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Mortality of Eggs and First-stage Larvae of the House Fly, *Musca domestica* L. (Diptera: Muscidae), in Poultry Manure[1]

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ABSTRACT: The activities of predators and scavengers found in accumulated poultry manure in Florida resulted in as much as a 97% reduction in the number of house flies recovered from artificially infested containers. The most abundant predators were *Carcinops pumilio* Erichson, *Solenopsis invicta* Buren, *Euborellia annulipes* (Lucas), and unidentified staphylinids, macrochelids and pseudoscorpions, while the most abundant scavenger was *Alphitobius diaperinus* (Panzer). These results suggest that competitors, scavengers, and generalist predators may be as important as parasitoids in reducing house fly numbers.

There is a rich biota of arthropods associated with accumulated poultry manure (Axtell, 1963; Legner, 1971; Legner and Olton, 1970; Peck and Anderson, 1969; Pfeiffer and Axtell, 1980). While themselves innocuous or nearly so, many of the members of this fauna through their activities as predators, competitors and scavengers may have a significantly deleterious impact on the various species of noxious Diptera which co-occur in the habitat. Legner (1971) demonstrated 53.4 to 99.45% mortality of *Musca domestica* L. attributable to the activities of predators and scavengers in poultry manure. Management of the habitat in a manner to conserve and augment these species has been recommended (Legner, 1971; Legner et al., 1975). Suggested practices include permitting manure to accumulate for at least several months, leaving a residual pad when manure is removed, and avoiding applications of broad-spectrum insecticides directly onto the manure.

Knowledge of the naturally-occurring mortality factors acting upon a pest population is essential to the development of an IPM program. Various species of the arthropod complex in poultry manure have been identified (Axtell, 1963; Legner, 1971; Legner and Olton, 1970; Peck and Anderson, 1969; Pfeiffer and Axtell, 1980), and predation of noxious Diptera by some of these species has been evaluated in the laboratory (Morgan et al., 1983; O'Donnell and Nelson, 1967; Peck, 1969; Rodriguez et al., 1970). However, with the exception of Legner's (1971) study, there have been few reported attempts to quantify in the field the impact of the complex of predators, competitors, and scavengers found in poultry manure. The present paper reports a quantitative assessment of mortality of eggs and first-stage larvae of the house fly in poultry manure in Florida.

Materials and Methods

The study was conducted at a caged-layer poultry farm in north central (Putnam Co.) Florida from 16 June to 19 November 1982. The poultry houses were open-

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[1] Mention of a commercial or proprietary product does not constitute an endorsement of this product by the USDA.

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sided, and each house had either two or four rows of cages. The poultry droppings accumulated in ca. 45 cm deep pits surrounded by concrete walks. The manure was rototilled every 1–2 weeks to enhance drying. At the time of each test, the manure had accumulated for ca. 4–6 months and was ca. 30–50 cm deep. In early July, treatment of the poultry feed with the fly larvicide (growth regulator) Larvadex® (CIBA-GEIGY Corp., Greensboro, North Carolina) was initiated by the farm manager to suppress an increasing population of house flies. The larvicide was subsequently used as a feed additive throughout the remaining period of this study. Because there were no untreated areas, the effect of this treatment on the non-target organisms was not evaluated.

Seven separate tests were conducted on seven different dates. Each test compared the survival of house flies exposed to the ambient biota with the survival of flies protected from the predators, scavengers and competitors. For each test twenty-four 300-ml (11 cm diam by 4 cm) cups containing a fly-rearing medium (Morgan et al., 1981) were infested with 100 eggs of the house fly. The sides of 12 of the cups were painted with Tack-Trap® (Animal Repellents, Inc., Griffin, Georgia) to exclude predators and scavengers. The remaining 12 cups were left unpainted so that the predators and scavengers would be able to enter these cups. The 24 cups were divided into four replicates of three painted and three unpainted cups. Three unpainted cups were placed so that the top of the cup was approximately flush with the surrounding manure to facilitate access by the predators and scavengers. Three painted cups were placed on top of the manure alongside the unpainted cups. The four replicates were located on adjacent areas of the manure within one house. Each replicate was covered with a 90 by 90 by 15 cm cage. The sides of the cage were solid boards and the top was 14 by 18 mesh standard insect screen. This cage excluded wild flies and prevented droppings from falling into the cups. The seven separate tests were conducted in a total of 5 different houses.

