

APHID PREY SUITABILITY AS ENVIRONMENTAL EFFECT ON *ADALIA BIPUNCTATA* REPRODUCTION

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ABSTRACT

Secondary plant metabolites (allelochemicals) play a major role in plant-insect interactions. Glucosinolates (GLS) and their degradation products from Brassica species are attractants and feeding stimulants for Brassicaceae specialist insects but are generally repellent and toxic for generalist herbivores. The impact of these compounds on crucifer specialist insects are well known but their effect on generalist predators is still not well documented. Prey host plant influence on reproduction of an aphidophagous beneficial, the two spot ladybird, was determined using the cabbage aphid, *Brevicoryne brassicae* reared on a crucifer plant, namely *Brassica napus* containing low GLS levels. As ladybird developmental and reproductive parameters were already shown to be strongly affected by the allelochemical presence in its preys, the unsuitable aphid and host plant combination was only momentarily used to feed the *A. bipunctata* adults. A strong impact of the diet was observed on the beetle fecundity and the emerging offspring. Changing *B. brassicae* aphid to a suitable prey slowly improved the temporary negative effect of the former diet. These results enhance the food environmental effect and the importance of tritrophic relations in pest management strategies by predators. Indeed, more than the choice of the beneficial species, the prey host plant has a major influence on the potential efficacy of biological agent to control herbivore species such as aphids.

INTRODUCTION

Plants of the Brassicaceae family contain secondary substances known as the glucosinolates (GLS). When the plant is damaged and the cell integrity destroyed, the enzyme myrosinase catalyses the degradation of GLS to volatile molecules, mainly isothiocyanates (ITC) (Fahey *et al.*, 2001). In contrast to their role as kairomone for insects that specialize on crucifers, the secondary plant substances are highly toxic for non-crucifer feeders and provide an efficient defence mechanism for the plant (Fenwick *et al.*, 1983; Porter *et al.*, 1991). The influence of the GLS-ITC system of Brassica plants is not limited to the second trophic level. The emitted odours from aphid infested cabbage leaves or from *B. brassicae* alone induced positive responses of the aphid parasitoid, *Diaeretiella rapae* M'Intosh (Hymenoptera: Braconidae). When uninfested plants were used, no behavioural changes of the beneficials was observed, suggesting an innate odour preference for crucifer feeding aphids (Reed *et al.*, 1995). In regard to the presence of GLS and ITC in the cabbage aphid feeding on several Brassicaceae species (Francis *et al.*, 2001a). Here we report the allelochemical effects on *A. bipunctata* reproduction through this unsuitable aphid when only provided for a short period to adult ladybirds.

MATERIALS AND METHODS

Broad beans (*Vicia faba* L.) were grown in 20×30 cm trays including a mixture of perlite and vermiculite (1/1) in a controlled environment room at 20±2 °C and 16 h daylight photoperiod. The plants were used to rear control diet of ladybirds. Oilseed rape (*Brassica napus* L.) containing low levels of GLS, was raised in 10cm diameter plastic pots containing ordinary compost in separated rooms with the same controlled conditions. While *Acyrtosiphon pisum* (Homoptera: Aphididae) was reared on broad beans, oilseed rape was used as *B. brassicae* host plants. Each aphid species had been reared in separate rooms of the laboratory for several years.

The influence of a momentary consumption of *B. brassicae* reared on *B. napus* was observed using newly emerged adult that had been fed at the larval stages with the optimal *Acyrtosiphon pisum* Harris on bean. Twenty adults were placed by couples (n = 10) in 11×14×4 cm aerated plastic boxes and were fed with *B. brassicae* reared on *B. napus* for 6 days before replacing the unsuitable prey and host plant combination by the optimal diet (for the next 9 days). Ten ladybird couples were full time fed with the control diet as reference. Experimental observations were performed for another ten days. Preoviposition duration, fecundity and egg viability were daily reported. Offsprings (n = 60) of ladybirds from each test were individually placed in 5cm Petri dish and fed with the control diet. Developmental parameters were daily observed (larval duration, mortality rates, adult weight at emergence).

