SUPERPARASITISM OF *EPILACHNA VARIVESTIS* [COL.: COCCINELLIDAE] 
BY *PEDIOBUS FOVEOLATUS* [HYM.: EULOPHIDAE]: INFLUENCE OF 
TEMPERATURE AND PARASITOID-HOST RATIO (1)

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Superparasitism of *Epilachna varivestis* Mulsant larvae by the hymenopterous parasitoid, *Pediobius foveolatus* (Crawford), occurred under laboratory conditions. However, *P. foveolatus* avoided previously parasitized larvae in a manner which was directly related to the number of times host larvae were initially parasitized. Increasing the parasitoid-host ratio also increased percent host mortality and highest overall host mortality occurred at 15.6°C when the parasitoid-host ratio was 10:10. Higher temperatures (22°C and 28°C) and higher parasitoid-host ratios yielded higher numbers of parasitized larvae although a significant number of parasitoids failed to emerge at the highest parasitoid-host ratio. Higher temperatures along with increasing parasitoid-host ratios favored production of more male parasitoids.

The eulophid parasitoid, *Pediobius foveolatus* (Crawford), has been shown to suppress populations of Mexican bean beetles (*Epilachna varivestis* Mulsant) in soybean fields (Stevens et al., 1975a). The biology of this parasitoid has been reported by Lall (1961), with additional reports by Angalet et al. (1968) and Stevens et al. (1975b). Parasitoids oviposit in late-stage larvae which mummify and produce an average of from 10.5 to 18.5 parasitoids per parasitized larva, depending upon the parasitoid-host ratio (Stevens et al., 1975b). Lall (1961) recognized that variations in the efficiency of *P. foveolatus* may be associated with climate, host density, and hyperparasitism (= superparasitism).

Friske (1910) first introduced the term superparasitism to denote conditions that result when any individual host is attacked by 2 or more species of primary parasites or by 1 species more than once. This definition was later restricted by Smith (1916) to mean multiple attacks on 1 host by different parasitoids of the same species.

The number of parasitoids which can find ample nourishment to complete their development within a single host is limited. The adaptive significance of being able to recognize hosts which are unsuitable (i.e., already parasitized) for survival of parasitoids

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in nature is obvious. On a practical basis, avoidance of superparasitism is necessary in order to maintain viable stock colonies for experimentation and for rearing for inoculative or inundative releases in the field.

SALT (1937) provided the first critical study of superparasitism and pointed out the relationship of this phenomenon to “host marking″ and the ability of parasitoids to discriminate between parasitized and healthy larvae. Numerous reports of host marking by parasitoids have since been published (ULLYETT, 1949a, b, 1950; BAKKER et al., 1967; PRICE, 1972; and others).

Optimum parasite-host ratios for laboratory rearing of *P. foveolatus* are reported by STEVENS et al. (1975), but information on superparasitism of *E. varivestis* has not been published. Also, there is a general paucity of information about temperature-parasitoid-host ratio interactions and the influence of these variables on superparasitism. The mymarid parasitoid, *Anaphes flavipes* (FOERSTER) was found to superparasitize its host, *Oulema melanopus* (L.), to the extent to which no parasitoid progeny were produced. Reports of changes in the sex ratio of certain Hymenoptera due solely to temperature have been published by SCHREAD & CARMEN (1934), DEBACH (1943), FLANDERS (1945), WILSON & WOOLCOK (1960), BOWEN & STERN (1966), and others.

The objectives of this study were to: 1) determine if superparasitism exists in *E. varivestis* larvae by *P. foveolatus*, 2) find out if the parasitoid will avoid previously parasitized *E. varivestis* larvae and relate the degree of avoidance by the parasitoids to the number of times individual *E. varivestis* larvae are previously parasitized, 3) investigate the influence of different constant temperatures and parasitoid-host ratios on superparasitism.

MATERIALS AND METHODS

*P. foveolatus* used in our experiments were mated females less than 48 h-old, which had been reared at 27° ± 2°C, 50 ± 10% RH and at a photoperiod of L:D 14:10. Adult parasitoids were fed honey by placing a drop on the top of the screened caps of rearing vials (10 × 3.5 cm). Hosts (*E. varivestis*) were reared in the greenhouse on snapbean (*Phaseolus* sp.) plants. All host larvae were 4th instars. Once parasitized, larvae were fed snapbean leaves until they formed pupae or mummies (parasitized larvae which died due to developing parasitoids inside them).

Experiments designed to show superparasitism and avoidance of previously parasitized larvae by *P. foveolatus* were conducted by varying the length of time between initial and subsequent parasitization and by varying the number of ovipositions by the parasitoid. Time intervals between initial and subsequent ovipositions were 1, 5, and 24 h for experiments 1, 2, and 3, respectively. Each test container (replicate) held 1 female parasitoid and 3 host larvae. One larva had been parasitized once, 1 parasitized 6 times and a 3rd larva, which served as a control, had not been parasitized. There were 24 combined replicates for the 3 tests. Individual larvae were recognized by marking them with a small amount of fluorescent pigment. Visual observations were made of the number of times individual *P. foveolatus* oviposited in each larva. When oviposition occurred, the parasitized larva was immediately replaced.

Observations were made using rectangular clear plastic containers which were 19 × 13 × 8 cm for experiments 1 and 3, and for experiment 2, the cylindrical containers were 3.5 × 8.75 cm. Observation times (exposure of *P. foveolatus* to each group of 3 larvae) were 70, 120 and 65 minutes for experiments 1, 2, and 3, respectively. An