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Sustained Releases of *Muscidifurax raptor* (Hymenoptera: Pteromalidae) for House Fly (*Musca domestica*) Control in Two Types of Caged-Layer Poultry Houses[1]

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ABSTRACT

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An indigenous strain of *Muscidifurax raptor* Girault and Sanders, a house fly pupal parasite, was mass-reared and released at 2 caged-layer poultry farms, one with narrow (California) houses and one with a high-rise house, from May through Nov. 1978. Weekly releases of 40,000 parasites in the narrow caged-layer houses resulted in a significant increase in the overall rate of parasitism of house fly pupae during the fly season in comparison to similar farms without releases; and a 2-fold increase in both the rate of parasitism and the proportion of *M. raptor* in the parasite population from that of the previous year; while parasitism rates and *M. raptor* populations remained essentially unchanged at farms receiving no parasite releases. In the high-rise house, weekly releases of 40,000 *M. raptor* resulted in a significant increase in the rate of parasitism of house fly pupae in the latter half of the fly season and a higher proportion of *M. raptor* in the parasite population in comparison to similar farms receiving no parasite releases. Concurrent with parasite releases, a reduction in the fly population occurred in the narrow caged-layer houses; however, no reduction was evident in the high-rise caged-layer house.

Limited successes with inoculative releases of *Muscidifurax raptor* Girault and Sanders for house fly, *Musca domestica*, control have been reported from California (Legner and Dietrick 1974, Olton and Legner 1975) and Denmark (Mourier 1972); however, the effect of sustained releases of *M. raptor* on fly populations has not been evaluated.

A survey of house fly parasites in North Carolina revealed that *M. raptor* was the predominant parasite species at caged-layer poultry farms in the Coastal Plain, Piedmont and Mountain regions and was the only parasite species active in the manure throughout the year (Rutz and Axtell 1980). Because of its predominance and year-round activity, we considered *M. raptor* a promising candidate for sustained releases as a biological fly control agent at poultry farms in North Carolina. Therefore, we mass-reared and released weekly during an entire fly season an indigenous strain of *M. raptor* in 2 types of caged-layer poultry houses and demonstrated increases in the rate of parasitism of fly pupae and slight reductions in fly populations.

Methods and Materials

Parasite Mass-rearing

M. raptor used in the releases were from a colony established in 1977 from several thousand house fly pupae collected from poultry manure in both the Coastal Plain and Piedmont regions of North Carolina. The parasites were reared in Plexiglas cages similar in construction to those described by Morgan et al. (1978) with a few modifications. The cages were 70 × 40 × 40 cm with 2, 8 cm diam ventilation ports and a 28 × 20 cm access opening at the front. The ventilation ports, one on each side of the cage, were covered with 40-mesh screen and the access opening was covered with a muslin sleeve. The cages were held in a dark room at 26.7°C and 60±10% RH. In each cage ca. 80,000 house fly pupae (24–48 h old) were placed into 2–3, 33 × 23 × 3-cm, aluminum trays and exposed to 22,000 mated parasites (19–21 days old). *M. raptor* maintained ca. a 1.2:1 male to female ratio; therefore, ca. 10,000 female parasites were present in each cage. Each cage was left undisturbed for 9 days. During this period adult flies emerged from any unparasitized pupae and died. The exposed pupae were then poured from the aluminum trays into a 16-mesh sieve and gently agitated within the cage to remove any living parasites, usually <1000/cage. This was the only practical way we found to separate living parasites from the exposed pupae since *M. raptor* was not readily attracted to a light source. The exposed pupae were then placed in a forced-air separator (Bailey 1970) to remove all empty puparia and dead adult flies from the heavier parasitized pupae. Each cage produced an average of 62,500 parasitized pupae. Three aliquots, 200 pupae each, were taken from each batch (cage) of parasitized pupae and held in the laboratory to determine percentage adult emergence and the male:female ratio. The parasitized pupae, including the aliquots, were held at 26.7°C and 60±10% RH. until they were either taken to the field for release or used for parasite culturing. Percentage adult emergence from the parasitized pupae ranged from 67 to 86% with an overall average of 77%.

