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INVASION AND ESTABLISHMENT OF HOUSE FLY, *MUSCA DOMESTICA* (DIPTERA: MUSCIDAE), PARASITES (HYMENOPTERA: PTEROMALIDAE) IN NEW CAGED-LAYER POULTRY HOUSES[1]

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Abstract. *Muscidifurax raptor, Spalangia* undescribed sp. near *drosophilae, S. cameroni, Pachycrepoideus vindemiae* and *Nasonia vitripennis* invaded manure at new caged-layer poultry houses near Raleigh, North Carolina within 8 weeks after the chickens were placed in the houses. After these houses were in operation for 16 weeks, *Spalangia endius* and *S. nigroaenea* were also recovered. *Spalangia nigra* was the only parasite species new to the collections at these houses during the 2nd year of operation (1978). During the 2-year study, *M. raptor, P. vindemiae* and *S. cameroni* ranked 1st, 2nd and 3rd, respectively, in relative abundance of all parasites collected. *M. raptor* and *P. vindemiae* were abundant from June through November. *S. cameroni* was prevalent in late summer and fall, while the other *Spalangia* species and *N. vitripennis* were most abundant during the summer. Weekly sustained releases of a Florida strain of *S. endius* did not increase house fly pupal parasitism at these poultry houses; only 3 specimens of *S. endius* were recovered during 3 months (August–October) of releases of 18,000 parasites per week.

Several indigenous house fly (*Musca domestica* L.) parasite species, normally active in manure at caged-layer poultry farms, play an important role in managing fly populations (Rutz & Axtell 1980a). Releases of indigenous parasites may further enhance their effectiveness (Morgan et al. 1975a, b, Olton & Legner 1975, Pickens et al. 1975, Rutz & Axtell 1980b).

In order to improve our understanding of the population dynamics of indigenous house fly parasites, we determined the sequence of invasion, relative abundance and seasonal abundance of parasites in manure at new caged-layer poultry houses during their first 2 years of operation. In addition, during the 2nd year of the study we evaluated the effect of sustained releases of a Florida strain of *Spalangia endius* Walker on house fly parasitism at these houses.

MATERIALS AND METHODS

The study was conducted at 2 narrow caged-layer poultry houses. These houses were open-sided structures (40 m long × 3 m wide; 1000 bird capacity each) with 1 row of 2-tiered wire stairstep cages, 2 or 3 birds per 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. Construction of the houses was completed in March 1977, with chickens being placed in the houses in late April.

The houses were located at a poultry research farm of North Carolina State University near Raleigh in the Piedmont region of the state. This research farm had several broiler houses, a controlled-environment wide-span caged-layer house with a flush manure-removal system and a broiler-breeder house. Although a potential problem, there was little evidence of fly production occurring or having occurred in these existing houses. The principal fly and fly parasite producing areas in the general vicinity appeared to be a beef cattle farm and a dairy farm, both located within 0.5–1.0 km of the new poultry houses.

Parasite populations at the new caged-layer houses were monitored from March 1977, approximately 2 months before chickens were placed in the houses, through November 1978 by the pupal bag collection technique. Pupal bags were made of 14-mesh (ca 6 mesh/cm) screen and each contained 25 laboratory-reared house fly pupae (<1 day old). In 1977, 16 bags were positioned weekly in each house on the periphery of the manure at a depth of 5–10 cm where naturally occuring fly pupation was likely to take place. After being exposed for 7 days, the bags were collected and new bags were positioned similarly in the manure at new locations; 8 bags per house were used in 1978. Parasite populations at the nearby beef and dairy cattle farms were also monitored weekly by the pupal bag technique (5–10 bags per farm per week) from March through June 1977. The exposed pupae from the pupal bags were held in the laboratory for ca 45–60 days at 26.7 °C and 60 ± 10% RH to allow time for parasite development and emergence.

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TABLE 1. Sequence of invasion, relative abundance and seasonal abundance of parasitic Hymenoptera that emerged from house fly pupae placed in poultry manure at 2 new narrow caged-layer poultry houses at Research Farm Unit 2, NCSU, Raleigh (1977).

