Discrimination by the Pupal Parasite *Spalangia cameroni* (Hymenoptera: Pteromalidae) Between Live and Freeze Killed House Fly (Diptera: Muscidae) Pupae[1]

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ABSTRACT Live house fly pupae were suitable as hosts for *Spalangia cameroni* Perkins at all age classes tested. However, no parasite emergence occurred from house fly pupae freeze-killed when 12 h old and very limited emergence occurred for pupae freeze-killed when 132 h old. Furthermore, significantly more parasites emerged from hosts that were alive when parasitized when compared with freeze-killed hosts parasitized under similar conditions. In choice experiments, *S. cameroni* exhibited a strong preference for live hosts over freeze-killed hosts at all parasite-to-host ratios. It does not appear that freeze-killed hosts will be useful as a survey tool or as a method for field propagation of *S. cameroni* as they are for other species of pteromalids.

KEY WORDS biological control, *Spalangia cameroni,* host discrimination, pteromalid wasps, house flies.

Freeze-killed house fly, *Musca domestica* L., pupae have been reported as suitable hosts for at least three species of pteromalid wasps, *Pachycreopideus vindemiae* (Rondani) (Pickens and Miller 1978), *Muscidifurax raptor* (Girault and Sanders (Klunker 1982), and *Muscidifurax zaraptor* Kogan and Legner (Petersen and Matthews 1984).

Petersen et al. (1986) reported that when given a choice *M. zaraptor* preferred live to freeze-killed house fly pupae; however, *M. zaraptor* readily used freeze-killed hosts even when live hosts were available. They suggested that freeze-killed hosts may be useful in measuring *M. zaraptor* activity under natural conditions. Petersen et al. (1986) also reported that freeze-killed hosts offered the advantages that they could be produced in the off-season and stored, and that when thawed, they remained suitable as hosts for longer periods than live pupae. Klunker (1982) reported that house fly pupae held at -21°C remained siutable as hosts for *M. raptor* for up to 53 wk.

Using the freeze-killed host system, Petersen (1986) was able to get high parasitism and recycling of *M. zaraptor* under field conditions. This led to the development of a large scale field propagation method for the release of *M. zaraptor* (Petersen and Pawson 1988, 1991; Petersen et al. 1992).

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This study was conducted to determine: (1) if *Spalangia cameroni* Perkins would oviposit and complete development on freeze-killed house fly pupae, if given a choice between live and freeze-killed hosts; (2) if host age influenced oviposition and development in live and freeze-killed hosts; and (3) if at higher parasite-to-host ratios, parasites would use less desirable (freeze-killed) hosts when essentially all of the more desirable (live) hosts were parasitized.

Material and Methods

The *S. cameroni* and *M. domestica* used in this study were obtained from Nebraska isolates and maintained in a colony for about 2 yr. The effect of age of live house fly pupae to serve as hosts of *S. cameroni* was tested by placing five replicates of six cohorts of 50 live house fly pupae at ages of 1, 24, 48, 72, 96 and 120 (± 1) h after pupariation in circular (9 cm diam × 5 cm) plastic containers (30 experimental units) and introducing 10 female *S. cameroni* to each container. After 24 h, the parasites were removed and the pupae were held for fly eclosion and parasite emergence. After parasite emergence ceased, remaining intact puparia were dissected and examined for aborted (died prior to emergence) parasites. The test was replicated four times.

The suitability of house fly pupae, freeze-killed at various stages of development, to serve as hosts for *S. cameroni* was determined by exposing five replicates of six cohorts of 50 house fly pupae freeze-killed (-7°C) at ages of 12, 36, 60, 84, 108 and 132 (± 1) h to 10 female *S. cameroni* (30 experimental units). All other conditions were the same as for tests with live hosts; the test were replicated four times.

To determine if this parasite would use freeze-killed hosts when live hosts were available, a cohort of 50 house fly pupae, freeze-killed when 48-72 h old, was placed in each of two opposite quarter sections of a standard, four sectioned 115 mm petri dish; 50 live house fly pupae, 48 ± 1 h old, were placed in each of the other two sections. Each open petri dish was placed in a circular (9 cm diam. × 5 cm) plastic container. Lids were placed on the containers and the appropriate number of 12-48 h old, host-fed, female *S. cameroni* were added through a small hole in the lids. Parasite-to-host ratios of 1:40, 1:20, 1:10 and 1:5 were tested by placing 5, 10, 20 or 40 female *S. cameroni* in a given container. Each treatment level was replicated five times, and the experiment was replicated four times. After 24 h, parasites were removed, and live and freeze-killed pupae were placed in separate containers. Eclosed flies from exposed live pupae were removed and counted 10 d after exposure. All remaining puparia were held for parasite emergence. After parasite emergence ceased, remaining intact puparia were dissected and examined for aborted parasites.

For all experiments, host pupae were aged at 26°C in preparation for the studies. All exposures and rearing of exposed hosts were conducted in total darkness at 30°C.

