INTEGRATED FLY CON

on poultry ranches

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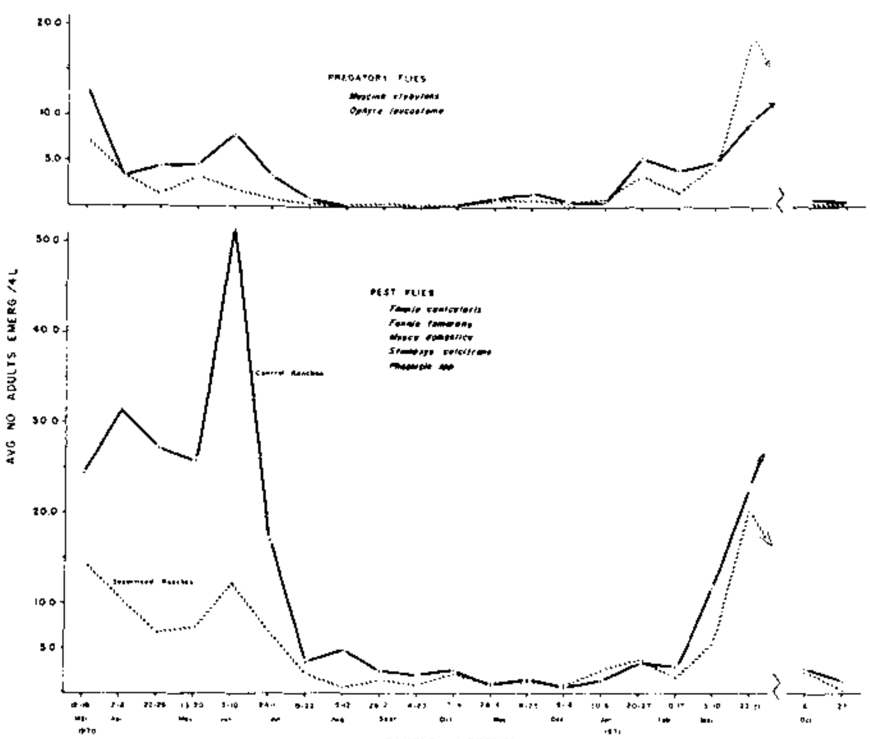
GRAPH 1. AVERAGE ADULT EMERGENCE DENSITY OF PEST AND PREDATORY FLIES FROM POULTRY MANURE SAMPLES ON 6 SUPERVISED AND 6 CONTROL RANCHES IN THE SAN BERNARDINO-CHINO AREA OF CALIFORNIA. MEANS ADJUSTED TO AREA OF CONTIGUOUS BREEDING HABITAT BY COVARIANCE ANALYSIS.