SPECIES	% RELATIVE ABUNDANCE AND (IN PARENTHESES) SEASONAL ABUNDANCE*, **										TOTAL NO. COLLECTED
	Mar.–Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean ***	
Muscidifurax raptor		80.0 (0.2)	51.3 (5.2)	74.3 (42.4)	63.1 (20.0)	49.1 (11.1)	82.1 (15.1)	53.5 (5.9)		66.1	2213
Spalangia cameroni			0.4 (0.4)		17.0 (49.4)	4.2 (8.7)	1.7 (2.9)	38.3 (38.6)		7.2	241
S. undescribed sp. near *drosophilae*		20.0 (6.7)		1.1 (93.3)						0.4	15
S. endius					7.8 (94.8)	0.6 (5.2)				1.7	58
S. nigroaenea					7.5 (74.6)	2.8 (19.7)	1.0 (5.6)			2.1	71
Pachycrepoideus vindemiae			37.2 (11.6)	24.6 (42.8)	4.6 (4.4)	43.3 (29.9)	15.2 (8.6)	8.2 (2.7)		21.7	725
Nasonia vitripennis			11.1 (100.0)							0.8	25
Total no. parasites collected/month	0	5	226	1263	702	501	408	243	0		3348
% parasitism†	0.0	0.1	7.0	39.4	17.7	15.7	10.3	7.7	0.0	13.6	

* Relative abundance values are the percentage of that species out of the total number of parasites (all species) collected each month from 3200 exposed pupae (25 pupae/bag, 16 bags/house/wk, 2 houses).

** Seasonal abundance values are the percentage of the total 10-month collection of that species recovered during that month.

*** Based on the total number of parasites collected over the 10-month survey period.

† Percentage of exposed house fly pupae from which adult parasites emerged.

In addition to parasite monitoring with pupal bags, attempts were made to collect naturally occurring fly pupae (pupal samples) from the manure at the new poultry houses and nearby beef and dairy cattle farms, but adequate numbers could not be collected regularly. A previous study at caged-layer poultry houses (Rutz & Axtell 1980a) indicated that both the pupal bag and pupal sample parasite monitoring techniques collected similar parasite species. Therefore, the pupal bag technique was considered adequate for monitoring the invasion and occurrence of parasites at the new poultry houses.

Sustained releases of *S. endius* were made weekly during August through October in 1978 at these houses. *S. endius* was obtained from the Insects Affecting Man and Animals Research Lab, USDA, SEA, in Gainesville, Florida. The parasites were shipped as parasitized pupae which were scheduled to emerge on alternate days, 4 to 8 days after shipment. On the day of their arrival the parasitized pupae were taken to the poultry houses and poured at 8 nearly equidistant locations within each of the houses on the drier peripheral areas of the manure where flies usually pupate. Aliquots of 200 pupae each were taken from each batch of pupae with different scheduled emergence dates and held in the laboratory for 30 days at 26.7 °C and 60 ± 10% RH to determine the percentage adult emergence and the male:female sex ratio. Parasites emerged from an average of 54% (range 24–80%) of the parasitized pupae, with 71% being females. With this aliquot information we determined that an average of 18,000 parasites were released each week.

RESULTS AND DISCUSSION

Seven house fly parasite species, listed here according to their sequence of invasion into new caged-layer poultry houses were collected in 1977 (TABLE 1): *Muscidifurax raptor* Girault & Sanders, *Spalangia* undescribed sp. near *drosophilae* Ashmead (identified by Z. Bouček, British Museum of Natural History), *S. cameroni* Perkins, *Pachycrepoideus vindemiae* Rondani, *Nasonia vitripennis* Walker, *S. endius* Walker and *S. nigroaenea* Curtis. No parasites were recovered from the new houses during March and April in the absence of chickens and manure. After the chickens were in the houses and the manure accumulated for about 2 weeks

TABLE 2. Relative abundance and seasonal abundance of parasitic Hymenoptera that emerged from house fly pupae placed in poultry manure during the 2nd year of operation of 2 new narrow caged-layer poultry houses at Research Farm Unit 2, NCSU, Raleigh (1978).

SPECIES	% RELATIVE ABUNDANCE AND (IN PARENTHESES) SEASONAL ABUNDANCE*,**									TOTAL NO. COLLECTED
	Jan.–Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Mean ***	
Muscidifurax raptor			55.3 (9.8)	75.6 (50.4)	57.7 (22.2)	32.7 (8.1)	11.8 (4.7)	27.3 (4.8)	48.8	1109
Spalangia cameroni			0.5 (0.6)	0.1 (0.6)	9.4 (24.8)	27.3 (46.6)	3.4 (9.3)	14.9 (18.0)	7.1	161
S. endius†			2.5 (62.5)		0.5 (25.0)		0.2 (12.5)		0.4	8
S. nigra					1.9 (100.0)				0.4	8
S. nigroaenea			0.5 (14.3)	0.1 (14.3)	0.7 (42.8)	0.4 (14.3)	0.2 (14.3)		0.3	7
Pachycrepoideus vindemiae		100.0 (0.1)	16.2 (3.6)	20.2 (16.5)	29.8 (14.1)	39.6 (12.1)	84.3 (41.2)	57.7 (12.4)	39.6	901
Nasonia vitripennis			24.9 (62.0)	4.0 (38.0)					3.5	79
Total no. parasites collected/month	0	1	197	740	426	275	440	194		2273
% parasitism††	0.0	0.1	12.3	38.4	26.6	17.2	22.9	16.9	22.3	