House flies (CSMA strain) were reared in a room maintained at 26.7°C and 60±10% RH. Adult flies were reared in stainless steel 16-mesh screen cages (39 × 31 × 31 cm) with ca. 3000–5000 flies/cage. Sugar, 15–20 lumps in a plastic dish, was placed into the cage as food. Another plastic dish containing tissue paper soaked in evaporated milk diluted 2:1 with water was also placed into the cage. Eggs were laid on the moist tissue paper in the milk dish. Milk dishes were changed every 24 h. Eggs were collected from the tissue paper and transferred to a beaker of water where the viable eggs sank to the bottom. Eggs were then transferred from the beaker

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with a medicine dropper to a graduated centrifuge tube containing water. The eggs were allowed to settle in the tube to achieve an accurate egg volume to be added to the larval medium. Larval medium was prepared by mixing 480 ml (135 g) wheat bran, 480 ml (145 g) CSMA fly larval medium (Ralston Purina Co., St. Louis, MO), 650 ml water and 1.5 g of yeast. To reduce rearing costs, wheat bran was substituted for CSMA as a fly larval medium. Several proportions of CSMA:wheat bran, including an all wheat bran medium, were tested; however, an equal volume of CSMA:wheat bran was found to be most satisfactory. The medium was mixed thoroughly in a 2-liter (17 cm diam × 12 cm) plastic container (larval container). Eggs (0.7 ml) were added to the medium and the container was then covered with organdy cloth and a plastic lid with 12 cm diam ventilation opening. Pupation was completed in 7 days and occurred in the upper, drier portion (top 2–4 cm) of the medium. This portion of the medium containing the fly pupae was removed from the container and placed in a forced-air separator. The separator blew off all the remaining larval medium leaving the heavier dry pupae. Approximately 4000 pupae were produced/rearing container. Complete development from egg to adult house fly required 10–11 days. New house fly cages were started by placing a rearing container containing pupae into a clean cage for 2–5 days until all flies emerged. Eggs were collected from each adult cage for 7–10 days after which the flies were discarded.

Field Sites

Six caged-layer poultry farms, 3 with narrow houses all located in the Coastal Plain (Craven and Lenoir Co.) and 3 with high-rise houses all located in the Piedmont (Chatham Co.) region of North Carolina were included in the study. Narrow or "California" houses were open-sided structures (35–75 m long × 3 m wide; 3000–5000 bird capacity) with 1 row of 2-tiered wire stairstep cages, 2–3 birds/cage, suspended 1–1.5 m above a dirt floor and running the length of the house along each side of a single concrete aisle. High-rise houses, sometimes referred to as deep-pit houses, were 2-story open-sided structures, 122 m long × 9–12 m wide with a 20,000–25,000 bird capacity. Birds were held on the 2nd story in rows of 3 or 4-tiered wire stairstep cages (2–3 birds/cage) which ran the length of the house along each of 3–4 wooden aisles. The 1st floor was used for manure accumulation.

Parasite Release and Monitoring

Parasites were released at 2 farms, one with narrow houses and one with a high-rise house. The other 4 farms were used as check farms, i.e., no parasites were released. Bird capacity at each of the parasite release farms was ca. 20,000 caged-layers, 4 houses with 5000 birds/house at the farm with narrow houses and 1 house with 20,000 birds at the high-rise farm. The parasites were released as 14–16 day old (3–4 days prior to adult emergence) parasitized house fly pupae which were sprinkled on the drier areas of the manure where fly pupation was likely to naturally occur. An average of 40,000 parasites, i.e., an average of 77% adult parasite emergence from 52,000 parasitized pupae, were released each week at each of the farms beginning May 22, 1978 and continuing through Oct. (22 wk). Parasite populations were monitored weekly at release and check farms by pupal bag and pupal sample collection techniques. Pupal bags were made of 14-mesh screen and each contained 25 laboratory-reared house fly pupae (< 1 day old). On each farm 10 bags were left for 7 days on the periphery of the manure at a depth of 5–10 cm. After 7 days these bags were collected and new bags were placed in the manure at new locations within the houses. Samples of naturally occurring house fly pupae (ca. 100–500 pupae/sample; 10 samples/farm) were also collected weekly from the manure. Pupae from the pupal bags and naturally occurring pupae were held in the lab for ca. 35–40 days at 26.7°C and 60±10% RH to allow time for parasite development and emergence.