After 48 hr, the cups were recovered and held in the laboratory until the surviving flies had pupated. The cups were tightly covered with organza to prevent the mature larvae from crawling out of the cups to pupate. The puparia were then separated by flotation in water and counted. The average number of puparia recovered from the three painted and the three unpainted cups in each replicate was compared by a t-test for paired observations. The per cent reduction in the number of flies was also determined.

With the exception of the first two tests, a composite ca. 4-liter sample of manure was taken from the immediate vicinity of each group of cups. A 1-liter subsample of each large sample was then processed through a Berlese funnel for 24 hr. The first two tests (16 and 21 June) were conducted in the same house, and one sample only was taken for the two dates. Known predaceous species as well as the most abundant scavengers found in these samples were counted.

Results and Discussion

The mean per cent reduction in the number of house flies recovered ranged from 1% to 97%, and significant values were obtained for four of the seven individual tests (Table 1). Although there was not a statistically significant reduction for the other three tests (28 June, 9 and 15 July), in all cases fewer flies were recovered from the cups to which the surrounding complex of arthropods

Table 1. Mean number of puparia recovered and mean per cent reduction of house flies when predators were present or excluded from cups containing artificial diet and 100 house fly eggs each. Containers were placed on accumulated poultry manure, Putnam Co., Florida, 1982.

Date of test	Mean no. puparia recovered[a]		Mean % reduction[a]	t^b
	Predators excluded	Predators present		
16 June	59	2	97	7.48**
21 June	71	10	85	8.18**
28 June	80	69	14	3.01 ns
9 July	71	35	51	3.12 ns
15 July	63	62	1	0.37 ns
10 November	51	14	70	4.47*
19 November	77	44	44	4.86*

[a] Average of 4 replicates. Each replicate had 3 cups with predators excluded and 3 cups with predators present.

[b] t-test for paired observations: ns = not significant; * = significant, $\alpha = 0.05$; ** = highly significant, $\alpha = 0.01$.

had access. Despite the extreme range of values observed for the various individual tests, a total average reduction of 52% demonstrates the importance of this arthropod complex as a mortality factor.

The effectiveness of Tack-Trap as a barrier was not specifically tested. However, we did not notice any extraneous arthropods in the painted cups at the end of the test. It is possible that adults flew into and out of the cups, but this would have been as likely to occur in painted as in unpainted cups and therefore probably had little effect on the results. Under laboratory conditions, small fly larvae do not tend to crawl out of these cups. It therefore seems unlikely that small larvae escaped from the cups used in this field test.

There may have been some difference in temperature between the buried cups and those on the surface. However, the buried cups were not completely surrounded by manure, and because the cups were small, the medium in the unburied cups was very close to the same level as the medium in the buried cups. It seems unlikely that temperature differences were great enough to have had a significant effect. Also, we noticed no difference at the end of the test in the moisture content of the medium in the buried vs. unburied cups.

Most studies on the management of synanthropic flies in accumulated poultry manure have emphasized the importance of pupal parasitoids normally found attacking the flies. While the complex of predators, scavengers and competitors in poultry manure has been well described qualitatively (Axtell, 1963; Legner, 1971; Peck and Anderson, 1969; Pfeiffer and Axtell, 1980), the capacity of this complex to suppress development of fly populations has not been sufficiently quantified in situ. Legner et al. (1975) noted positive correlations between fly host density and the density of some common predators, although the activity of any given species varied seasonally. Our study and Legner's (1971) suggest that mortality caused by predators, competitors, and scavengers could equal or exceed parasitism if expressed as real (generation) mortality. For example, in four of the tests (16 and 21 June, 9 July, and 10 November) mortality of eggs and small larvae exceeded 50%. In such cases, this would constitute the largest component of real mortality regardless of subsequent mortality of the cohort. It has been

Table 2. Predators and scavengers encountered in accumulated poultry manure in north central Florida.