Data for the host age studies were analyzed by one way analysis of variance and least square means. Data for choice studies were analyzed using a paired Student t-Test (Minitab 1985).

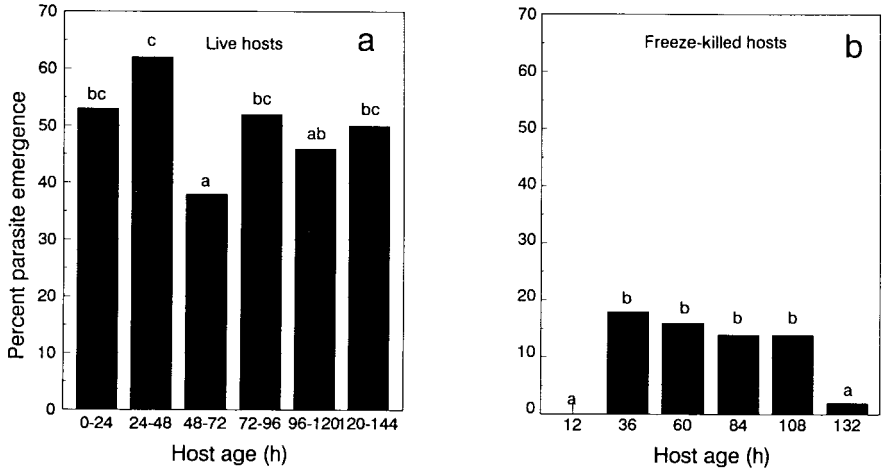

Fig. 1. Mean percent emergence of *S. cameroni* from live (a) and freeze-killed (b) house fly pupae exposed at six age classes for 24 h at 30°C at ratios of 10 parasites to 50 hosts. Columns with the same letters are not significantly different. ($P > 0.05$). Note: live pupae aged an additional 24 h during the exposure period.

Results and Discussion

Live house fly pupae were suitable as hosts for *S. cameroni* at all age classes tested (Fig. 1a). Under the conditions of this experiment (24 h exposure at a 1:5 ratio and 30°C), mean parasite emergence exceeded 45% at all age classes except the 48-72 h age class. In comparison, no parasite emergence occurred from freeze-killed hosts that were freeze-killed when 12 h old, and only limited emergence (2%) occurred from hosts freeze-killed when 132 h old (Fig. 1b). Furthermore, parasite emergence averaged only 15 (14-18)% for the other four age classes of freeze-killed hosts tested; and none were significantly different. It is well documented that house fly pupae are not suitable as hosts for many pteromalids until the pupa separates from the puparium (Klunker 1982, Petersen and Matthews 1984). Pupation within the puparium usually requires about 20-24 h at 25°C. Thus, 12 h old freeze-killed hosts were not suitable, but 1 h old live hosts held at 30°C and exposed for 24 h, matured to a stage where parasitism could occur before termination of the exposure period. This experiment demonstrated that *S. cameroni* will use freeze-killed house fly pupae as hosts when they are freeze-killed between the ages of 36 and 108 h old. However, parasite emergence was substantially lower (about one third) from freeze-killed hosts than from live hosts maintained under similar conditions.

At all four parasite-to-host ratios, *S. cameroni* exhibited a significant and strong preference for live hosts (Fig. 2). Discrimination between live and freeze-killed hosts did not change at the highest parasite-to-host ratio as it did in a

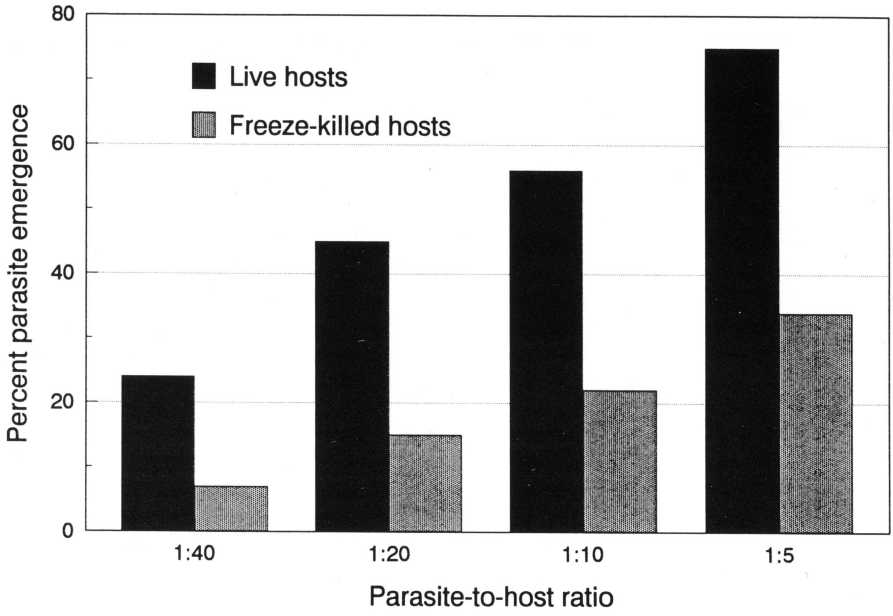

Fig. 2. Mean percent emergence of *S. cameroni* from live and freeze-killed house fly pupae in choice experiments at four parasite-to-host ratios.

similar study with *M. zaraptor* (Petersen et al. 1986). However, discrimination may decrease at higher parasite-to-host ratios, or after longer exposure periods than were tested in this study.

