

Mating and oviposition decisions of the parasitoid *Diaeretiella rapae* (M')

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Abstract. 1. The reproductive fitness of a parasitoid depends on its mating and ovipositing success. Virgin haplodiploid females can reproduce, but produce only males, and may diminish fitness by producing more male offspring than required. Therefore, females must decide on whether to mate or oviposit first.

2. This study was conducted to assess the mating versus ovipositing decision and its impact on the reproductive fitness of *D. rapae* (Hymenoptera: Aphididae), an endoparasitoid of the cabbage aphid *Brevicoryes brassicae* (Hemiptera: Aphididae).

3. When newly emerged females were given a choice between mating and ovipositing, about 62% of *D. rapae* females preferred to mate before ovipositing. Those females who oviposited before mating parasitised only 10% of the available aphids. After mating, females superparasitised their hosts with fertilised eggs, which resulted in a highly female-biased sex ratio in the offspring.

4. Mating success was very high (91%) in the presence of hosts (cabbage aphid nymphs) compared with that in the absence of aphids. However, mating success was not influenced by the quality (size) of the hosts present in the mating arena, despite a parasitoid preference for larger hosts during oviposition. The time between pairing and mating was also shorter in the presence of host aphids. The mean number of aphids parasitised and the parasitism rate were significantly greater after mating.

Key words. Mating, oviposition, reproductive fitness, sex ratio, superparasitism, trade-off.

Introduction

In sexual reproduction, females must mate to produce viable offspring. However, in haplodiploid Hymenoptera, in which males are haploid and females are diploid, virgin females can produce viable male offspring, but need to mate and fertilise their eggs to produce female offspring (Godfray, 1994). After mating, sperm transferred by the male is stored in the spermatheca; subsequently, throughout her life, the female fertilises the eggs facultatively with the stored sperm, adjusting the sex ratio of her offspring in response to the prevailing conditions (Charnov, 1982; Fauvergue *et al.*, 2008). Therefore, the sex ratio and ultimately the reproductive success of parasitic wasps are directly linked to the mating status of ovipositing females.

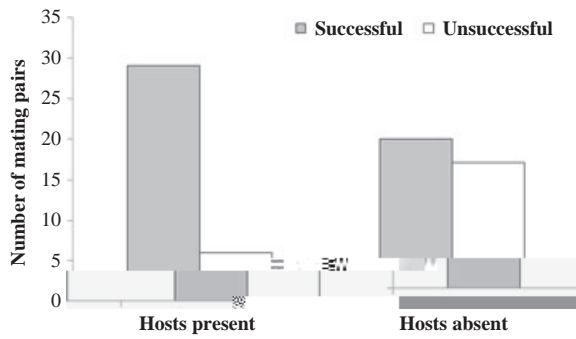
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When a female parasitoid emerges from her host, she can choose between searching for a host and immediately producing male offspring, or searching for a mate and producing both male and female offspring later. Mate searching may differ between gregarious and solitary parasitoids. In gregarious parasitoids in which a number of males and females emerge from one host, parasitoids may immediately mate with one another (King & Copland, 1969; Greeff, 1996). However, solitary parasitoids may actively search for mates (Hardy *et al.*, 2005). For example, virgin females of the aphid parasitoid *Lissonota* (Hymenoptera: Braconidae) attract males for mating while foraging and males are attracted to host volatiles (Fauvergue *et al.*, 2008).

The decision by a virgin female on whether to mate or oviposit first can affect her fitness. If the female lays eggs before mating, she may produce more males than are required for inseminating all available females (Ode *et al.*, 1998). Females that emerge with a full or partial complement of developed eggs (pro-ovigenic or weakly synovigenic,

respectively) are generally egg-limited and may therefore be cautious in choosing to oviposit before mating as they run the risk of reducing overall fitness by depleting their egg supplies and producing too many male offspring (Jervis & Ferns, 2004). However, females that can produce eggs throughout their lifespan (synovigenic parasitoids) are not constrained in this way. If they oviposit before mating, they may be able to compensate for pre-mating oviposition (production of only males) by increased oviposition after mating (production of female and males). Thus, they are capable of manipulating the overall sex ratio of their offspring by producing more fertilised eggs after mating later in life.

D. (M'Intosh) (Hymenoptera: Aphidiidae) is the only parasitoid of the cabbage aphid, *B.* (Hemiptera: Aphididae), although it also parasitises several other aphids of cruciferous and non-cruciferous plants (Pike et al., 1999). It is a solitary endoparasitoid, of which a single adult emerges per host, irrespective of the number of eggs laid in the host (Bernal & Gonzalez, 1997; Kant et al., 2011). Previous studies of *D.* have shown that males of this

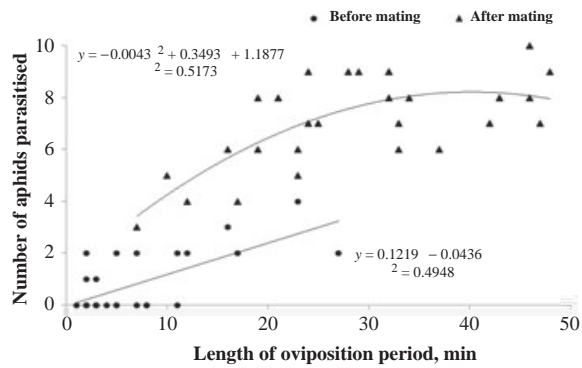


F. . 1. Numbers of male–female *Drosophila* pairs that successfully copulated within 30 min of pairing in the presence and absence of host cabbage aphid nymphs (*Brevicoryes brassicae*).

30 min; the configuration of the experiment was identical to that of the first experiment in all other respects. Pairs that copulated within 30 min were considered successful. Pre-mating time was recorded for each successful pair.

Logistic regression was used to analyse mating success in *Drosophila* adults in the presence and absence of the aphid host. Pre-mating times in the absence and presence of hosts and parasitism in large and small hosts were compared using analysis of variance (ANOVA).

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F . 4. The relationship between oviposition duration and the number of cabbage aphid nymphs parasitised by *D* during pre-mating and post-mating oviposition. Length of oviposition period for 'pre-mating' is the time between the first host encounter after pairing and mating; for 'post-mating' it is the time between the first host

., 2006). The longer pre-mating time in the absence of aphid hosts suggests that female *D.*

Greeff, J.M. (1996) Alternative mating strategies, partial sibmating and split sex ratios in haplodiploid species. *J. Ecol.* **9**, 855–869.