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Short communication

The influence of conspecific males on spermatophore deposition in the eriophyid mite *Aculus fockeui*

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Abstract. Similarly to males of *Aculus fockeui* on plum, males inhabiting peach showed interest in quiescent female nymphs and behaved non-aggressively in contact with each other. When maintained on fresh leaf arenas for 5 h, males in groups of seven deposited significantly fewer spermatophores per male than solitary ones. The inhibitory effect of the presence of conspecific males on spermatophore deposition rate is indicated and discussed in the context of previous opposite observations on this mite.

Key words: eriophyid mites, intrasexual competition, mate dissociation, spermatophore deposition

Introduction

In arthropods that exhibit mate dissociation (syn. non-pairing), males deposit spermatophores regardless of the presence of females while the females on their own search for spermatophores and accomplish insemination. As shown in several species of water mites, spermatophore deposition rate of non-pairing males can be rigid and independent of contacts with conspecifics. In others, however, the presence of females and/or their odours as well as the presence of competitor males appear to have a distinctive impact on sperm production. It may inhibit or incite spermatophore depositions (Witte, 1991; Proctor, 1992; Oppedisano *et al.*, 1995). It is likely that the fluctuations in the availability of receptive females as well as male–male competition leading to intrasexual selection promote the development of flexibility in spermatophore deposition of arthropods. These aspects of non-pairing behaviour, however, still require further investigations.

Eriophyid mites are a highly specialised group of plant parasites, among which many are serious pests of crop plants (for review see Jeppson *et al.*, 1975; Lindquist *et al.*, 1996). As revealed by Oldfield *et al.* (1970), they trans-

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fer sperm via spermatophores deposited on a substrate and reproduce without pairing. Recent findings indicated however, that in some eriophyid species, in spite of mate dissociation, males are interested in females and the intensity of competition between males can be high. It is exemplified by *Aculus fockeui*, *Acalitus essigi* and *Vasates robiniae*, in which males search for quiescent female nymphs and deposit spermatophores beside them. Moreover, *V. robiniae* males guard preemergent females, interacting aggressively with competitor males (Michalska and Boczek, 1991; Michalska, 1999). Both, males of *A. fockeui* (Oldfield and Newell, 1973) and *V. robiniae* (Michalska, unpubl. data) also deposit spermatophores in the absence of the opposit sex.

In eriophyids, the flexibility of spermatophore deposition was preliminarily investigated in *Aculus fockeui* on peach (Oldfield and Newell, 1973). Males that were put together on a leaf arena for two consecutive four-day-periods, deposited spermatophores at a daily rate similar to that demonstrated by solitary individuals. It suggested that contacts with other males had no impact on spermatophore deposition rate of *A. fockeui* males. In this experiment, however, males were exposed not only to the presence of conspecifics, but also to spermatophores abundantly deposited during the trial and odours of leaves injured by feeding.

The aim of this study was to determine the influence of the presence of conspecific males on spermatophore deposition of *A. fockeui* from peach. As contacts between *A. fockeui* males and female quiescent nymphs were previously reported only for the mite from plum (Michalska and Boczek, 1991), this paper also presents some field observations of its behaviour on peach.

Materials and Methods

Mite

Aculus fockeui is a free-living eriophyid mite, inhabiting leaves of the wide range of palearctic *Prunus* species. It is reported as a serious pest of plum, peach and cherry. It overwinters as a deutogyne female in bark crevices, bud scale scars and between bud scales of dead buds. As reported by Boczek *et al*. (1984), in the field on European plums, the eriophyid develops quickly, producing about 11 generations per year. At 26°C, protogyne females deposited ca. 3.4 eggs and males about 30 spermatophores per day (Oldfield *et al.*, 1970).

Field observations

Field observations on *A. fockeui* were carried out from 17 August to 24 September, 1999, on two ornamental peach trees (*Prunus persica*) grown near a laboratory. Infested leaves were collected daily and examined under a dissecting microscope fitted with a cold light source. For microscopic observations mites were previously cleared in Hoyer's medium.

Experiment

Rearing and experiments were conducted using young potted 'Rose' peach trees grown in a glasshouse. Mites were mass reared on the upper side of leaves, in the detached leaf cages as described by Tashiro (1967) and modified by Oldfield *et al.* (1970). As those cages precluded the use of leaves less than 2 cm wide, another cage was constructed, with a smaller rearing chamber (11 mm in diameter) situated laterally 15 mm from the shorter edge. The cages were watered on portable watering platforms described by Beavers and Oldfield (1970).

The experiments were carried out on fresh, uninfested leaves using cages (5.6 $\times$ 4.7 $\times$ 0.1 cm) with holes of 0.55 cm in diameter. They were constructed similarly to cages described by Royalty and Perring (1987), except for the bottom plastics that had no circulation holes. To keep leaves moist, additionally a wet pad of gauze was put on an adhesive foam stuck to the bottom of the cage, and leaf petioles were wrapped with wet cotton.

To prevent mites from escaping, a ring of beewax was put around the top of each cell and sealed by a 'breathing' dialysis membrane (Union Carbide Corp., Chicago, USA). Cages were kept in a growth chamber at 26°C, 31% RH and 16/8 L/D photoperiod.

In the experiments, 2–3-day-old males were used. They were selected from mass rearing as quiescent male nymphs and maintained on separated leaf arenas until the trials started.