* Relative abundance values are the percentage of that species out of the total number of parasites (all species) collected each month from 1600 exposed pupae (25 pupae/bag, 8 bags/house/wk, 2 houses).

** Seasonal abundance values are the percentage of the total 11-month collection of that species recovered during that month.

*** Based on the total number of parasites collected over the 11-month survey period.

† 18,000 *S. endius* released weekly from August through October.

†† Percentage of exposed house fly pupae from which adult parasites emerged.

(May), *M. raptor* and *S.* undescribed sp. near *drosophilae* parasitized 0.1% of the exposed fly pupae. Parasitism increased to 7% in June with *M. raptor, S. cameroni, P. vindemiae* and *N. vitripennis* now active in the manure. *S. endius* and *S. nigroaenea* were first observed in August, approximately 3 months after chickens were placed in the houses.

M. raptor was recovered from pupal bags placed at the nearby beef and dairy cattle farms, indicating that those farms were possible sources of at least 1 species of fly parasite invading the new poultry houses. Because of difficulty in recovering the exposed pupal bags, parasite monitoring was discontinued at these nearby farms in June.

M. raptor, with a mean relative abundance of 66.1%, was the most abundant parasite collected at the new poultry houses. *P. vindemiae* was second in overall relative abundance, followed by *S. cameroni, S. nigroaenea, S. endius, N. vitripennis* and *S.* undescribed sp. near *drosophilae.*

With regards to seasonal abundance (TABLE 1), *M. raptor* and *P. vindemiae* were most abundant in July but both species were prevalent during June through November. *S. cameroni* was abundant in late summer and fall, while *S. endius* and *S. nigroaenea* were most abundant in August.

Parasitism increased from 0.1% in May to a high of 39.4% in July, followed by a steady decrease to 7.7% in November with an overall average of 13.6% (TABLE 1). No parasites emerged from pupae exposed in December.

In January of 1978 the old chickens were removed and new chickens were placed in the houses. During this same period, the manure was partially cleaned out, leaving a 15–20 cm manure base as a refuge for overwintering parasites.

During the 2nd year of operation, no parasites emerged from pupae exposed during January through April and only 1 species (*P. vindemiae*) was recovered from the pupae exposed during May (TABLE 2). *M. raptor, S. cameroni, P. vindemiae,* and *N. vitripennis,* as in 1977, were active in the manure in June. In 1978, however, a few *S. endius* and *S. nigroaenea* were also collected in June, 2 months before they were observed in the manure in 1977.

As in 1977, *M. raptor, P. vindemiae* and *S. cameroni* were, respectively, the 1st, 2nd and 3rd most abundant parasite species collected (TABLE 2). *N.*

TABLE 3. Fly populations at 2 new (in 1977) narrow caged-layer poultry houses at Research Farm Unit 2, NCSU, Raleigh.

	AVG NO. FLIES/RIBBON/2 DAYS/WK OR NO. SPOTS/CARD/WK*							
	May	June	July	Aug.	Sept.	Oct.	Nov.	MEAN
1977								
Musca domestica	4.3	26.7	29.2	35.6	48.6	44.6	27.1	30.9
Fannia spp.**	15.5	18.4	3.2	0.2	0.0	0.0	0.0	5.3
Ophyra leucostoma	0.5	0.7	0.2	0.1	0.1	0.1	0.1	0.2
Spot card counts	12.7	28.1	32.1	37.2	37.8	21.1	19.1	26.9
1978								
M. domestica	71.9	199.5	191.1	150.1	79.7	59.2	43.9	113.6
Fannia spp.	18.3	37.8	77.3	31.1	25.4	10.6	0.5	28.7
O. leucostoma	5.1	5.8	4.8	16.7	2.4	1.1	0.0	5.1
Spot card counts	75.2	162.7	106.6	130.2	78.3	43.9	24.1	88.7

* Averages of 8 sticky ribbons and 8 spot cards/house/week for 2 houses. Ribbons were exposed for 7 days/week in 1977; however, numbers presented are 2-day averages of the 7-day counts.

