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PARASITISM AND MORTALITY CAUSED BY FIELD AND LABORATORY STRAINS OF *BRACHYMERIA INTERMEDIA* (NEES) (HYMENOPTERA: CHALCIDIDAE)

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Abstract.—A laboratory strain of *Brachymeria intermedia* (Nees), which has been in culture for several years and a field strain were examined for differences in parasitic activity. The gypsy moth pupae were exposed to the wasp for 30, 60, 90 and 120 min. In the latter three time periods the laboratory strain visited significantly more hosts than the field strain. In the two shortest time periods the field strain parasitized significantly more hosts. However, total mortality was the same for both strains. Possible reasons for the similarity in mortality are discussed.

The most recent outbreak of gypsy moth, *Lymantria dispar* L. in the northeastern United States and expansion of its range into Maryland and central Pennsylvania hardwood forests continues to stimulate interest in the development of an integrated pest management system for this insect. Because of public concern from insecticide spraying near homes, one potential tactic is augmentative releases of gypsy moth natural enemies in suburban woodlots.

Brachymeria intermedia (BI) has been a candidate for augmentative release because it is relatively easy to rear. The wasp is a polyphagous parasitoid but its principal host is the gypsy moth (Dowden, 1935). Its initial introduction into the United States was in 1918 from material collected in France and Italy (Howard and Fiske, 1911). Subsequently, no recoveries of the wasp were reported until Burks (1960) found a pinned specimen that had been collected in 1942. Another release of BI was made in Connecticut in 1963 and Leonard (1966, 1967) reported establishment in Connecticut and Maine. The wasp is established throughout the northeastern United States. An augmentative release program requires use of wasps that are competitive in the field, so the purpose of this study was to find if there were differences in behavior or actual parasitism of newly cultured strain of BI and one that had been in culture the New Jersey Department of Agriculture (NJDA) since 1966.

MATERIALS AND METHODS

Collection of field strain BI was made by the New Jersey Department of Agriculture in the summer of 1981 from a heavily defoliated site of predominately oak. The subsequent colony was maintained continuously on gypsy moth pupae through the time of this experiment (1982). The laboratory strain has been maintained at various intervals on gypsy moth and the greater wax moth (*Galleria mellonella* L.) since 1966. For three generations prior to this experiment, both strains of BI were reared solely on gypsy moth pupae. Laboratory conditions were maintained between 21–23°C; 46–48% RH and a 16:8 LD cycle.

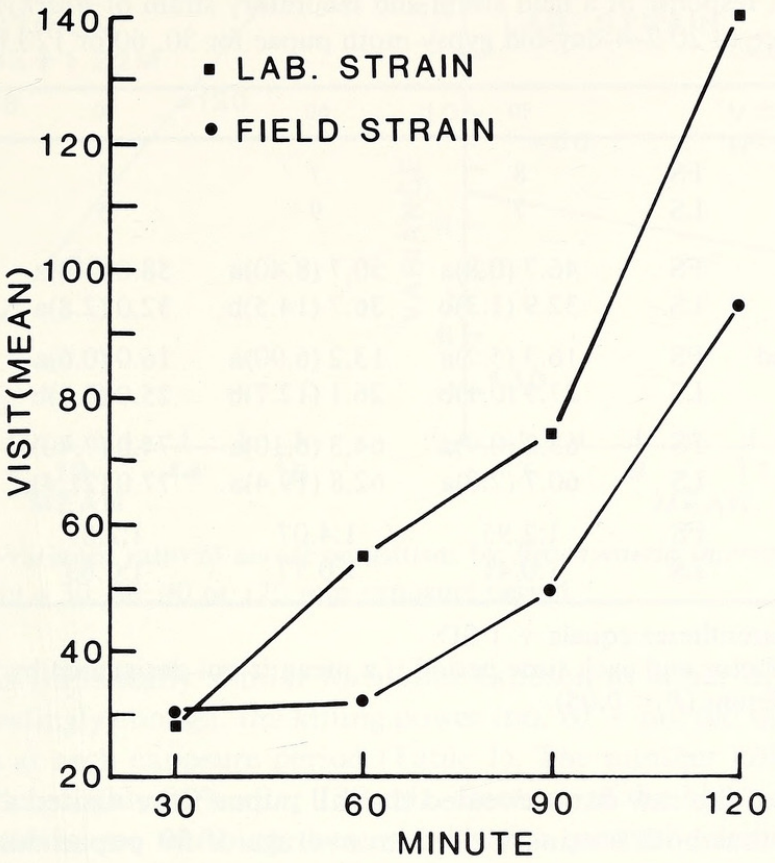

Fig. 1. Mean number of visits by a laboratory or field strain of *Brachymeria intermedia* (Nees) to 20 three to four-day-old gypsy moth pupae over a 30, 60, 90 or 120 min exposure period.