Egg viability were analysed by ANOVA after arcsin√x transformation (Dagnelie, 1975). Other results were directly analysed by ANOVA and decomposed in two contrasts using the Minitab software (vs 11.2).

RESULTS

Feeding *A. bipunctata* with *B. brassicae* on *B. napus* from adult emergence did not have an influence on the preoviposition duration (4.56±0.44; 4.22±0.36 and F = 0.34 and P = 0.570). The observation of the ladybird fecundity showed the unsuitability of *B. brassicae* reared on *B. napus* even as a momentary adult food (Figure 1). Egg numbers laid by *A. bipunctata* fed with the latter diet were significantly lower than the ones related to control fed ladybirds for the first 3 days but not for the next days (F = 9.13 and P = 0.008; F = 1.97 and P = 0.180 respectively). After having changed the unsuitable prey by the control diet (next 3 periods of three days), no more significant differences of beetle fecundity were observed (F = 0.33 and P = 0.574; F = 0.01 and P = 0.905; F = 0.91 and P = 0.354).

The most striking effect of the unsuitable diet on the ladybird reproduction was the strong egg viability reduction during the *A. bipunctata* feeding period with *B. brassicae* reared on *B. napus* ($F = 11.49$ and $P = 0.004$; $F = 9.97$ and $P = 0.006$ for days 1-3 and 4-6 respectively, Figure 2). The negative effect of the momentary unsuitable food was continuously observed on the beetle fecundity after having changed the tested diet by the standard food ($F = 1.59$ and $P = 0.228$; $F = 6.07$ and $P = 0.026$; $F = 0.03$ and $P = 0.860$ for days 7-9, 10-12 and 12-15 respectively).

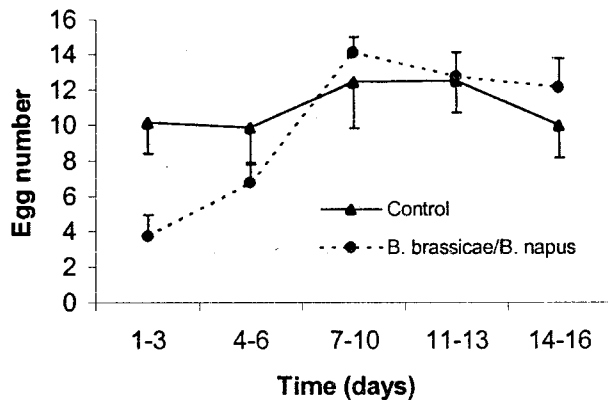


Figure 1. Effect of a momentary Brassicaceae aphid feeding (days 1-6) on the *Adalia bipunctata* fecundity (mean \pm SE). *Acyrtosiphon pisum* reared on *Vicia faba* was the control diet.

Offspring viability related to *B. brassicae* on *B. napus* fed parent ladybirds was much lower than the control mortality rates, none of the six surviving larvae reached the pupae stage. After having changed to the standard diet, no significant difference of the former diet was observed ($F = 4.53$ and $P = 0.118$). Total developmental duration of the offspring was longer when the parents had been fed with the unsuitable preys ($F = 15.64$ and $P < 0.001$). The adult weight at emergence showed a negative influence of the *B. brassicae* on *B. napus* past intake of the ladybird parents (Figure 3.). Both females (11.83 ± 1.65 mg; $F = 4.33$ and $P = 0.047$) and males (8.7 ± 1.44 mg; $F = 28.56$ and $P < 0.001$) fed with *B. brassicae* were lighter than the control diet fed individuals (13.26 ± 2.05 and 11.54 ± 1.38 respectively).