Fly Population Monitoring

Sticky fly ribbons, spot cards and baited traps were used to monitor fly populations at the release and check farms. Sticky ribbons (8/house) were hung from the roof supports at equal intervals along the midline of the narrow houses. In the high rise houses, 10 sticky ribbons were hung from the roof supports, 3 each at equal intervals at both ends of the house and 2 each at equal intervals along the sides of the house. The number and species of flies collected on the ribbons, which were hung for 2 days during each week, were counted and the ribbons discarded. Spot cards (7.5 × 12.5 cm white file cards; 10/house) were positioned similarly to the sticky ribbons in the narrow houses and high-rise houses. The cards remained in position on the roof supports for 7 days each week after which the fecal and regurgitation spots were counted and new cards installed. Baited traps were 3.8-liter plastic milk jugs with four 5 cm diam holes cut in the upper part of the sides to allow entrance of the flies which were attracted to 25 g of Super Golden Malrin® fly bait placed on the inside bottom of the jug. Five traps were suspended with wire (30 cm) from roof supports at equal intervals directly above the cages in each narrow house. In the high-rise houses, 10 traps were used. On the 2nd floor of the high-rise house, 6 traps were hung with 30-cm wire from the roof supports, 2 at equal intervals on each end and one midway down each side of the house. On the 1st floor, 4 traps were hung with 60-cm wire from the floor supports of the 2nd floor, 2 at equal intervals on each end of the house. The baited traps were left for 2 days each week and then the number and species of flies collected were counted. The traps were cleaned and fresh bait was added at the beginning of each sample period. Some farms with narrow houses had 3 or 4 houses; however, the ribbons, spot cards and baited traps were installed in only 2 of the houses.

As part of the integrated fly management program, the farmers at the parasite release and check farms were requested to follow recommended manure management and chemical control practices known to be effective in reducing fly populations (Axtell 1970 a,b). Baits (Super Golden Malrin) were used at the parasite release and check farms throughout the fly season while insecticides (pyrethrin mists) were used only on 2 occasions (May 23 and June 13) at the high-rise parasite release farm but

used weekly from June through Sept. at check farm 3 (narrow houses).

Results and Discussion

Narrow Houses

At the farm having narrow caged-layer houses and the weekly releases of *M. raptor* there was an overall significantly higher percent parasitism of exposed house fly pupae than at the 2 similar check (no parasite release) farms (Table 1). The higher rate of parasitism at the release farm was significant for both the entire fly season (June–Oct.) and the latter half of the season (Aug.–Oct.) being 40.9 and 47.9%, respectively. Parasitism at check farms 2 and 3 averaged 29.0 and 22.9%, respectively, during June–Oct.; 37.2 and 26.7% during Aug.–Oct. Parasitism at the release farm increased from 24.4% in June to 52.0% in Oct. while at the 2 non-release farms parasitism increased from 11.5 to 40.0% and 1.4 to 22.3% during the same period. However, there was a peak of 45.7% in Sept. at check farm 2 and 35.2% in Aug. at check farm 3. In spite of the significant overall increase in the rate of parasitism at the release farm as compared to the check farms, there were monthly significant differences only in Sept. and Oct. and those were in the case of only 1 of the 2 check farms.

Data on the rates of parasitism at these farms was obtained in 1977 prior to the parasite release study. Parasitism in June–Oct. 1977 was 26.1 and 22.0% at check farms 2 and 3, respectively, which are similar to the rates in 1978; the rate of parasitism at the release farm was only 20.4% in 1977 vs. 40.9% in 1978. Thus the parasitism rate concurrent with the sustained releases of *M. raptor* was about double the rate occurring in the previous year.

The species of parasites recovered were determined at the 3 farms in 1977, prior to the releases, and in 1978 during the releases of *M. raptor*. As shown in Table 2, the percentage of *M. raptor* among all parasites recovered was nearly double in 1978 (87.2%) compared to 1977 (46.4%) at the farm where *M. raptor* was being released weekly in 1978. Concurrently, at the 2 check farms there were only slight changes in the percentage of *M. raptor* recovered in the 2 yr. Although there were variations, the proportions of other less abundant species of parasites were similar at the 3 farms and these included *Spalangia cameroni* Perkins, *S. endius* Walker,

Table 1.—Parasitism of laboratory-reared *Musca domestica* pupae placed in manure at poultry farms with and without (check) the weekly release of *Muscidifurax raptor* and with either narrow or high-rise type of caged-layer houses.

