

Parasitic Natural Regulatory Agents Attacking *Musca domestica* L. in Puerto Rico

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INTRODUCTION

The occurrence of houseflies in relatively low numbers in Puerto Rico when compared to other parts of the world of similar latitude and climatic conditions, stimulated a search for natural enemies there in 1963 for future use in biological control tests in California. Previous workers had been attracted to the Island to determine why houseflies fail to build up in great numbers. Recently Pimentel (10)² studying *Musca domestica* L. and other filth-breeding species, attributed 91-percent control to ants, primarily affected by the fire ant, *Solenopsis geminata* (F.). His work was conducted in unstable, artificial breeding sites of urban areas (e.g. garbage cans).

The primary purpose of this investigation was the acquisition of living parasites for culture in the Department of Biological Control, University of California, Riverside, Calif.; therefore, housefly breeding habitats were investigated throughout Puerto Rico. Potential predators and associated Diptera breeding in the same habitat were recorded, but this discussion will be limited to the parasitic forms found attacking *Musca domestica* only.

METHODS AND MATERIALS

Samples of breeding media consisting primarily of cow, chicken, and pig dung found on large commercial ranches and small farms throughout Puerto Rico, were taken in two principle ways: 1, Breeding media were recovered from the field and confined in the laboratory in sealed gallon and quart polyethylene containers fitted with inverted, screened funnels and screened plastic collection receptacles (fig. 1). Houseflies, associated Diptera, their parasites, and some predators were trapped alive in the receptacles. Streaks of honey on the screens provided ample nourishment

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² Italic numbers in parentheses refer to Literature Cited, p. 375-6.

for Hymenoptera trapped in this way, and these could be collected at intervals for exposure to larval and pupal cultures of *Musca domestica* for parasitization. Other material was preserved for identification. 2, Housefly pupae were handpicked directly from manure in the field, or the



FIG. 1.—Polyethylene container fitted with inverted screened funnel and screened plastic receptacle for collection of housefly parasites emerging from manure.

breeding media were retrieved in polyethylene bags and viable dipterous pupae and potential predators were gathered in the laboratory, using the water float-off method of Moore (8).

Fresh viable pupae were generally lighter in color and denser than older individuals which had formed in a previous generation. Housefly and other dipterous pupae were segregated according to species and shipped to Riverside where they were incubated at room temperature for a minimum

of 6 months in screened plastic containers for emergence of hosts and parasites. Unemerged pupae at the end of the 6-month period were dissected for the presence of dead parasites, partly developed hosts, and hosts where no development occurred. The last category included pupae which showed no distinguishable adult morphological structures and probably included individuals with genetic defects and those which had succumbed to pathogens.

The second method gave fairly reliable data on the percentage of host pupae parasitized in any given collection site and also yielded a greater number of potential predatory forms which, by nature of their fossorial habit, would not be trapped by the first method. Final parasitization figures obtained by the second method, of course, included pupae which died from causes other than parasitism, so that a true percentage parasitization figure is difficult to obtain, especially as one has no way of telling which pupae were suitable for parasitization at the time the female parasites were active in a given area.

A third method whereby about 4,000 larvae and pupae were intermittently exposed in the field failed to produce any parasites.

The study was conducted in the spring and summer of 1963 in two separate phases. The first phase was from March through May and the second from August through September. Collections were made intermittently during these two periods.

RESULTS AND DISCUSSION

Immature stages of houseflies were usually difficult to find in any particular site and medium. A thorough search through a manure pile, or beneath chicken coops, would more often than not reveal an extremely localized housefly infestation; many times this area would represent less than 1 percent of the apparent breeding-sites available. Certain situations that seemed favorable for housefly breeding were invariably nonproductive, such as in corrals where cattle were allowed to stamp in the manure and presumably crush immature stages, or in the field, where frequent rains would disperse manure to a point where the sun would readily dry it out.

Six hymenopterous parasites were discovered attacking *Musca domestica* L. in natural breeding sites in Puerto Rico. One species of Diapriidae, *Trichopria undes*. sp.; and four Pteromalidae, *Spalangia endius* Walker, *Spalangia stomoxysiae* Girault, *Spalangia nigroaenea* Curtis, *Muscidifurax raptor* Girault and Sanders, and *Pachycrepoideus vindemmiae* (Rond.) were involved. These species are listed in table 1 together with notations on their effectiveness in parasitizing houseflies in the respective localities.

