Resistance of the little house fly to insecticides on poultry facilities

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The fly has developed surprisingly little resistance to the insecticides most commonly used to control it.

Filth fly control on poultry facilities in California is not limited to the house fly but also includes the little house fly. In fact, the little house fly, *Fannia canicularis* (L.), is of greater economic importance to poultry producers than the house fly, *Musca domestica* L., mainly because it occurs during the cool and wet season, when standard manure-drying practices are not always reliable control options.

With California's population growth of the past 20 years, urban and suburban communities have extended into areas previously dedicated to poultry production. Since the little house fly readily coexists with humans, it is not surprising that complaints by residents to public health officials have increased with the population growth. During a seven-year period, the greatest proportion of legal notices filed in connection with infestations of various fly species in Riverside County occurred during the peak of the little house fly season (fig. 1). To meet the need for more immediate and effective control of little house fly, poultry producers have relied heavily on the use of insecticides, thus setting the stage for development of insecticide resistance.

The pyrethroid permethrin has become the predominant insecticide for filth fly control on poultry facilities in recent years. Before pyrethroids were commercially available for fly control, they were found to be nearly as toxic to field-collected, organophosphate-resistant house flies as to susceptible house flies. Since their introduction for fly control on livestock and poultry facilities in the late 1970s, several cases of house fly resistance to pyrethroids have been reported, implying that the same problems might be developing in the little house fly populations.

In light of the 17-year time span since the last published survey of little house fly resistance to insecticides in California, and the advent of pyrethroids as a completely new class of commercially available insecticides, we conducted a study to determine the current status of resistance of this species in various areas of the state. Our results suggested that, although resistance was higher for permethrin than for the other insecticides tested, levels were not excessive at any of the sites.

Resistance monitoring

Little house fly adults were collected in 1984 from one poultry facility in each of four areas in southern and central California: Moorpark, Ventura County; El Cajon, San Diego County; Cherry Valley, Riverside County; and Fresno, Fresno County. All facilities were caged-layer operations, except for the one in Fresno, which housed broiler-breeder birds. Each facility, chosen with the assistance of the local poultry farm advisor, had a current problem with the little house fly and a history of moderate to heavy insecticide use.

Flies from the Moorpark facility were collected on January 30. The use of insecticide against house fly and little house fly at this facility had declined following the resistance studies during 1965; since 1980, no space or residual sprays had been used for little house fly control. At the time of collection, chemical fly control consisted only of methomyl-formulated fly bait.

Collection from the El Cajon facility was on May 12. Ravap (stirofos + vapona) and naled sprays, as well as methomyl-formulated bait were used for house fly and little house fly control and had been applied quite extensively during the 12 months before the collection. The insecticide sprays were alternated routinely and applied every two weeks as long as the flies remained dense. Fly bait was present continuously at the site.

The facility at Cherry Valley had been in operation for approximately 40 weeks before the collection on March 8. The little house fly population was excessive at the site during most of that time and the manager had been confronted with neighbors' complaints. Ravap had been sprayed three times a week and permethrin once a week since the beginning of the operation. Methomyl-formulated fly bait was distributed liberally throughout the facility on a weekly basis.

The program for little house fly control at the Fresno facility had consisted mainly of insecticides for at least two years before the collection date, February 2. The broiler-breeder flock was maintained in a two-thirds slatted floor, one-third litter type of house. The housing design was such that access to the manure was impossible unless the house was empty of birds, thereby excluding manure management as an option for fly control. Since 1981, organophosphate insecticides such as naled and malathion had been routinely applied against the various filth fly species. Permethrin had been used every other week from August through October 1983 with little apparent success in reducing the fly population. Naled space sprays were then substituted, applied every other day, for quick knockdown of little house flies. Methomyl-formulated bait had been used liberally at the facility since 1981.

The insecticides evaluated in the resistance study were permethrin, dimethoate, dichlorvos, naled, methomyl, and deltamethrin. All except deltamethrin are currently registered for use against little house fly on poultry and livestock facilities in California. Deltamethrin has not been used for filth fly control but was included in this survey to determine possible cross-resistance due to the use of permethrin.

