Different maternal effects on offspring performance in tetranychid mites, *Tetranychus kanzawai* and *T. urticae* (Acari: Tetranychidae)

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**Abstract**

Female adults and their offspring of tetranychid mites, *Tetranychus kanzawai* and *T. urticae*, live together on the same leaf. To clarify whether the presence of female adults affects the performance of offspring (maternal effect), we examined the performance index (fecundity after maturation) of juveniles that had lived with female adults, or without them. In either species, the presence of female adults reduced the performance index of juveniles. The effect of *T. kanzawai* was more conspicuous than that of *T. urticae*. On the other hand, female adults of *T. kanzawai* dispersed from an infested leaf earlier than those of *T. urticae*. The correlation between the maternal effect and dispersal capacity of *T. kanzawai* and *T. urticae* was discussed.

**Key words:** Maternal effect, density effect, fecundity, *Tetranychus kanzawai*, *Tetranychus urticae*

**INTRODUCTION**

Maternal effects are defined as nongenetic effects of the maternal phenotype or environment on offspring phenotypes (Mousseau and Dingle, 1991a, b). Maternal effects have an influence on offspring phenotypes either before or after the oviposition (Falconer, 1989). For example, feeding damage by herbivores alters the quality of some host plants, which may in turn affect the fitness of the herbivores (Karban and Baldwin, 1997). Therefore, any effects on offspring that are mediated by a host plant damaged by the mother would be examples of a maternal effect.

Closely related species, *Tetranychus kanzawai* Kishida and *T. urticae* Koch, have many host plant species in common (e.g. Eghara and Shinkaji, 1996). There are, however, some differences in ecological traits of the two species. Female adults of *T. kanzawai* disperse from infested host plants earlier than those of *T. urticae* (Kondo and Takafuji, 1985). Furthermore, *T. kanzawai* occurs not only on cultivated plants but also on wild ones, whereas empirical observations show that *T. urticae* is not distributed on wild plants in Japan (Takafuji and Morishita, 2001). Since female adults of tetranychid mites and their offspring live together on the same leaf (e.g. So, 1991; Hinomoto and Takafuji, 1994), the presence of female adults should affect the fitness of their offspring. Although maternal effects have been studied in many animals and plants (e.g. Roach and Wulff, 1987; Mousseau and Dingle, 1991a, b; Shine and Downes, 1999), only a few studies have examined these effects in spider mites (e.g. Goka and Takafuji, 1991). In this study, therefore, we discuss the differences between the maternal effects of *T. kanzawai* and *T. urticae*, as a determinant of the differences in their ecological traits.

**MATERIALS AND METHODS**

**Mites.** The mite population of *T. kanzawai* was collected from a strawberry garden in Kyoto City, and that of *T. urticae* from a rose garden in Kyoto City. Each population was maintained on bean (*Phaseolus vulgaris*) leaf discs pressed on water-saturated cotton in petri dishes (90 mm in diameter and 14 mm deep). All dishes were placed together in a transparent plastic container at 25°C: 16L8D.

For each species, we randomly selected twenty teleiochrysalis females together with ten male adults from the stock cultures. We transferred the mites onto a bean-leaf disk on water-saturated cotton in a petri dish as described above. We allowed them to oviposit for 2–3 days at 25°C: 16L8D. All eggs used in this study were obtained by the above
Effect of female adults on juvenile fitness. Preliminary tests showed that the fitness indices of juvenile mites such as survival rate and developmental period on bean did not differ significantly among individuals. Therefore, the number of eggs produced within a certain period after maturation was used as the fitness index of the mite.

To examine whether the presence of female adults affects the fitness of juveniles feeding on the same leaf, we transferred five eggs onto each of twenty leaf squares (10×10 mm) in petri dishes. We transferred three virgin female adults onto each of half (n = 10) of the leaf-squares (treatment), while the rest of the leaf-squares served as controls. The two species are arrenhotokous, and virgin adult females oviposit on host plants as well as mated females, although eggs by the former are unfertilized. Therefore, we could easily identify female juveniles that were initially introduced. Male juveniles emerged from the initial five eggs were excluded from the following experiment. After eight days, female juveniles in the teleiochrysalis stage were individually transferred onto the leaf squares. The number of eggs produced after maturation (hereafter “fecundity”) was measured for seven days.