	% parasitism[a,b]							
							Mean	
	May	June	July	Aug.	Sept.	Oct.	Jun.–Oct.	Aug.–Oct.
Narrow houses				(Craven & Lenoir Co.)				
Farm 1 parasite release[c]	0.8a	24.4a	32.9a	46.6a	44.6a	52.0a	40.9a	47.9a
Farm 2 no release (check)	0.8a	11.5a	17.5a	27.7a	45.7a	40.0a	29.0b	37.2b
Farm 3 no release (check)	2.5a	1.4a	31.3a	35.2a	21.5b	22.3b	22.9b	26.7c
High-rise houses				(Chatham & Alamance Co.)				
Farm 4 parasite release[c]	0.4a	3.8a	30.2a	41.2a	38.3a	25.0a	28.2a	34.6a
Farm 5 no release (check)	6.8a	14.7a	31.7a	34.6a	22.4a	9.7b	22.0ab	21.4b
Farm 6 no release (check)	—	14.0a	12.7a	14.8b	19.0a	7.2b	13.6b	13.8b

[a] Percent parasitism is based on the total number of parasites emerging from 1000 exposed house fly pupae/farm/mo (25 pupae/14-mesh screen bag; 10 bags/farm/wk).
[b] For each type of house, means in the same column followed by the same letter are not significantly different from each other (5% level)(Duncan's multiple range test).
[c] 40,000 *M. raptor* released/week at each farm from June through Oct.

Table 2.—Relative abundance of house fly pupal parasites collected from manure at narrow house caged-layer poultry farms with and without (check) the weekly release of *Muscidifurax raptor*.

	Relative abundance %[a]					
	Farm 1 Parasite release[b]		Farm 2 No release (check)		Farm 3 No release (check)	
	1977	1978	1977	1978	1977	1978
Muscidifurax raptor	46.4	87.2	78.8	70.3	73.1	84.4
Spalangia cameroni	11.4	2.9	8.6	11.6	4.8	10.5
S. endius	11.2	2.7	3.1	4.5	7.2	1.8
S. nigra	0.0	0.0	0.4	0.0	0.0	0.0
S. nigroaenea	27.7	4.2	8.6	2.5	9.6	2.2
Pachycrepoideus vindemiae	3.3	3.0	0.5	11.1	5.3	1.1
Total no. of parasites collected	1197	7028	571	2068	711	2454

[a] Relative abundance percentages are based on total number of parasites recovered during June through Oct. at each farm by both pupal bag (25 laboratory-reared pupae/14-mesh screen bag, 10 bags/farm/mo, 1977 and 10 bags/farm/wk 1978) and pupal sample (ca. 100–500 naturally occurring pupae/sample, 10 samples/farm/mo, 1977 and 10 samples/farm/wk, 1978) collections.
[b] *M. raptor* (40,000/wk) released during June through Oct. in 1978.

S. nigroaenea Curtis and *Pachycrepoideus vindemiae* (Rondani). About 3 times as many parasites were recovered from the release farm (7028) than from the check farms (2068 and 2454) in 1978. Thus, the weekly releases of *M. raptor* in the narrow caged-layer houses resulted in: an increase in the overall rate of parasitism of house fly pupae during the fly season in comparison to similar farms receiving no parasite releases; an increase in the rate of parasitism at the release farm to about double the rate of the previous year while the rate remained essentially unchanged at the farms receiving no parasite releases; and an increase in the proportion of *M. raptor* in the parasite population to about double that of the previous year while the proportion remained essentially unchanged at the farms receiving no parasite releases.