To check the impact of the presence of males on the spermatophore deposition, a comparison was conducted between the number of spermatophores produced by solitary individuals and by those held in groups of seven. To diminish the influence of released spermatophores and odours of leaves injured by feeding males on the deposition rate, duration of each treatment combination was limited to 5 h. After this time mites were removed and spermatophores counted. Spermatophores were released under light conditions. Initial number of males was seven per treatment, each replicated $k = 4$ times.

In each trial, the mean number of spermatophores deposited by a male after 5 h was calculated and then, the mean of average values for each treatment combination was assigned. Means were compared using an independent t-test, at significance level $\alpha = 0.05$. Data are given as $\overline{x} \pm 1$SE

Results and Discussion

Field observations

Mites mostly inhabited the upper side of leaves of ornamental peach trees. The depression along the midribs of leaves was the site preferred by the mites for egg laying, quiescence and moulting as well as for spermatophore deposition. Males visited quiescent female nymphs and occasionally, for several seconds, clung tightly to them. It confirms the previous observations by Michalska and Boczek (1991) on male interest in females of *Aculus fockeui* from plum trees.

On infested peach leaves, male–male contacts were also occasionally observed. Males behaved non-aggressively and markedly tolerated each other, even if they were in very close body contact, e.g. during feeding. Also, unlike males of other 'dissociated' arthropod species (for review see Proctor, 1998), they did not destroy previously deposited spermatophores.

Experiment

Males of *A. fockeui* that were held on 'fresh' leaf arenas in groups of seven individually deposited significantly fewer spermatophores (8 ± 0.639) than solitary specimens (11.125 ± 0.421) (unpaired t-test; $t = 4.08357$; $p < 0.0065$; $k = 4$). These results indicate the inhibitory effect of the presence of other males on spermatophore deposition in this species. Similar observations were also reported for the prostigmatic mite *Limnesia maculata* (Witte, 1991). The mechanism of this phenomenon, however, has not been explained until now.

A. fockeui males search for females in their emergence sites and deposit spermatophores beside quiescent female nymphs (Michalska and Boczek, 1991). It may be especially unprofitable for them to deposit spermatophores on pathes (like a fresh leaf arena used in this experiment) that are uninhabited by a colony and additionally visited by competitor males. On such patches, there seems to be a low probability of the presence of any receptive female and also a low chance for a male that a female would pick up a sperm from his spermatophore (but not from a competitor).

Time and energy are fundamental constraints that impinge on animal behaviour. Therefore animals must budget accordingly and allocate their priorities to activities, both in a general way as well as from minute to minute (McFarland, 1993). By inhibiting spermatophore production, eriophyid males could allocate more time and energy for dispersal from 'unprofitable' patches and continue searching for mates. Nonetheless, male–male contacts and perhaps mutual interference in spermatophore depositions could also lead to the decrease of deposition rate in grouped males and this aspect of *A. fockeui* behaviour will be further investigated.

Contrary to observations of this study, Oldfield and Newell (1973) did not find any influence of the presence of conspecific males on spermatophore deposition in *A. fockeui*. One of the factors that differentiated the results obtained in both experiments could be the differences in male density. In the present test, the number of grouped males per unit of leaf area was several times higher than that used by Oldfield and Newell (1973). As shown by observations of the oribatid mite *Pergalumna* sp., deposition rate may decrease at higher densities of males (Oppedisano *et al.*, 1995). Therefore, it seems that in eriophyids, the effect of the presence of other males does not appear when males are not abundant, such as in Oldfield and Newell's test (1973).

Another factor that could have an impact on *A. fockeui* males and deposition rate in both experiments was the presence of spermatophores on leaves. In several species of mites and pseudoscorpions, encountered spermatophores induce further depositions by the same or other males (for review see Proctor, 1998). It appears to be connected with sperm competition or/and a male tactic aimed to increase attraction of his own sperm by 'stealing' pheromonal output of spermatophores of other males.

In the present experiment, *A. fockeui* males often placed spermatophores nearby those previously deposited. Thus, it is likely that in this eriophyid, encountered spermatophores induce further depositions or at least arrest males within a patch. It may also refer to the males that were held in groups and diminished the deposition rate. One cannot exclude that during a longer period of time, such as in Oldfield and Newell's test (1973), the influence of stimulating surfeit of spermatophores on leaf arenas could compensate the inhibitory effect of conspecific males. As a consequence, in spite of the presence of other males, grouped males may deposit at a similar rate as single individuals.

As shown for other herbivorous mites, odours of infested plants can mediate information about conspecifics (see e.g. Pallini *et al.*, 1997). In the case of *A. fockeui* males, emission of such odours could testify to the settlement of a colony and indirectly, also to the presence of potential mates. Therefore, also volatiles of a leaf injured by male feeding and perhaps other substances like male excreta and secretory products left on a leaf surface, may stimulate the males to deposit spermatophores. It could again, after a longer period of time, such as in the test by Oldfield and Newell (1973), 'mask' the negative effect of the presence of conspecific males.

Differences in the deposition rate can also arise from different temperature conditions, under which non-pairing males produce spermatophores. In the experiment with the prostigmatic mite *Limnesia maculata*, Rutkis (1987, after Witte, 1991) found a marked effect of temperature on spermatophore deposition rate and male response to the presence of conspecifics. However, as the present experiment and Oldfield and Newell's test (1973) were conducted at similar temperature conditions, such effect should not be taken into account in order to explain the disagreement of results obtained in both tests.

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