Twenty (5 cm diam) plastic condiment cup lids were spaced evenly on 20.3 × 27.9 cm cardboard sheets and fixed with Elmers glue. The cardboard sheets with attached lids were then placed in the bottom of a 34 × 34 × 40 cm wood and screen cage with a sliding glass door. One, 3 to 4 day old, female gypsy moth pupa was placed on each lid; then 20 five to seven day old mated female BI's were introduced into the cage. To examine for differences in BI activity relative to exposure time, we used 30, 60, 90 and 120 min exposures of the wasp to the pupae. During the exposure period the number of BI landing (visits) was recorded for 1 min in every 5 min. Due to the size of the cage we were only able to determine if a female was sitting on a pupa. After the exposure was complete, the pupae were placed individually in 29.5 ml plastic cups and observed daily for emergence of a moth or parasitoid. Pupae from which nothing emerged were dissected to determine the cause of mortality. If the pupae contained any stages of BI it was calculated as successful parasitism. On each of the 13 days that an experiment was conducted, 20 unexposed pupae were held during the experimental period and placed individually in condiment cups to account for natural mortality.

RESULTS AND DISCUSSION

Adults emerged from all unexposed pupae that were held during the experiments emerged in to adults so no correction due to natural mortality is necessary.

Table 1. Mean response of a field strain and laboratory strain of *Brachymeria intermedia* Nees after exposure to 20 2–4-day-old gypsy moth pupae for 30, 60 or 120 min.*,**

Min		30	60	90	120
No. of replicates	FS	8	7	5	5
	LS	7	9	5	5
% parasitism	FS	46.7 (0.8)a	50.7 (8.40)a	58.0 (1.3)a	70.0 (14.4)a
	LS	32.9 (1.3)b	36.7 (14.5)b	52.0 (2.8)a	67.0 (11.0)a
% apparently killed by feeding	FS	16.3 (5.2)a	13.2 (6.90)a	16.0 (0.6)a	21.3 (7.4)a
	LS	27.9 (0.1)b	26.1 (12.7)b	25.0 (0.3)b	19.0 (4.2)a
Total % mortality	FS	63.2 (0.9)a	64.3 (6.10)a	74.0 (7.40)a	91.3 (9.2)a
	LS	60.7 (2.0)a	62.8 (19.4)a	77.0 (21.4)a	86.0 (7.4)a
Sex ratio F:M	FS	1:2.95	1:4.07	1:2.87	1:5.22
	LS	1:0.41	1:0.57	1:0.63	1:0.43

* Number in parentheses equals + 1 SD.

** Within each factor and each time period if a mean is not designated by the same letter it is significantly different ($P < 0.05$).

Examination of the raw data revealed that all pupae were visited at least once and Figure 1 shows that both strains visited an average of 30 pupae during the 30 min exposure period. So, individuals of both strains were sufficiently active in this time period to begin the host recognition–acceptance process (sensu Doutt, 1964). The 60, 90 and 120 min exposures resulted in the laboratory strain visiting significantly more pupae than the field strain ($P < 0.05$ in each). From the 30 to 120 min period the laboratory strain increased from just over 1.5 visits/pupa to 7 visits/pupa while the field strain increased from slightly over 1.5 pupa at 30 min to 5/pupa at 120 min.

High parasitism per female is the desired result in a mass rearing program and ultimately reflects on the parasitoids ability to search for and find a host. Table 1 shows that the field strain in shorter exposure periods (30–60 min) successfully parasitize more hosts than the laboratory strain. At the 30 min exposure the field strain parasitized 46.7% of the hosts while the laboratory strain parasitized only 32.9% ($P < 0.05$). The magnitude of the differences in parasitism between the two strains remained similar at the 60 min exposure period; the field strain parasitized 50.7% of the hosts and the laboratory strain parasitized 36.7% ($P < 0.05$). At the longer exposure periods (90–120 min) there were no significant differences in successful parasitism between the two strains.