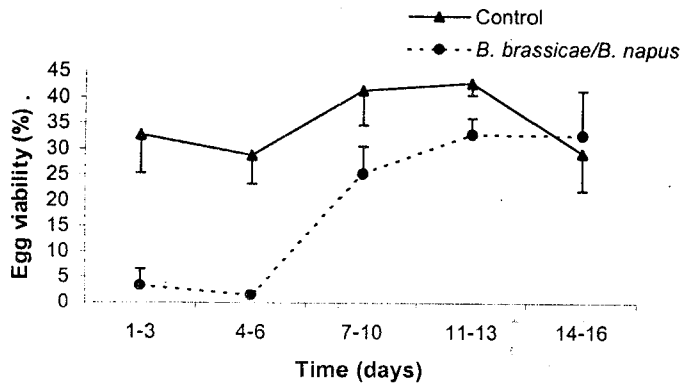


Figure 2. Effect of a momentary Brassicaceae aphid feeding (days 1-6) on the egg viability of *Adalia bipunctata* (mean \pm SE). *Acyrtosiphon pisum* reared on *Vicia faba* was the control diet.

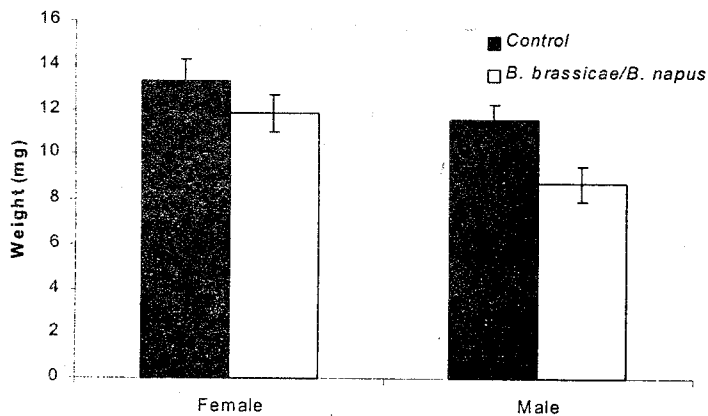


Figure 3 : Effect of a momentary Brassicaceae aphid feeding on the adult weight at hatching of *Adalia bipunctata* (mean \pm SE). *Acyrtosiphon pisum* reared on *Vicia faba* was the control diet.

DISCUSSION

After having tested the foraging efficacy of *Adalia bipunctata* on aphid species reared on host plant containing allelochemical substances, both generalist and specialist Brassica aphid were shown to be unsuitable for the beetle development and reproduction (Francis *et al.*, 2000, 2001b). The cabbage aphid, *B. brassicae*, was the most negative ladybird tested food. As the feeding behaviour of ladybirds change according to the prey and host plant availability (Hemptinne *et al.*, 1995), we only used the unsuitable prey for a short time to assess the impact of the latter on the beetle reproduction.

The GLS and related degradation products do not influence the preoviposition duration of *A. bipunctata* but as long as the secondary substances were present in the diet, the fecundity and the egg viability were severely reduced. After the change to the control diet, the negative effects slowly disappeared. All hatched larvae from eggs laid by *B. brassicae* fed adults died. One week after having changed to the control diet, the effects were still observed: increased development durations and lower weight of freshly emerged adults. The food quality was showed to be an environmental effect. Unsuitable diet of *Lymantria dispar* L. (Lepidoptera: Lymantriidae) parents also negatively influenced the development of their offspring (Rositer, 1991). Environmentally based maternal effect of the aphid prey suitability had already been observed in *A. bipunctata* when the diet was changed from the optimal *A. pisum* prey to *A. fabae*: both the fecundity and the egg viability of the next generation were greatly reduced (Francis *et al.*, 2000).

Even if the predator contributes to pest population limitation and is considered as an efficient biological control agent in integrated pest management programs, the two-spot ladybird has a high prey specificity and is sensitive to variable aphid quality. The transitory use of an unsuitable prey by adult ladybirds occurs frequently when no better prey is available (Hodek & Honek, 1996) but this temporary feeding can have important consequences on the predator's fitness.

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