The *Trichopria undes*. sp. (determined by C. F. W. Muesebeck) was located at Maní in cow dung on August 23; of 80 host pupae sampled,

TABLE 1.—Emergence of parasites and development of *Musca domestica* L. from viable field-collected puparia in Puerto Rico, in 1963

| Species | Collection site and date | Hosts sampled and media | Emerged para- | Emerged | Dead | Un- | Dead | Live | Parasite sex ratio |
|---|--------------------------|-------------------------|---------------|---------|----------------|-------------------------|-------------------------|------------|--------------------|
| | | | sites | adults | partial adults | devel-oped ¹ | para-sites ² | para-sites | |
| | | | Number | Number | Number | Number | Number | Percent | |
| Diapriidae | | | | | | | | | |
| <i>Trichopria</i> undes. sp. | Maní, Aug. 23 | 80, cow dung | 13 | 18 | 40 | 9 | 0 | 16.2 | 12:1 |
| Pteromalidae | | | | | | | | | |
| <i>Muscidifurax raptor</i> G. and S. | Aibonito, Aug. 28 | 72, chicken dung | 11 | 36 | 15 | 5 | 5 | 15.3 | 11:0 |
| | Parguera, Sept. 9 | 73, cow dung | 2 | 38 | 27 | 5 | 1 | 2.7 | 1:1 |
| <i>Pachycrepoideus vindemmiæ</i> (Rond.) | Río Piedras, Apr. 10 | Emerged, cow dung | — | — | — | — | — | — | — |
| <i>Spalangia endius</i> Walk. | Río Piedras, Apr. 11 | Emerged, cow dung | — | — | — | — | — | — | — |
| <i>Spalangia nigroaenea</i> Curtis and <i>Spalangia endius</i> Walk. ³ | Hormigueros, Apr. 16 | 20, cow dung | 2 | 8 | 8 | 2 | 0 | 10.0 | 1:1 |
| | Hormigueros, Aug. 14 | 65, cow dung | 3 | 35 | 20 | 7 | 0 | 4.6 | 2:1 |
| | Mayagüez, Aug. 15 | 55, chicken dung | 10 | 41 | 4 | 0 | 0 | 18.2 | 1:1 |
| | Rincón, Aug. 23 | 109, cow dung | 14 | 41 | 30 | 21 | 3 | 12.8 | 13:1 |
| | Maní, Aug. 23 | 80, cow dung | 13 | 18 | 40 | 9 | 0 | 16.2 | 12:1 |
| | La Fe, Aug. 27 | 224, cow dung | 4 | 52 | 113 | 54 | 1 | 1.8 | 3:1 |
| | Aibonito, Aug. 28 | 72, chicken dung | 1 | 36 | 25 | 5 | 5 | 1.4 | 1:0 |
| | Parguera, Sept. 9 | 118, cow and pig dung | 15 | 48 | 47 | 8 | 0 | 12.7 | 15:0 |
| | Lajas, Sept. 9 | 90, cow dung | 6 | 49 | 24 | 11 | 0 | 6.7 | — |
| | Sabana Grande, Sept. 11 | 184, cow dung | 37 | 92 | 48 | 5 | 2 | 20.1 | — |
| | Villa Pérez, Sept. 16 | 416, cow dung | 79 | 196 | 110 | 27 | 4 | 19.0 | — |
| | Guayanilla, Sept. 16 | 8, cow dung | 2 | 2 | 1 | 3 | 0 | 25.0 | — |
| <i>Spalangia stomoxysiae</i> Gir. | Río Piedras, Apr. 11 | Emerged, cow dung | — | — | — | — | — | — | — |
| | Aibonito, Mar. 14 | Emerged, chicken dung | — | — | — | — | — | — | — |

¹ No visible adult structures present.

² Includes unidentified teneral adults and immature stages.

³ These 2 species treated combined because of difficulty in taxonomic separation.

16.2 percent were parasitized. The female:male sex ratio was 12:1. West, in 1951 (14), noted a diapiiid parasite, *Ashmeadropria* sp., parasitizing 10 percent of the houseflies in Puerto Rico in the 1930's; and Muesebeck (personal communication) referred to one previous unnamed recovery of this species from Puerto Rico. A culture of the Puerto Rican diapiiid was obtained at Riverside, but subsequently became lost by a mishap.