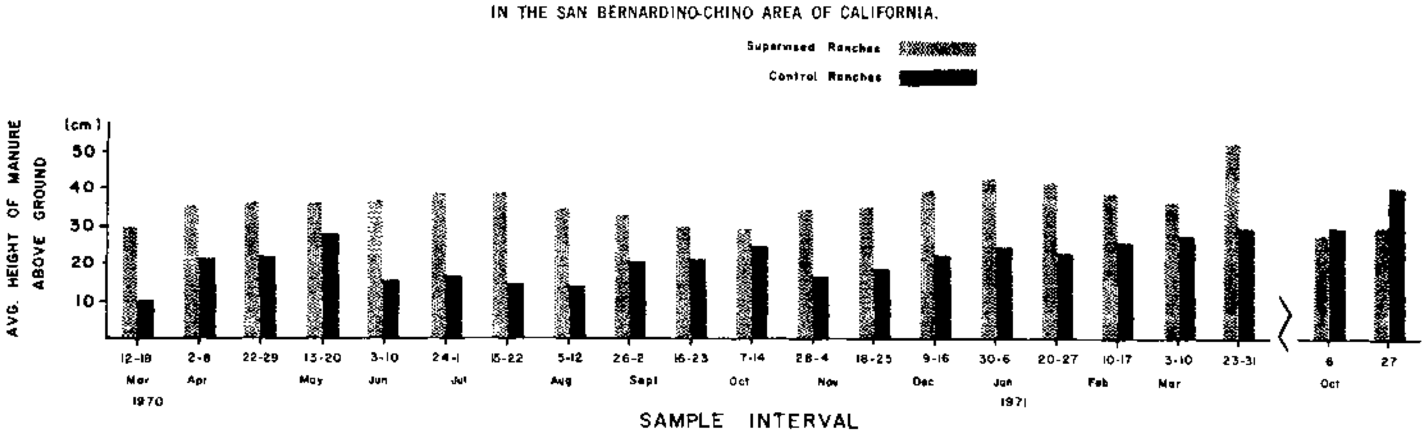


INTEGRATED BIOLOGICAL, cultural, and chemical control of noxious flies on poultry ranches includes the preservation of natural enemies, maintenance of a relatively stable manure habitat for breeding, and the periodic application of fly adulticides and parasite releases. All are used throughout California to keep fly population densities as low as possible. However, the relative merits of maintaining residual manure deposits and the use of periodic inoculative parasite releases have not been assessed. This study compares two management systems on caged layer poultry ranches in the San Bernardino-Chino area of California, a concentrated egg-producing region with an annual output of over 1.4 billion eggs.

Twelve poultry ranches were randomly selected from over 200 in the San Bernardino-Chino area of California. The length and breadth of the area that contained the 12 ranches measured about 16×45 km. Six of the ranches served as test ranches for supervised fly control and the other six as controls. All twelve ranches were roofed, had no walls, and contained laying hens in suspended wire cages along concrete aisles.

Routine fly control practices such as the maintenance of drip-free water systems, the production of coned manure

GRAPH 2. AVERAGE HEIGHT ABOVE THE GROUND OF POULTRY MANURE ON 6 SUPERVISED AND 6 CONTROL RANCHES IN THE SAN BERNARDINO-CHINO AREA OF CALIFORNIA.



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Significant reductions of seven species of flies breeding in poultry manure were attained over a 20-month period through procedures that favored the natural increase of predatory and scavenger arthropods and by periodic inoculative releases of four parasitic Hymenoptera. Parasite releases during springtime had an apparently greater direct effect on fly reduction than did similar releases in the summer. Autumn releases were not evaluated. A minimum manure height of 8–12 inches (20–30 cm) was considered essential for minimum fly production. The importance of manure stability and importations of additional beneficial species are also discussed.

deposits, and the use of poisoned adult fly baits at infrequent intervals were already being employed on all ranches (test and control) according to the directions of the San Bernardino County Health Department. Additionally, supervised ranches employed a careful manure removal plan where a minimum residual deposit of at least 6.5 inches (16 cm) was retained following every cleaning operation in order to sustain a maximum fly predator and scavenger population and also to hasten physical decomposition of the manure. The use of poisoned baits on control ranches averaged about one treatment every two months between April and September, and only about once during that time on the supervised ranches.

Three native and one imported species of parasitic Hymenoptera were released as adults 48 times in 1969 to 1970, at 7- to 15-day intervals on supervised ranches beginning on December 19, 1969. Average numbers of native species released per ranch were 11,549 *Spalangia endius* Walker; 21,095 of a combination of *Muscidifurax raptor* Girault & Sanders and *M. zaraptor* Kogan & Legner; and 35,590 of the imported Australian *Tachinaephagus zealandicus* Ashmead. In 1971 there was an average of 18,212 *Spalangia endius* released per week for 17 weeks, beginning on July 5.

Manure samples were taken every three weeks from March 12, 1970, through March 31, 1971, and October 6–27, 1971. A complete sample of all 12 ranches required 7–8 days, but was accomplished in one day on any given ranch. These samples were transferred to four screened emergence cages and incubated in the shade within the ranch proper for three weeks. All adult flies were identified and counted after they emerged into collection receptacles at the cage apices, or dropped back onto the manure itself.

Two series of fly puparia samples were taken on June 17, 1970, and October 12 and 13, 1971, to measure the impact of parasite releases on the respective ranches. A minimum of 1,000 puparia was gathered at random from each ranch by two independent groups of collectors, separated to species and incubated individually in the laboratory for six months to insure emergence of diapausing parasites.