Did the sustained releases of *M. raptor* significantly affect the fly populations in the narrow caged-layer houses? Fly populations at the parasite release farm, as sampled by 3 methods (sticky ribbons, baited traps and spot cards), were equal to or greater than those at the 2 non-release farms during May through July (Table 3). In Aug. the fly population declined sharply at the parasite release farm and remained generally lower than the check farms for the remainder of the season. Appreciable numbers of flies occurred at the release farm, however, and perhaps releases of greater numbers of *M. raptor* earlier in the season would have been effective in preventing the early (June–July) build-up of the fly population.

High-Rise Houses

The effects of sustained releases of *M. raptor* in a high-rise caged-layer house were less obvious than in the narrow type houses. Evaluation in the high-rise houses was difficult due to poor management (especially leaking water systems causing wet manure), the occurrence of large populations of soldier fly larvae (*Hermetia illucens* L.) in the manure and large numbers of adult black garbage flies, *Ophyra leucostoma* (Wiedemann) which complicated the fly sampling. However, even under these adverse conditions, at the farm having the weekly releases of *M. raptor* there was during Aug.–Oct. a significantly higher percent parasitism of exposed house fly pupae than at the 2 similar check (no parasite release) farms (Table 1). Parsitism at check farms 5 and 6 was 21.4% and 13.8%, respectively, while it was 34.6% at the release farm (farm 4). These parasitism rates are lower than those reported above for the narrow houses. For the entire season (June–Oct.) the rate of parasitism at the release farm (28.2%) was significantly higher than at only 1 of the 2 check farms (13.6 and 22.0%). Parasitism at the release farm increased from 3.8% in June to 25.0% in Oct. but was highest (41.2%) in Aug. Similarly the parasitism rate at check farm 5 changed from 14.7% in June to only 9.7% in Oct. but was highest (34.6%) in Aug. At check farm 6 parasitism changed from 14.0% in June to only 7.2% in Oct. and the highest rate during the season was only 19.0% (in Sept.).

The percentage of *M. raptor* among all parasites recovered at the release farm was 84.6% which was considerably higher than at the check farms (56.0 and 41.0%) (Table 4). Data are not available on the parasite populations at these farms in the year prior to the releases. The other parasites recovered from these high-rise houses included the same species which were recovered from the narrow houses. Up to 4x as many parasites were recovered from the release high-rise farm (2924) than from the check farms (1132 and 720).

Thus, the weekly releases of *M. raptor* in the high-rise house resulted in an increase in the rate of parasitism of house fly pupae in the latter half of the fly season (Aug.–Oct.) in comparison to similar farms receiving no parasite releases, and a higher proportion of *M. raptor* in the parasite population at the release farm than at the farms receiving no parasite releases.

Fly populations in the high-rise houses were variable and generally declined during the season (Table 5). There was no clear difference between the fly popula-

Table 3.—*Musca domestica* populations at narrow house caged-layer poultry farms with and without (check) weekly releases of *Muscidifurax raptor*.

	Avg no. flies/(ribbon & trap) or no. spots/card[a,b]						
	May	June	July	Aug.	Sept.	Oct.	Mean Aug.–Oct.
Sticky ribbons							
Farm 1 parasite release[c]	34a	219a	413a	43a	120a	44a	71a
Farm 2 no release (check)	18a	50b	203b	176b	109a	65a	121b
Farm 3 no release (check)	27a	89b	398a	187b	180b	88a	157b
Baited traps							
Farm 1 parasite release[c]	8a	113a	243a	9a	21a	9a	13a
Farm 2 no release (check)	2a	3b	59b	119b	35a	9a	58a
Farm 3 no release (check)	4a	28b	266a	248c	103b	30a	136b
Spot cards							
Farm 1 parasite release[c]	28a	146a	241a	16a	31a	13a	21a
Farm 2 no release (check)	4a	26a	64b	58b	32a	22a	39a
Farm 3 no release (check)	12a	42b	180ab	104c	60b	29a	68b

[a] Averages from 16 sticky ribbons, 10 baited traps and 20 spot cards/farm /wk. Ribbons and traps were exposed for 2 days/wk, spot cards for 7 days/wk.
[b] For each sampling technique, means in the same column followed by the same letter are not significantly different from each other (5% level) (Duncan's multiple range test).
[c] *M. raptor* (40,000/wk) released during June through Oct.

Table 4.—Relative abundance of house fly pupal parasites collected from manure at high-rise caged-layer poultry farms with and without (check) the weekly release of *Muscidifurax raptor*.