Muscidifurax raptor Girault and Sanders (determined by B. D. Burks) parasitized 15.3 percent of 72 housefly pupae collected from chicken dung at Aibonito on August 23, and 2.7 percent of 73 pupae collected from cow dung at Parguera on September 9. The sex ratios for the two discoveries were all females and 1:1, respectively. The Puerto Rico Report (12) lists *M. raptor* as having been reared from a puparium of *M. domestica* collected at Hormigueros on June 21, 1937, which was the first record of this species from the Island.

Since its successful culture in Riverside, virgin females have been observed to produce bisexual progeny at room temperature. The phenomenon is quite common among the parasitic Hymenoptera according to Clausen (3) and Flanders (4) and (5), but has never been reported with this species.

Pachycrepoideus vindemmiae (Rond.) (determined by B. D. Burks) emerged from housefly-infested cow dung collected at Río Piedras on April 10, and subsequently parasitized housefly puparia in the laboratory. West, in 1951, reported *P. dubius* (a synonym) as a true housefly parasite active in Puerto Rico; but it is not known whether the present individual would have behaved similarly under natural conditions, since it was not collected from host puparia directly. This species has been recently reported as a natural housefly parasite in Nebraska (McCoy (7)). Culture at Riverside was not obtained.

Spalangia endius Walker and *Spalangia nigroaenea* Curtis (both determined by B. D. Burks) were by far the most active species found during the survey. They were collected from all survey sites from April through September, and parasitized from 1.4 to 25 percent of houseflies breeding naturally (table 1). Their close morphological similarity made it impossible to separate these two species when cultures were being established, hence data referring to them will be treated combined. Sex ratio of the combined parasitic females: males ranged from 1:1 to 13:1 and all females.

West, in 1951, reported *Spalangia endius* as already occurring in Puerto Rico and he and Pinkus (11) cited cases where it parasitized other hosts such as *Stomoxys calcitrans* L. and *Haematobia irritans* L. in other areas. Lindquist (6) reported on occurrences of over 40-percent parasitization of dung-infesting Diptera by *S. endius* in Texas. Richardson (13) gave an

excellent description of its development as a solitary parasite of housefly pupae. *Spalangia nigroaenea* has not been previously associated with houseflies on the Island. Both of these species are now in culture at Riverside.

A final parasite, *Spalangia stomoxysiae* Girault, which may be synonymous with *S. endius* (Boucek (1), but which was identified as a separate species by B. D. Burks and was so catalogued by Peck (9), was active in housefly-infested chicken dung at Aibonito on March 14, and in cow dung at Río Piedras on April 11. Adults which emerged from the dung successfully parasitized *M. domestica* pupae in the laboratory. Culture of this species was not attained at Riverside.

The only other species parasitic on houseflies reported from Puerto Rico, other than the already discussed *P. dubius* (Ashm.), is *Spalangia*

TABLE 2.—Parasitization of field-collected puparia of *Musca domestica* (L.) in 4 Sections of Puerto Rico in 1963

| Section | Total puparia collected | Total parasitized puparia | Parasitization |
|---------------------|-------------------------|---------------------------|----------------|
| | <i>Number</i> | <i>Number</i> | <i>Percent</i> |
| Northeast | 333 | 18 ¹ | 5.4 |
| Central (3,000 ft.) | 488 | 91 ² | 18.8 |
| West Central | 220 | 41 ³ | 18.6 |
| Southwest | 473 | 62 ² | 13.1 |

¹ Parasitization by *S. endius* and *S. nigroaenea*.

² Parasitization by *M. raptor*, *S. endius*, and *S. nigroaenea*.

³ Parasitization by *M. raptor*, *S. endius*, and *Trichopria* sp.

philippinensis Fullaway. Native to the Philippines, it has been introduced into Puerto Rico (West 1951), but from present observations either apparently did not become well established, or is synonymous with one of the collected species. In the recent paper by Boucek (1), *S. endius*, *S. stomoxysiae*, and *S. philippinensis* have all been declared as belonging to one species, *S. endius* Walker.

The degree to which these Hymenoptera parasitized housefly populations in Puerto Rico in 1963 may be estimated from the total counts of collected hosts compared with total hosts parasitized. Of 1,414 viable housefly pupae collected from natural breeding sites scattered throughout the Island, 212 were parasitized by viable parasites.

This is 14-percent parasitization effected definitely by four parasitic species, *Trichopria* sp., *M. raptor*, *S. endius*, and *S. nigroaenea*.

