Effects of multiple matings on reproductive fitness of male and female *Diaeretiella rapae*

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success. In the second experiment, multiple mating was examined once every day (daily mating). Males and females were paired for 18–24 h in daily mating. On the following photophase, males were taken out of the mating arena and paired with another virgin female, and the process continued for the entire life of the males. Mating success in daily mating males was analysed. Fifteen males were examined in daily multiple mating.

Progeny production and sex ratio from multiple-mated males

The effects of hourly- and daily-multiple mating of males on progeny production and progeny sex ratio was examined using the insects from multiple mating experiments described above. The mated females from hourly-mating experiments were each offered 15 fresh aphids for 2 h in a was hourly or daily (G = 9.54, d.f. = 14, P = 0.002) (Figure 1). As the number of male mating sessions increased, the mating success decreased. This was true for both hourly- and daily-mating sessions; however, the rate of decline was greater in hourly mating (G = 5.01, d.f. = 13, P = 0.025) (Figure 1). All males died by the ninth day in the daily multiple mating. The mean (SE) number of times males mated in the single day was 3.4

per day. Therefore, under natural/field conditions the chances of females encountering sperm-depleted males should be low (Godfray, 1994; Hardy et al., 2005b).

We found that female *D.ˎ φ a* mate only once in their life. Mating with a sperm-depleted male did not increase the tendency of females to mate again. This could be due to some physiological constraint on re-mating in female *D.ˎ φ a*. During copulation, males might transfer certain chemicals with the spermatozoa that might prohibit females from mating again (Davey, 1985; Neubaum & Wolfner, 1999; Avila et al., 2011). By doing so, sperm-depleted males would increase their reproductive success by inseminating more females and preventing the females from mating with other males (Gardner & West, 2004; Damiens & Boivin, 2006). Absence of re-mating in females experiencing sperm shortage has also been reported in other species (Gardner & West, 2004; Damiens & Boivin, 2006).

In some parasitoid species, the longevity of adult females is relatively longer than the offspring developmental time which provides the opportunity for females mate with their own sons and produce female offspring (King & Copland, 1969; Greeff, 1996). However, in *D.ˎ φ a*, development takes longer than the lifespan of adult females (Kant et al., 2012c), thus, there is no opportunity for inbreeding (females to mate with their own sons) in this species. Therefore, the strategy for females that live for a shorter period of time is probably to mate once and spend more time on oviposition. In contrast, females of longer lived species have more options; they can mate several times if they become sperm deprived in later life and/or choose best sperm stored in their spermatheca (Jacob & Boivin, 2005). As *D.ˎ φ a* is a monandrous species, there is no opportunity for sperm competition.

The results of this study suggest that male *D.ˎ φ a* continue to mate even after sperm-depletion. They probably increase their reproductive fitness by optimizing the amount of sperm transferred per female to maximize the number of matings. Ageing negatively affected the insemination capacity of males. Female *D.ˎ φ a* rejected multiple-mated males, and the females mated with multiple-mated males received less sperm and produced fewer offspring.

Acknowledgements

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