Species	Mean number adults per liter of poultry manure					
	June		July		November	
	16 and 21	28	9	15	10	19
Predators						
Histeridae						
Carcinops pumilio Erichson	47.5	48.8	70.5	110.5	29	81
Other	0.5					
Staphylinidae	0.3	0.3	1	4.8	0	0
Formicidae						
Solenopsis invicta Buren	32.5	0.5	1.3	1.3	44	0
Labiduridae						
Euborellia annulipes (Lucas)	0.8	4.3	0.3	0.8	0	0.5
Pseudoscorpionida[a]	14.8	16.5	25.8	29.3	3.5	5.5
Macrochelidae[b]	6.0	2.3	1.8	0.5	6.0	4.5
Scavengers						
Tenebrionidae						
Alphitobius diaperinus (Panzer)	42.0	38.3	107.3	104.5	85	60

[a] All stages.
[b] Adult females only.

demonstrated for other systems that predation on the early stages (eggs and small larvae) of a pest by generalist predators represents the major contribution to real mortality (e.g., Bisabri-Ershadi and Ehler, 1981; Ehler, 1977).

The most abundant predators recovered from the manure samples were the histerid, *Carcinops pumilio* Erichson, the formicid, *Solenopsis invicta* Buren, the labidurid, *Euborellia annulipes* (Lucas), acarines of the family Macrochelidae, and unidentified pseudoscorpions (Table 2). The tenebrionid, *Alphitobius diaperinus* (Panzer) was also abundant. Although these insects are probably not predators of house flies, their activities in the manure likely have a significant deleterious effect on the flies. When the cups were recovered, several contained numerous tenebrionids and no or few house flies.

Many of the predators encountered in this study are probably generalists, and their potential as fly predators has been suggested by various authors. For example, Peck (1969) tested predation by *C. pumilio* and several species of staphylinids on house flies in the laboratory. Morgan et al. (1983) observed that *C. pumilio* mutilated house fly eggs in addition to those eggs the beetles consumed. Jenkins (1964) lists pseudoscorpions and Dermaptera as predators of house flies.

Macrochelid mites are regarded as important predators of fly eggs (Axtell, 1963; O'Donnell and Nelson, 1967; Rodriguez, 1970). These mites were not particularly abundant in our samples. There are several possible explanations for their low numbers: samples were taken from dry areas of the manure not favorable for fly oviposition and possibly unfavorable for the mites as well; rototilling could be disadvantageous to the mites; and application of the larvicide to reduce the fly population could have caused the mites to be reduced by starvation if they do not utilize alternate prey.

Pimentel (1955) found that ants killed up to 91% of the filth flies developing in domestic garbage. *Solenopsis invicta* is an abundant species in northern Florida, and we have frequently observed workers carrying fly larvae and pupae to nests near poultry manure. Although it is generally regarded as a pest of humans, *S. invicta* has also been shown to cause significant mortality to pests of cotton (Sterling, 1978), pecan (Dutcher and Sheppard, 1981), and soybean (Krispyn and Todd, 1982).

Rototilling the manure to enhance drying is commonly practiced in poultry houses in Florida. The effect of this habitat disruption on the arthropod complex has not to our knowledge been investigated. Any adverse effect on beneficial organisms may be offset by mortality to the flies as a result of mechanical stirring and drying of the substrate.

Because the poultry feed for all the houses was treated with a fly larvicide, we were not able to determine the effects of the treatment on non-target organisms by comparing treated and untreated areas. Larvadex® is included in the group of insecticides classified as insect growth regulators and is not a broad-spectrum toxicant. Application of the larvicide apparently did not adversely affect the non-target species because the abundance of predators and scavengers was as great or greater following initiation of the treatment as before (July and November vs. June, Table 2).

In a study such as this, it is not easy to separate the effects of predators, competitors, and scavengers. Although we have assumed that most of the mortality can be attributed to predation, we do not discount the activities of competitors and scavengers. Regardless of the agents responsible, significant benefit in terms of suppression of fly populations is derived from this complex. Our results support Legner's (1971), and we strongly concur with his recommendations to manage the habitat in a way that conserves this complex.

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