Bioassays were made on two- to three-day-old male and female flies in the first

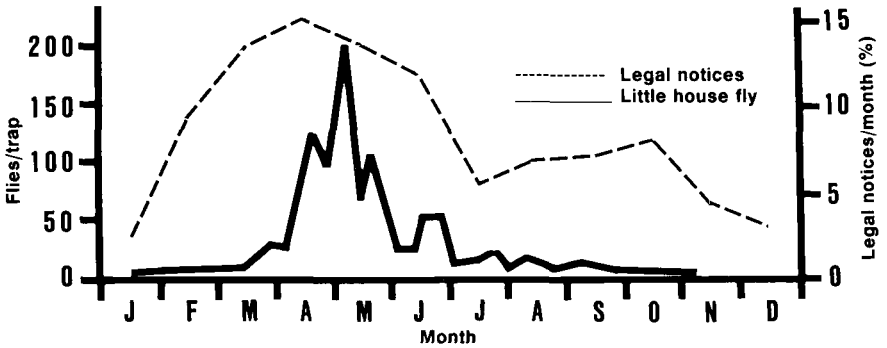

Fig. 1. The peak in typical seasonal distribution of little house flies over a seven-year period coincided with the greatest numbers of legal complaint notices.

through fourth generations (F1 through F4) following colonization. Technical-grade insecticide was dissolved in acetone and applied to the fly's notum (back) at the rate of 1 microliter (μl) per fly. Each insecticide was tested at a minimum of five dosages, replicated four or more times on different days with 20 insects per replication. The dose-mortality results were statistically analyzed, by probit analysis, and the LD_{95} values (amount causing 95 percent mortality of the test population) expressed in micrograms (μg) per fly. Resistance ratios (resistance levels) were calculated by comparing the LD_{95} values of the field strain with those of a susceptible reference strain (table 1). The susceptible strain of little house fly was colonized from a caged-layer facility in San Diego County in 1983.

The Cherry Valley and Fresno strains were more resistant to naled than were the other two strains. The 4.3-fold level of resistance in the Fresno strain probably would be expected in light of the past heavy use of naled at that site.

Dimethoate had not been used to a great extent at any of the four sites, but relatively high resistance to it was detected in the Fresno and Cherry Valley strains, probably because of cross-resistance with other organophosphate insecticides. The Fresno strain had a 2.3-fold level of resistance to dichlorvos, a relatively low level, but the highest of the field strains.

Methomyl was the only carbamate tested and was the only insecticide used in a bait formulation at the facilities surveyed. The resistance ratio of the Fresno strain was three to four times higher than those of the other strains, and the relatively lower slopes of the dose-mortality lines offer additional evidence of evolving resistance.

At all sites, flies showed greater resistance to permethrin than to the other compounds. The LD_{95} values for permethrin in the Cherry Valley and Fresno strains were about twice those in the other strains, a finding that correlates with the higher use of permethrin at the two facilities.

The assays with deltamethrin essentially measure cross-resistance from permethrin since deltamethrin is not registered for any fly control uses in California. Cross-resistance to this pyrethroid is apparently present in all strains; the highest level was found in the Cherry Valley strain.

Implications for control

From a practical standpoint, the results of the study are somewhat encouraging, in that resistance was not excessive for any of the insecticides at any of the sites. The fly populations were not sampled randomly; that is, we attempted to locate populations that had a high probability of being resistant to one or more insecticides. The little house fly is the most economically important pest problem for poultry producers in California, and insecticides are by far the most frequently used control method.

Permethrin, naled, and methomyl are probably the most popular insecticides for control of the little house fly. Permethrin is used primarily as a residual spray and is the only pyrethroid registered for fly control in California poultry facilities. The highest resistance ratio encountered for permethrin, 9.0 at Cherry Valley, may be considered low in light of the intensive use of the insecticide at that location. Recent studies with cyromazine, a feed-through larvicide for use in caged-laying facilities, have shown extremely high populations of little house fly adults at a test facility despite nearly complete elimination of a larval population. Little house fly adults are obviously strong fliers and actively disperse. It must be noted that the Cherry Valley site is surrounded by several other large poultry facilities, which undoubtedly supply susceptible immigrants and delay the evolution of resistance through dilution.

Widely used in poultry facilities, methomyl-based poison bait stations are effective and may delay development of pesticide resistance.

Nevertheless, resistance ratios were higher for permethrin than for any other chemical tested. One reason may be the relatively long persistence of permethrin on treated surfaces, which would exert more effective selection toward resistance. Significant resistance problems with permethrin have been recently detected in house fly populations on southern California dairies.

Naled is a very popular, economical space-spray that provides quick knockdown of little house fly adults. Previous evaluations of the resistance levels of three little house fly populations collected from poultry facilities in southern Cali-

TABLE 1. Toxicity of various insecticides to the little house fly, *Fannia canicularis*, collected from various California localities