Species	Relative abundance %[a]		
	Farm 4 Parasite release[b]	Farm 5 No release (check)	Farm 6 No release (check)
Muscidifurax raptor	84.6	56.0	41.0
Spalangia cameroni	4.2	14.7	35.3
S. endius	0.8	2.1	2.7
S. nigra	0.6	0.0	0.4
S. nigroaenea	1.6	1.2	14.6
Pachycrepoideus vindemiae	8.2	26.0	6.0
Total no. of parasites collected	2924	1132	720

[a] Relative abundance percentages are based on the total number of parasites recovered during June through Oct. at each farm by both pupal bag (25 laboratory-reared pupae/14 mesh screen bag, 10 bags/farm/wk) and pupal sample (ca. 100–500 naturally occurring pupae/sample, 10 samples/farm/wk) collections.
[b] *M. raptor* (40,000 wk) released during June through Oct.

tions (house flies and black garbage flies) throughout the season at the parasite release farm and check farm 6 receiving no releases. The apparently lower fly numbers at check farm 5 were attributed to the lack of fresh manure caused by the removal of chickens from the house in mid-June. Chickens were not re-stocked until mid-Aug. These fly population data could not be validly compared with data from farms 4 and 6 where chickens were present at all times; therefore, they were not included in the statistical analyses. Perhaps earlier releases of greater numbers of *M. raptor* along with substantial improvements in management to achieve dryer manure would have been necessary to demonstrate reductions in the fly populations in these high-rise houses.

The results of our sustained releases demonstrate that *M. raptor* abundance and parasitism of the house fly can be increased in caged-layer poultry houses in North Carolina. In our study this was more apparent in narrow houses than in a high-rise house which we attribute principally to the poor management of the high-rise houses, i.e., wet manure resulting from leaking water systems, poor air circulation due to underutilization of fans, and poor drainage. Wet manure enhanced fly populations and reduced overall parasite effectiveness. Our results also indicate that earlier releases of greater numbers of *M. raptor* is advisable in order to prevent the early-season build up of large fly populations in both types of caged-layer houses.

It should be noted that we used an indigenous strain of *M. raptor*. Since parasites must be climatically adapted to the area where they are released (Legner and Olton 1971, Tingle and Mitchell 1975), it is possible that a parasite species acquired from one geographic region will not be effective when released in another climatically different area. Unless it is established experimentally that the parasites are effective in the area of introduction, shipping insectary-grown parasites from one climatic region to another is a questionable procedure.

As pointed out by Legner (1977), generalizations about the effectiveness of various species of house fly parasites are risky due to great variation among strains in their responses to different habitat and climatic conditions. Species of *Spalangia* (particularly *endius*) have been favored for rearing and release for house fly control but we have demonstrated that an appropriate strain of *M. raptor* can be an effective agent also. Our results using releases of *M. raptor* together with previous results using releases of *S. endius* alone (Morgan and Patterson 1977, Morgan et al. 1975a,b, 1976) and in combination with *M. raptor, M. zaraptor* Kogan and Legner and *Tachinaephagus zealandicus* Ashmead (Legner and Dietrick 1974, Olton and Legner 1975) and releases of only *P. vindemiae* (Pickens et al. 1975) demonstrate the potential for use of all these species of parasites for reducing fly populations under certain habitat and climatic conditions. Sustained releases of appropriate strains of one or more of these species is a logical part of a fly

Table 5.—Fly populations (*Musca domestica* and *Ophyra leucostoma*) at high-rise caged-layer poultry farms with and without (check) weekly releases of *Muscidifurax raptor*.