Differences between the supervised and the control ranches were tested with covariance analysis where the area of available breeding habitat on any given ranch was the covariant. The range of contiguous breeding area was 811–5747 square meters among the 12 ranches, and the size of any given ranch directly influenced the number of flies produced.

For the present discussion flies are divided into two groups: pests and predators. Pest fly species present on all ranches during the study were *Fannia canicularis* (L.), *F. femoralis* (Stein), *Musca domestica* L., *Stomoxys calcitrans* (L.), and *Phaenicia* spp., with the first two species representing over 70% of the total numbers collected. Two predatory fly species, *Muscina stabulans* (Fallen) and *Ophyra leucostoma* (Wiedemann) were also present. The estimated emergence densities of the two groups of flies are shown in graph 1 for supervised and control ranches.

A great difference between supervised and control ranches is immediately apparent during spring and early summer periods, with supervised ranches sustaining the greatest reduction of both fly groups. During late summer and autumn months fly densities were comparatively low on both kinds of ranches, but supervised ranches still showed the greatest reduction. Spot checks using sticky tapes to estimate fly densities after March 1971 indicated the same trends as shown in 1970, and are indicated as arrows on the curves in graph 1.

Coincident investigations showed that a minimum manure depth of 8–12 inches (20–30.5 cm) produced the lowest fly emergence densities. That depth was related to greater habitat stability and the subsequent increased action of physicochemical effects and increased activity of scavenger, predatory, and parasitic arthropods. Indeed, supervised ranches averaged the highest manure deposits through most of the study (graph 2), although there was a tendency for control ranches to retain higher deposits in the latter part of the study in 1971. This is thought to have been due to a deliberate effort on the part of control ranch owners as they learned of the success on supervised ranches in 1970.

An appraisal of the impact of parasite releases on fly densities required a consideration of host emergence, degree of parasitization, and relative abundance of the parasitic species. These factors were compared at two critical periods: late spring (June) and early autumn (October), since each period with distinctive weather conditions characteristically favors different parasite species.

On the supervised ranches, an average

EMERGED ADULTS OF PARASITIC SPECIES FROM ALL HOST PUPARIA, SAN BERNARDINO COUNTY, CALIFORNIA.

Parasite*	Sample date	Percent parasite abundance†			
		Supervised ranches		Control ranches	
		abundance	% ♀♀	abundance	% ♀♀
Muscidifurax raptor Girault & Sanders	6/17/70	59.5	29.2	2.9	0
	10/12–13/71	82.7	54.1	75.3	59.6
Muscidifurax zaraptor Kogan & Legner	6/17/70	3.3	100	0	...
	10/12/–13/71	12.9	88.9	15.2	84.5
Spalangia endius Walker	6/17/70	21.5	69.2	45.7	87.5
	10/12–13/71	2.9	100	3.9	46.7
Spalangia cameroni Perkins	6/17/70	9.1	63.6	5.7	50.0
	10/12–13/71	0.5	100	4.9	52.6
Spalangia nigroaenea Curtis	6/17/70	0	..	0	...
	10/12–13/71	0.9	100	0.5	100
Aleochara castaneipennis Mannerheim	6/17/70	0	..	14.3	?
	10/12–13/71	0	..	0	..

* **Fannia canicularis** sustained additional parasitization by **Stilpnus anthomyiidiperda** (Viereck).
† Average of six ranches.

of 20% of the collected puparia had emerged as adults by mid-June in 1970, and an average of 42.5% had emerged by mid-October in 1971. On the control ranches, the figures were 35.4% and 37.2%, respectively. Also, on the supervised ranches, 22.5% of the adults emerged by mid-June were parasites, while 57.5% of the adults emerged by mid-October were parasites. On the control ranches, the figures were 12.9% and 62.8%, respectively.

A higher percent parasitization of all fly species on supervised ranches was also observed (95% significance). The *Muscidifurax* species appeared to be most responsible for parasitization up to this date, with no evidence of *Tachinaephagus zealandicus*, which is now known to be active only during winter (see table). In comparison, samples from supervised and control ranches in mid-October show that there was no apparent effect of the parasite releases, since the relative abundance of parasitic species did not change significantly. Final checks of parasitization on the respective ranches in the winter and spring of 1972 were unfortunately precluded by the imposition of a temporary quarantine against manure removal during an outbreak of Newcastle disease.