** Primarily *F. canicularis* in May, June and early July in 1977 and 1978 and *F. femoralis* from mid-July through October in 1978.

vitripennis, S. endius, S. nigra Latreille, and *S. nigroaenea* were also collected. *S. nigra* was new in the collections in 1978; however, no specimens of *S.* undescribed sp. near *drosophilae* were collected in 1978.

Seasonal abundance of the different parasite species in 1978 (TABLE 2) was similar to that observed both in these houses in 1977 and at caged-layer poultry farms in operation for several years in the same geographic region (Rutz & Axtell 1980a). *M. raptor* and *P. vindemiae* were prevalent during June through November, with *M. raptor* being most abundant in July; however, in 1978, *P. vindemiae* was most abundant in October. *S. cameroni* was again abundant during August through November. Too few (7–8) *S. endius, S. nigra* and *S. nigroaenea* were recovered to justify any statement about their seasonal abundance. *N. vitripennis* was only collected in June and July. The total number of parasites collected in 1978 was less than that collected in 1977 because the number of pupal bags placed in each house was reduced from 16 per week in 1977 to 8 per week in 1978. However, the average number of parasites collected per bag was greater in 1978 than 1977.

Parasitism rates in 1978 (TABLE 2) were similar to those observed in 1977 during the first 7 months of the year but were generally higher in 1978 during August through November. Parasitism in 1978 again peaked in July, with an overall average (May through November) of 22.3%. The July parasitism peaks in 1977 and 1978 and overall average parasitism in 1978 at these new houses were also similar to parasitism (42.4% peak parasitism in July and an overall average of 26.5%) observed at caged-layer poultry farms in operation for several years in the same geographic region (Rutz & Axtell 1980a).

During the 2-year period of parasite monitoring, there were appreciable fly populations at the new poultry houses, which should have been sufficient to sustain indigenous parasite populations. *Musca domestica* was the predominant fly at the poultry houses in 1977 and 1978 (TABLE 3). *Fannia canicularis* (L.), *F. femoralis* Stein and *Ophyra leucostoma* (Wiedemann) were also collected. Fly populations all generally increased 4- to 5-fold from 1977 to 1978.

Sustained releases of *S. endius,* which were initiated during the 1st week of August and continued through October, had no apparent effect on house fly pupal parasitism (TABLE 2). Only 3 specimens of *S. endius* were recovered from the exposed pupae during the release period. Since the parasitized pupae were poured on the surface of the manure (a recommended procedure for release of commercially available parasites), they were susceptible to predators, particularly ants. Ants were occasionally observed in and on the poultry manure; however, they did not appear numerous enough to be a significant threat to the parasitized pupae. In addition, in our release studies with *M. raptor* (Rutz & Axtell 1980b), we used this same method of parasite release with no apparent predation problem. Although predation is a potential problem in need of consideration when parasites are released, it is doubtful that predators greatly affected the performance of *S. endius* in this investigation. Biased sampling techniques were also considered but dismissed as a possible cause for the failure of these *S. endius* releases. In a statewide house fly parasite survey in which we

used both pupal bag and pupal sample parasite monitoring techniques (Rutz & Axtell 1980a), we found that the pupal sample technique, i.e., collection of naturally occurring pupae from the poultry manure, produced relatively more *Spalangia* than the pupal bag technique; however *Spalangia* specimens were readily collected by both monitoring techniques. In the present study, large numbers of *Spalangia* (primarily *S. cameroni*) were recovered with pupal bags in both 1977 and 1978. This indicates that the low numbers of *S. endius* in the collections both before and after the releases were initiated were not due to biased sampling techniques but due to their absence in the manure. Legner & Olton (1971) and Tingle & Mitchell (1975) emphasized the need for house fly parasites to be climatically adapted to the area where releases are to be made. It is possible that climatic conditions in Florida and North Carolina were dissimilar enough to adversely affect the Florida strain of *S. endius* when released in North Carolina. Our field conditions (climatic and/or habitat) may have greatly reduced or even prevented adult emergence from the parasitized pupae (adult emergence, observed only in the laboratory, averaged 54%) or possibly the parasites, once emerged, failed to engage in activities necessary for parasitism. It is also possible that the colonization of the Florida strain reduced its adaptation to field conditions. Whatever the cause(s), the failure of our parasite release experiment demonstrates the need for more data on the factors affecting the efficacy of laboratory-reared parasites for house fly control.

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