	Avg no. flies/(ribbon & trap) or no. spots/card[a,b]						
	May	June	July	Aug.	Sept.	Oct.	Mean Aug.–Oct.
Sticky ribbons							
Farm 4 parasite release[c]	410a	292a	348a	100a	11a	71a	64a
Farm 5 no release (check)	188a	118b	6[d]	4	8	35	14
Farm 6 no release (check)	—	313a	269a	118a	44b	83a	85a
Baited traps							
Farm 4 parasite release[c]	35a	267a	352a	350a	61a	83a	179a
Farm 5 no release (check)	177a	240a	27[d]	31	25	38	29
Farm 6 no release (check)	—	114a	223a	228a	41a	84a	126a
Spot cards							
Farm 4 parasite release[c]	64a	69a	49a	18a	6a	9a	12a
Farm 5 no release (check)	44a	61a	4[d]	6	9	10	8
Farm 6 no release (check)	—	103a	97a	34a	17a	28b	27b

[a] Averages from 10 sticky ribbons, 10 baited traps and 10 spot cards/farm/wk. Ribbons and traps exposed for 2 days/wk, spot cards for 7 days/wk.
[b] For each sampling technique, means in the same column followed by the same letter are not significantly different from each other (5% level) (Duncan's multiple range test).
[c] *M. raptor* (40,000/wk) released during June through Oct.
[d] Data from farm 5 not included in statistical analyses because of uncommonly low fly populations caused by the absence of chickens in the house from June 15 through Aug. 10.

management program for caged-layer poultry houses. Such a program must include, however, maximum effort to reduce fly breeding by manure management practices which promote drying and large populations of a variety of indigenous natural enemies of flies.

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REFERENCES CITED

Axtell, R. C. 1970a. Integrated fly control program for caged-poultry houses. J. Econ. Entomol. 63: 400–5.

1970b. Fly control in caged-poultry houses: Comparison of larvicidng and integrated control programs. Ibid. 63: 1734–7.

Bailey, D. L. 1970. Forced air for separating pupae of house flies from rearing medium. Ibid. 63: 331–3.

Legner, E. F. 1977. Temperature, humidity and depth of habitat influencing host destruction and fecundity of muscoid fly parasites. Entomophaga 22: 199–206.

Legner, E. F., and E. J. Dietrick. 1974. Effectiveness of supervised control practices in lowering population densities of synanthropic flies on poultry ranches. Ibid. 19: 467–78.

Legner, E. F., and G. S. Olton. 1971. Distribution and relative abundance of dipterous pupae and their parasitoids in accumulations of domestic animal manure in the southwestern United States. Hilgardia 40: 505–35.

Morgan, P. B., and R. S. Patterson. 1977. Sustained releases of *Spalangia endius* to parasitize field populations of three species of filth breeding flies. J. Econ. Entomol. 70: 450–2.

Morgan, P. B., R. S. Patterson, G. C. LaBrecque, D. E. Weidhass and A. Benton. 1975a. Suppression of a field population of houseflies with *Spalangia endius*. Science 189: 388–9.

Morgan, P. B., R. S. Patterson, G. C. LaBrecque, D. E. Weidhass, A. Benton, and T. Whitefield. 1975b. Rearing and release of the house fly pupal *Spalangia endius* Walker. Environ. Entomol. 4: 609–11.

Morgan, P. B., R. S. Patterson, and G. C. LaBrecque. 1976. Controlling house flies at a dairy installation by releasing a protelean parasitoid, *Spalangia endius* (Hymenoptera: Pteromalidae). J. Ga. Entomol. Soc. 11: 39–43.

Morgan, P. B., G. C. LaBrecque, and R. S. Patterson. 1978. Mass culturing the microhymenopteran parasite *Spalangia endius* (Hymenoptera:Pteromalidae). J. Med. Entomol. 14: 671–3.

Mourier, H. 1972. Release of native pupal parasitoids of house flies on Danish farms. Vidensk. Meddr dansk naturrh. Foren. 135: 129–37.

Olton, G. S., and E. F. Legner. 1975. Winter inoculative releases of parasitoids to reduce houseflies in poultry manure. J. Econ. Entomol. 68: 35–8.

Pickens, L. B., R. W. Miller, and M. M. Centala. 1975. Biology, population dynamics, and host finding efficiency of *Pachycrepoideus vindemiae* in a box stall and a poultry house. Environ. Entomol. 4: 975–9.

Rutz, D. A., and R. C. Axtell. 1980. House fly parasites associated with poultry manure in North Carolina. Environ. Entomol. (In press).

Tingle, F. C., and E. R. Mitchell. 1975. Seasonal reproduction of *Muscidifurax raptor* and *Spalangia endius* under simulated Florida conditions. Environ. Entomol. 4: 383–4.

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