To examine the possible interaction among juveniles feeding on the same leaf, we transferred either one or fifty eggs onto a leaf-square. After eight days, female juveniles in the teleiochrysalis stage were individually transferred onto the leaf squares. Fecundity was measured by this procedure.

Feeding by female adults vs. tolerance of juveniles. To determine whether the lower juvenile fecundity in *T. kanzawai* (see Result) is attributed to a characteristic of female adults and/or juveniles, we investigated four combinations of female adults and juveniles: 1) *T. urticae* female–*T. kanzawai* juvenile; 2) *T. kanzawai*–*T. urticae*; 3) *T. kanzawai*–*T. kanzawai*; and 4) *T. urticae*–*T. urticae*. Five eggs and three female adults were each transferred onto the leaf squares as described above. The fecundity was measured for five days. The data was then subjected to the repeated measures of ANOVA testing the effects of coexisting adult and juvenile characteristics on juvenile fitness.

Dispersal from infested leaves. Female adults of tetranychid mites mate immediately after adult emergence (Cone, 1985) and disperse from the colony (Kondo and Takafuji, 1985). To compare the dispersal capacity of adult females from infested leaves, we used the experimental sets shown in Fig. 1. Five mated females, of two to three days postmaturation, were introduced onto a bean leaf square (initial leaf) at one side of a vinyl bridge (40 mm length and 2 mm width). Since the leaf square was surrounded by a water-barrier, the mites could escape the square only via the bridge. The other leaf square (second leaf) served as a trap, to which mites that had escaped from the initial one moved. We counted the cumulative number of individuals that moved to the second leaf at intervals of 12 h for 4 d, and then removed them.

**RESULTS AND DISCUSSION**

Effect of female adults on juvenile fitness

In both species, female adults significantly reduced the fitness index of juveniles (Fig. 2). Especially in *T. kanzawai*, the mean fecundity of juveniles that had lived together with female adults was reduced to less than one third of those without adults. Furthermore, in *T. kanzawai*, the fecundity of juveniles that had developed with companion juveniles was significantly lower than those that had developed alone (Fig. 3, top). By contrast, the fecundity did not differ in *T. urticae* (Fig. 3, bottom).

The effect of female adults on juvenile fitness seemed to be larger than the interaction among juveniles. We did not use real mothers and daughters in this study. However, the above negative density effect would be observed between real mothers and daughters in the wild, because juveniles and female adults that live together on a plant are likely to be
real mothers and daughters (So, 1991; Hinomoto and Takafuji, 1994). Therefore, the negative density effect can be seen as a maternal effect. Whether the mechanism of the effect is attributed to the deterioration of the offspring’s environment via feeding damage and/or direct interference by female adults remains to be explored.

**Feeding by female adults vs. tolerance of juveniles**

Based on the fact that the density effect of *T. kanzawai* was more conspicuous than that of *T. urticae*, we interchanged the combination of female adults and juveniles between the two species in order to determine whether the female adults or juveniles were responsible for the difference. The results are shown in Fig. 4 and Table 1. Only the juvenile characteristic was responsible for the lower fecundity of *T. kanzawai*. In addition, no congeniality was detected between the species since the interaction effect was not significant.

**Dispersal from infested leaves**

Female adults moved to the second leaves as the initially introduced leaves deteriorated due to their infestation. Female adults of *T. kanzawai* dispersed significantly earlier than those of *T. urticae*.
This result agreed with that reported by Kondo and Takafuji (1985).

The agreement between the density effect and the dispersal capacity of *T. kanzawai* and *T. urticae* may be explained as follows. Firstly, female adults of *T. kanzawai* disperse earlier in order to avoid fitness reduction of offspring whose density-tolerance is low, while female adults of *T. urticae* do not need to do so because their offspring have higher tolerance. Since predators of tetranychid mites are attracted to the prey colonies only after a certain period of infestation (e.g. Maeda and Takabayashi, 2001), *T. kanzawai* may escape predation more effectively than *T. urticae* (see Huffaker, 1958; Kennedy and Smitley, 1985). Therefore, *T. urticae* needs to disperse from its colony, as does *T. kanzawai*.

In addition, characteristics of juveniles other than fecundity, which were not examined in this study, would also be affected as a result of the maternal effect. This point will be discussed in a forthcoming paper.

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**REFERENCES**


