, naled, dichlorvos, and dimethoate in graphs 2 and 3, represent the combined contact and stomach toxicity of these compounds to the susceptible (S) and resistant (R) strains. The little house fly and the coastal fly are known to be less readily attracted to sugar than is the house fly; hence, the relatively slower kill recorded on the S strains of these two species. The difference in time required for equal kill of the S and R strains of a species represents the degree of resistance in the R strain as obtained by the test method employed. Of considerable interest was the relatively high toxicity of the naled bait to both S and R strains of the house fly (graph 2) despite the 11.86x resistance detected. Resistance to diazinon in the house fly and the little house fly was also evident in these tests. The extremely low kill obtained with dichlorvos on the R strains of the three species was rather unexpected and requires further investigation.

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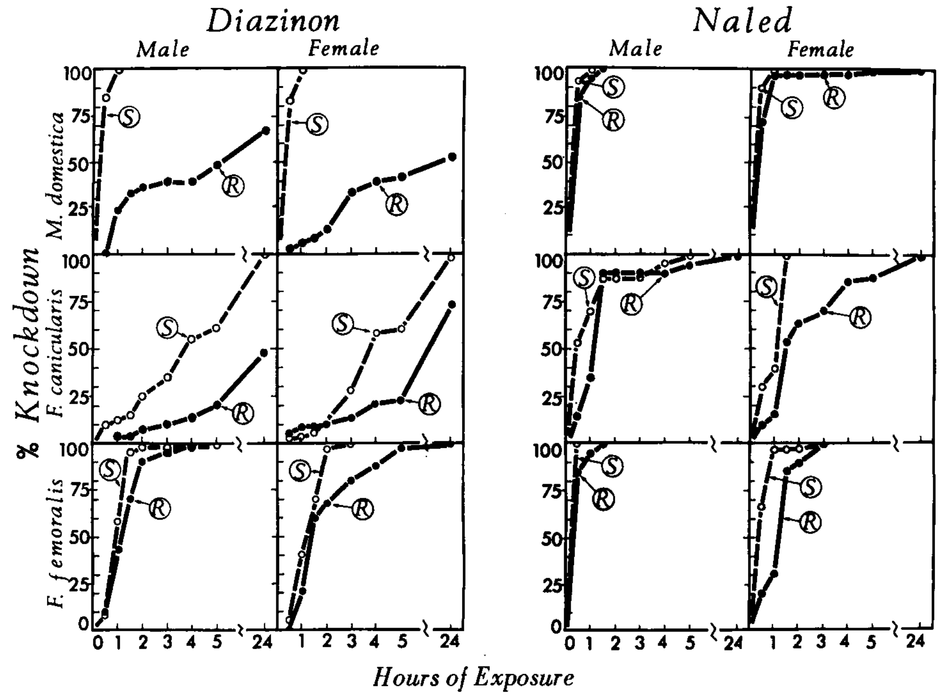
GRAPH 2. TOXICITY OF DRY SUGAR BAITS OF 0.1% DIAZINON AND 0.1% NALED TO SUSCEPTIBLE (S) AND RESISTANT (R) STRAINS OF THREE SPECIES OF FLIES.



GRAPH 3. TOXICITY OF DRY SUGAR BAITS OF 0.1% DICHLORVOS and 0.1% DIMETHOATE TO SUSCEPTIBLE (S) AND RESISTANT (R) STRAINS OF THREE SPECIES OF FLIES.