Another behavioral difference between the laboratory and field strains is the amount of host killing by feeding on host fluids. Under close scrutiny of the wasp in the laboratory we observed this behavior and Rotheray et al. (1984) also report this behavior. Due to the size of the experimental cage, we were unable to collect empirical data on feeding, however since no unexposed pupae died, and many exposed pupae were dehydrated, we assign the cause to dehydration to feeding by BI. The laboratory strain killed nearly twice the number of pupae in this manner than the field strain at 30, 60, and 90 min ($P < 0.05$ for each). But at the 120 min exposure this cause

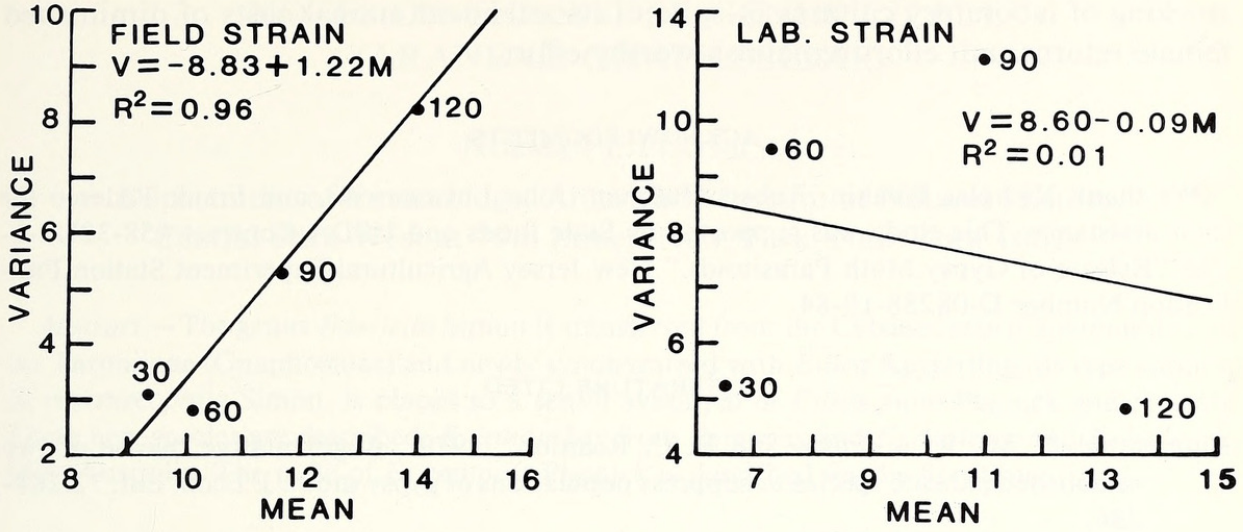

Fig. 2. Mean–variance ratio of actual parasitism by *Brachymeria intermedia* (Nees) or 20 gypsy moth host in a 30, 60, 90 or 120 min exposure period.

of mortality was statistically similar for pupae exposed to either of the two strains (Table 1). Interestingly enough, the killing power (no. BI + no. fed upon) is the same for both strains at each exposure period (Table 1). The number killed ranged from 60% at 30 min to roughly 90% after 120 min. Because of the high visitation rate by the laboratory strain, we attribute these results to a gradual selection for a longer handling time in the rearing laboratory.

Figure 2 shows the mean–variance ratio of the number of BI emerging/replicate for each strain at each exposure period. With the field strain the variance increases with the mean in a linear fashion indicating that parasitism by BI was randomly distributed within the replicates (Southwood, 1978). The laboratory strain mean–variance ratio does not increase with the mean indicating that the ability of BI to parasitize the host does not follow a random distribution. That is, in the years that the laboratory strain has been in culture selection has been for wasps with a longer handling time resulting in non-random parasitism in the laboratory. Aggressiveness is of primary importance when culturing parasitoids. We argue that the longer time for successful parasitism by the laboratory strain could diminish effectiveness of the wasp in an augmentative release program, especially in light of the host defenses described by Rotheray et al. (1984).

Hoy (1976) stated that genetic deterioration of laboratory cultures is difficult to circumvent. In a mass rearing facility, conditions for selection of an increased handling time is difficult to avoid because too short exposure time will result in poor reproduction of the parasitoid thus increasing production costs. The tendency then is to increase exposure time to yield higher numbers of wasps.

Another trade off to be considered in a rearing program is maintenance of a favorable sex ratio. Both for insects used in a laboratory production colony and those intended for field release, it would be more cost effective to have a high female to male sex ratio. In this study, the laboratory strain had a more favorable sex ratio by producing 2 to 2.5 more females than males (Table 1). Exposures of the field strain to gypsy moth pupae produced a range from 3 to 5 males to females. Declining female to male sex ratio greatly increases production costs. We conclude that annual re-

stocking of laboratory cultures in spite of its attendant annual costs of diminished female returns/unit effort remains a worthy effort.

ACKNOWLEDGMENTS

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