Predator and scavenger activity

Judging by their abundance and cohabitation with prey, predatory species that were most responsible for the destruction of immature flies during the study were the histerids, *Carcinops pumilio* Erichson and *Gnathoncus nanus* Scriba; the staphylinid, *Philonthus sordidus* Gravenhorst; the dermapteran, *Euborellia annulipes* (Lucas); the anthocorid, *Lyctocoris campestris* (F); and to a lesser extent the uropodid mites, *Fuscuropoda* spp. The latter species also appeared significant in the drying of fresh manure, although the mechanism by which this is accomplished is not yet fully understood. The macrochelid mites, generally regarded as significant in predation of filth flies, were poorly dispersed and did not attain densities great enough to be considered of major importance in predation when compared to the other predatory species present.

Scavengers were widely distributed, but, compared to predators, occurred at much lower densities. The most abundant species included the dermestid, *Dermestes maculatus* DeGeer; the scarab, *Aphodius lividus* (Olivier); and the tenebrionids, *Alphitobius diaperinus* (Panzer) and *Blapstinus* spp. The presence of these scavengers may have aided in the decomposition of manure, but otherwise their role in fly reduction is not established. Other predatory and scavenger species were encountered, but their densities were extremely low and probably were of no significance.

Periodic random samples revealed a significantly higher (at least double) activity of the above predators on supervised ranches throughout the entire study interval, which in turn is thought to have been partly responsible for the lower fly densities observed on these ranches. The interaction of the predatory complex with parasitic species has been shown in other studies to cause an overall decrease in fly density.

Conclusions

The stability of the manure habitat is probably one of the most important goals in integrated fly control, whether the manure is located on ranch premises or translocated to remote deposition sites. Relatively stable habitats acquire a diverse biota of beneficial predatory and scavenger species whose impact on flies seems to be proportional to their abundance and distribution. The species involved in predation vary according to geographical, climatic and seasonal differences. Consequently, their respective impact on flies also varies. These complexes can also be expected to change as additional beneficial species are introduced from abroad.

There also appears to be some merit in parasite releases made during springtime, when fly reproduction is favored through lower average density of predators and native parasites. The extent of fly control can be expected to increase as additional natural enemies are introduced from the native ranges of pest flies.

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Effect of

The dusky-veined walnut aphid, *Panaphis juglandis* (Goeze), appears in three distinct forms: alate viviparous parthenogenetic females, apterous oviparous females, and alate males. Commonly, only the alate viviparous parthenogenetic female form of this aphid can be found during the spring and summer months. The apterous oviparae and males appear during the fall. This suggests that temperature, day length, or host plant (English walnut) condition influences form.

Preliminary investigations indicate that long day length and high temperatures result in successive generations of alate viviparous parthenogenetic females, while short day length and high temperatures influence the production of males and apterous oviparous females. To further investigate the effects that photoperiod and temperature have on the biology of *P. juglandis*, a series of experiments was conducted at various photoperiod-temperature combinations. Each experiment was carried out in a single growth chamber at temperatures of 25 or 15° C. and photoperiods of 16 or 10 hours. A stock colony on seedling English walnuts was established and maintained in a modified refrigerator growth chamber. Lights in the chamber were operated for 16 hours daily; the temperature was maintained at approximately 25° C. The humidity in the chamber was not controlled, and it varied from 48 to 81% relative humidity. Under these conditions, only parthenogenetic reproduction perpetuated the generations of the stock colony. The parent aphids used in each study were the progeny of a single alate viviparous parthenogenetic female selected from this stock colony. A single parent aphid was placed in a leaf cage on a six-week-old walnut seedling growing in a clay pot, one parent on each of seven seedling trees. The leaf cages used on the leaflets were prepared from clear plastic pill boxes, with the bottoms removed, measuring 4.7 cm square × 1.7 cm deep. A large hole cut in the lids was covered with fine mesh organdy and provided ventilation. Each day that the parent aphid de-