At the termination of the exposure period during the choice study, the location of the female *S. cameroni* was recorded. More parasites were recovered from sections of the exposure dishes that contained live hosts than from sections containing freeze-killed hosts at all parasite-to-host ratios (Table 1). The location of females suggests that *S. cameroni* spent a greater proportion of their time examining live house fly pupae for suitable hosts, and supports the parasite emergence results that occurred from live and freeze-killed hosts.

Development time for *S. cameroni* to emergence was the same (20-26 d) for both live and freeze-killed hosts, and abortion rates were the same for both host types (0-2%).

Data from the exposure of live hosts at the four parasite-to-host ratios permitted observations within a given cohort of host pupae on the effects of different rates of attack on parasite induced mortality (PIM). PIM is defined as host mortality attributed to parasite attack which does not result in successful emergence of parasite progeny (Petersen et al. 1991). Host cohorts were grouped arbitrarily by the percent parasite emergence that occurred (Fig. 3). When parasite emergence was below 15%, host eclosion averaged 57%, and PIM averaged 35%. As parasite emergence increased, a corresponding decline in host eclosion occurred. However, PIM remained between 35 and 28% even as

Table 1. Location of female *S. cameroni* in test containers at the termination of choice preference studies.

Site	Location of parasites (%) at the indicated parasite-to-host ratios			
	1:5	1:10	1:20	1:40
Freeze-killed hosts	30	22	28	24
Live hosts	57	71	70	68
Other locations	13	7	2	8

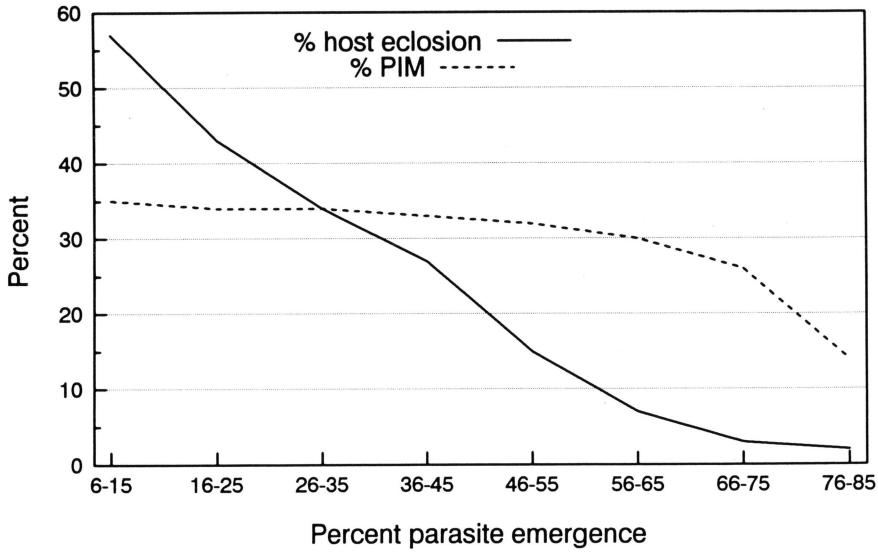

Fig. 3. Mean percent fly eclosion and parasite induced mortality (PIM) from host cohorts that produced the indicated percent parasite emergence.

parasite emergence increased up to 65-75%. At the highest parasite emergence levels obtained in this study (76-85%), PIM decreased to 13%. In the study by Petersen et al. (1991), the opposite response, an increase in the percent PIM as parasite emergence increased, occurred with *M. zaraptor, M. raptor, Muscidifurax raptorellus* Kogan and Legner, and *P. vindemiae*. Perhaps the difference in behavior is in the ability of the females of *S. cameroni* to discriminate between parasitized and unparasitized hosts, and to refrain from ovipositing.

Petersen (1986) attempted to use freeze-killed house fly pupae as hosts for *S. cameroni* under field conditions. However, when released in close proximity to freeze-killed hosts, *S. cameroni* did not oviposit on the readily available freeze-killed hosts and presumably moved away in search of more suitable hosts. Thus, it does not appear that freeze-killed hosts will be useful as a survey tool or as a method for field propagation of *S. cameroni*. However, *S. cameroni* will develop normally on freeze-killed house fly pupae, and may be of value in laboratory or commercial production of this parasite.

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