Table 2 shows this parasitization broken down for four sections of the Island in which housefly collections were made. The highest total percentage

parasitization (18.8) was observed in the Central Section at an altitude of $\pm 3,000$ feet, in the vicinity of Villa Perez and Aibonito, where three species, *M. raptor*, *S. endius*, and *S. nigroaenea* were involved. The next highest percentage was 18.6 in the West Central Section just north of Mayagüez. Four species, *M. raptor*, *S. endius*, *S. nigroaenea*, and *Trichopria* sp. were active there. In the Southwest Section near Yauco and Lajas, 13.1-percent parasitization occurred, effected by *M. raptor*, *S. endius*, and *S. nigroaenea*. Both *S. endius* and *S. nigroaenea* were responsible for the low 5.4-percent natural parasitization observed in the Northeast Section, east of Río Piedras. Although these percentages afford some idea of the relative activities of parasites in Puerto Rico in 1963, they may not be regarded as fixed, principally because of the variability in housefly breeding sites, and consequently the varied degree of accessibility of hosts to their parasites.

Although *P. vindemmiae* and *S. stomoxysiae* were present in the northeast and central sections, they were not picked up from field-gathered puparia. This would suggest that they normally occurred on other hosts or at extremely low densities on *M. domestica*.

There appeared to be no significant difference in parasite activity among the three principle types of media sampled, cow, chicken, and pig dung.

There was considerable variation in the sex ratio of emerged parasites between collection sites and dates, with males never exceeding females. Since so many variables can influence the sex ratio of the parasitic Hymenoptera (Clausen (2)), no attempt is made here to discuss the cause of the high variation observed in this survey.

It can be concluded from the present study that pupal parasitization alone was insufficient to reduce the housefly population to nonsignificant numbers. The fact that an average of 86 percent of the pupae in breeding sites survived parasite attack, points to other natural control factors involved. It may be assumed that ant predation of housefly eggs, as reported by Pimental (10), contributed to the low numbers of housefly pupae found in breeding sites; but it probably does not account for the high mortality rate of the pupae themselves (table 1), since Pimentel could attribute only a very little pupal predatism to ant species.

The answer undoubtedly lies in the activities of other predators. Dung samples often contained large numbers of predatory histerid, ptilinid, and staphylinid beetles which, in fact, were frequently seen attacking exposed larvae and pupae. Such predators, through their general feeding activity, could have mutilated the pupae and thereby stopped their further development. Determinations are currently being sought for these predators and a report will follow of the species involved when identifications are complete.

SUMMARY

Immature stages of *Musca domestica* L. were sampled in Puerto Rico during 1963 for the purpose of securing parasitic material for use in biological control work in California. Six hymenopterous parasites were discovered in more or less stable breeding sites. One undescribed species of Diapriidae, *Trichopria* sp., and five Pteromalidae, *Spalangia endius* Walker, *Spalangia nigroaenea* Curtis, *Spalangia stomoxysiae* Girault, *Muscidifurax raptor* Girault and Sanders, and *Pachycrepoides vindemmiae* (Rond.) were involved. Parasitization at any given collection site ranged from 1.4 to 25 percent of viable pupae. The Central and West Central Sections of the Island showed highest parasite activity. The role of predators other than ants was thought to be of prime importance in natural control of the more advanced immature stages of houseflies.

RESUMEN

Durante el año 1963 se tomaron en Puerto Rico especímenes de los varios estados preliminares de desarrollo de la *Musca domestica* L., con el propósito de obtener material parasítico para usarse en trabajos de control biológico en California. Se descubrieron seis parásitos himenópteros en criaderos más o menos permanentes. Comprendieron éstos una especie sin describir de la familia Diapriidae, *Trichopria* sp., y cinco de la Pteromalidae, *Spalangia endius* Walker, *Spalangia nigroaenea* Curtis, *Spalangia stomoxysiae* Girault, *Muscidifurax raptor* Girault y Sanders, y *Pachycrepoides vindemmiae* (Rond.). En cualquier lugar dado en que se coleccionaron especímenes, la acción parasitaria sobre los puparios viables varió de 1.4 a 25 por ciento. La máxima acción parasitaria tuvo lugar en las regiones central y oeste de la Isla. El papel que desempeñan los insectos rapaces con excepción de las hormigas, se consideró de principal importancia en el control natural de los estados preliminares de desarrollo más avanzados de la mosca casera.

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