Insecticide	Strain	LD_{95} (95%FL)*	Slope (SE)†	Resistance ratio‡	Insecticide	Strain	LD_{95} (95%FL)*	Slope (SE)†	Resistance ratio‡
		μg/fly					μg/fly		
Naled	Cherry Valley	0.10 (0.08-0.13)	4.2 (0.5)	2.5	Methomyl	Cherry Valley	0.65 (0.57-0.81)	5.2 (0.7)	1.3
	Fresno	0.17 (0.14-0.23)	3.4 (0.4)	4.3		Fresno	2.03 (0.99-4.26)	2.4 (0.4)	4.0
	El Cajon	0.07 (0.01-0.32)	4.0 (1.3)	1.7		El Cajon	0.51 (0.45-0.63)	5.5 (0.7)	1.0
	Moorpark	0.07 (0.06-0.10)	3.5 (0.4)	1.7		Moorpark	0.83 (0.23-3.81)	2.1 (0.5)	1.6
	Susceptible	0.04 (0.03-0.04)	8.8 (0.8)	—		Susceptible	0.51 (0.45-0.63)	5.5 (0.7)	—
Dimethoate	Cherry Valley	0.09 (0.03-0.36)	1.9 (0.4)	2.3	Permethrin	Cherry Valley	0.72 (0.54-1.17)	2.4 (0.3)	9.0
	Fresno	0.17 (0.09-0.33)	3.3 (0.6)	4.3		Fresno	0.66 (0.49-0.98)	2.2 (0.2)	8.3
	El Cajon	0.06 (0.03-0.13)	2.2 (0.4)	1.5		El Cajon	0.39 (0.32-0.52)	2.9 (0.2)	4.9
	Moorpark	0.18 (0.05-0.64)	2.2 (0.5)	4.5		Moorpark	0.43 (0.36-0.53)	2.9 (0.2)	5.4
	Susceptible	0.04 (0.03-0.05)	3.9 (0.3)	—		Susceptible	0.08 (0.06-0.09)	4.6 (0.3)	—
Dichlorvos	Cherry Valley	0.08 (0.06-0.13)	3.0 (0.4)	1.0	Deltamethrin	Cherry Valley	0.26 (0.18-0.43)	2.0 (0.2)	3.3
	Fresno	0.18 (0.11-0.32)	2.7 (0.3)	2.3		Fresno	0.17 (0.13-0.24)	1.9 (0.1)	2.1
	El Cajon	0.06 (0.05-0.09)	2.9 (0.4)	0.8		El Cajon	0.15 (0.05-0.46)	1.5 (0.3)	1.9
	Moorpark	0.09 (.007-0.12)	3.4 (0.3)	1.1		Moorpark	0.25 (0.13-0.51)	2.8 (0.5)	3.1
	Susceptible	0.08 (0.07-0.09)	4.7 (0.4)	—		Susceptible	0.08 (0.06-0.13)	1.8 (0.1)	—

* FL = fiducial limits.
† SE = standard error.
‡ Resistance ratio = LD_{95} field strain/LD_{95} susceptible strain.

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The pupa, larva, and adult stage of little house fly, *Fannia canicularis*, an economically important pest in California poultry facilities.

fornia in 1967 showed less than ten-fold resistance to naled, in spite of intense selection by this and other organophosphate insecticides. The same pattern held for this evaluation, in which the Fresno population had the highest resistance ratio for naled (4.3). Naled had been used at the Fresno facility routinely since 1981 and had been sprayed every other day from early October 1983 up to two weeks before the January 2 collection.

The lowest resistance to any insecticide tested was to methomyl; the highest level was 2.4-fold in the Fresno strain. Methomyl is the active ingredient in many commercial fly baits and is the only carbamate currently registered to control flies. Methomyl-formulated bait is widely used by poultry producers and was especially plentiful at the Fresno facility. This degree of selection would be expected to produce higher resistance levels than were actually measured. The general lack of resistance could be related to the fact that methomyl is formulated in a bait and is a stomach poison. The flies may thus acquire quantities that may be lethal not only to susceptible individuals but also to moderately resistant flies (heterozygous individuals, containing equal numbers of resistant and susceptible genes). This renders the potential resistance functionally recessive and may delay or forestall its evolution. The same effect of methomyl has been determined for the house fly.

These observations emphasize the value of the use of poison baits as a resistance-delaying strategy. Many commercial methomyl-formulated baits also contain a synthetic house fly pheromone, Z-9-tricosene. The pheromone, however, is of no value in attracting the adults of the little house fly. University of California poultry farm advisors have developed a fly bait station that includes fermenting molasses as an attractant for little house flies, making fly baits a valuable control tactic.

It is interesting that the little house fly has such low resistance in spite of the intense insecticide pressure at some of the sites (Cherry Valley, Fresno). Several factors may be involved in keeping resistance levels low. The dilution of the resistant population with susceptible flies is undoubtedly very important. Also, the colonized field strains may have reverted to a more susceptible level through time. In southern California, little house fly adult populations tend to peak in April or May. The collection dates fell between January and early March, possibly preceding the period when insecticide use was at its peak.

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