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Food supplements for *Amblyseius swirskii*: supporting predator or prey populations?

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Abstract: In order to reduce the cost of repeated introductions of natural enemies in protected crops, food supplements can be provided when target prey levels are low. However, selecting such foods should be done with extreme care, as some omnivorous pests may also benefit from those resources. Western flower thrips, *Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae) is such an omnivorous herbivore feeding on both plant and animal materials. In the present laboratory study, we tested three supplemental foods used in protected cultivation to support populations of the phytoseiid predators: pollen of narrow-leaved cattail *Typha angustifolia* L. (Nutrimite™), dry decapsulated *Artemia franciscana* Kellogg (Branchiopoda: Artemiidae) cysts of high quality, and a commercial product consisting of decapsulated cysts of *Artemia* sp. (Artefeed). The value of these supplemental foods for sustaining population growth of the predatory mite *Amblyseius swirskii* Athias-Henriot (Acari: Phytoseiidae) and its prey *F. occidentalis* was investigated. Furthermore, we assessed the impact of the presence of the supplemental foods on the predation efficacy of *A. swirskii* on first instars of *F. occidentalis*. Results showed that the foods differentially affected population growth of both pest and predator. Thrips performed better on pollen than on *Artemia* cysts when provided on bean leaves (*Phaseolus vulgaris* L.). Similarly, when fed on *T. angustifolia* pollen, the population growth rate of *A. swirskii* was higher than on both types of *Artemia* cysts.

Key words: *Frankliniella occidentalis*, *Typha angustifolia*, *Artemia*, population growth, predation efficiency

Introduction

In protected crops, the generalist predatory mite *Amblyseius swirskii* Athias-Henriot (Acari: Phytoseiidae) is becoming increasingly important in integrated pest management programs to control mainly thrips and whiteflies (Nomikou *et al.*, 2002; Messelink *et al.*, 2006; Calvo *et al.*, 2011). However, repeated introductions remain a prerequisite when beneficials are released preventively to cope with poor establishment and/or low prey levels (i.e., "insurance policy" (Messelink *et al.*, 2014)), thereby increasing costs for the growers. To increase the retention of *A. swirskii* in the crop, supplemental foods can be provided, of which pollen has received considerable attention (van Rijn *et al.*, 1999; Messelink *et al.*, 2009; Nomikou *et al.*, 2010). Recently, a commercial product consisting of pollen of narrow-leaved cattail, *Typha angustifolia* (Nutrimite™, Biobest N.V., Belgium), was launched to support generalist predatory mites in the field. However, when considering omnivorous (pollen-feeding) pests, such as the western flower thrips, *Frankliniella occidentalis* (Pergande), pollen products should be applied with extreme care in order not to promote pest populations (Hulshof *et al.*, 2003), especially in ornamentals with a zero tolerance for crop damage.

In the present laboratory study, we assessed to what extent *F. occidentalis* benefits from *T. angustifolia* pollen and two types of dry decapsulated cysts of the brine shrimp *Artemia franciscana* Kellogg (Branchiopoda: Artemiidae), which are known to be a suitable food source for generalist predatory mites (Nguyen *et al.*, 2014; Vangansbeke *et al.*, 2014). We tested both high quality decapsulated cysts of *A. franciscana* from a research laboratory (Artemia Reference Centre, Ghent University) and a commercial product of decapsulated *Artemia* cysts (Artefeed, Koppert BV, The Netherlands). We also tested the developmental and reproductive performance of *A. swirskii* on the three supplemental foods whether or not in combination with their target prey, first instars of *F. occidentalis*. Additionally, we assessed the impact of the supplemental foods on the predation efficacy of *A. swirskii* females on first instars of *F. occidentalis*.

Material and methods

Insect and mite rearing

Predatory mites were obtained from Biobest N.V. (Westerlo, Belgium) and were maintained on plastic arenas, of which the edges were covered with moist tissue paper. Pollen of *Typha latifolia* L. was dusted over the arenas biweekly as a food source. A laboratory colony of *F. occidentalis* was reared on green beans (*Phaseolus vulgaris* L.) in plastic boxes provided with a layer of vermiculite. Colonies were reared and experiments done at 25 ± 1 °C, 65 ± 5% RH and a 16 L:8 D h photoperiod.

Population growth of thrips

For each experiment, 50 first instar larvae (< 6 h old) of *F. occidentalis* were collected from the stock colony and were transferred individually to bean leaf discs (ø 5 cm) placed upside down on a 7 mm layer of agar (1% w/w) in a closed insect breeding dish (5 x 1.5 cm). The first series of 50 larvae received no extra food, whereas for the other three series, bean leaf discs were supplemented with either Nutrimite^{TM}, high quality *A. franciscana* cysts or Artefeed cysts. Foods were replenished once a week. Development and survival were monitored twice a day up to adulthood. Thereafter, females were paired with a male and reproduction was followed daily during the first 5 days and thereafter every other day on bean leaf discs with or without supplemental food. Reproduction was assessed by counting the number of hatched larvae. To determine the egg incubation period, 10 cages with a bean leaf disc were provided with 10 gravid female *F. occidentalis* for 8 h, after which the females were removed. Next, egg hatching was monitored every 12 h. After 6 days, leaf discs were checked for non-hatched eggs.

Population growth of A. swirskii

For each diet, 50 predatory mite eggs (< 8 h) were collected from the stock colony and were placed individually on square (2.5 x 2.5 cm) bean leaf arenas (*P. vulgaris*). The leaf arenas were placed upside down on a water-soaked sponge and the edges were covered with moist tissue paper to provide free water and prevent the mites from escaping. Development and survival was monitored twice a day. Once the adult stage was reached, oviposition was monitored daily, eggs were collected and allowed to develop to adults to assess the sex ratio. The different diets tested were: thrips larvae, Nutrimite^{TM}, Nutrimite^{TM} + thrips larvae, *A. franciscana* larvae, *A. franciscana* larvae + thrips larvae, Artefeed and Artefeed + thrips larvae.

Influence of supplemental foods on predation capacity of A. swirskii
Gravid four-days-old females of *A. swirskii* fed on either Nutrimite^{TM} + thrips, *A. franciscana* + thrips or Artefeed + thrips were used to assess their predation capacity on first instars of *F. occidentalis*, either with or without the aforementioned supplemental foods. For each diet, two groups of 30 females (with or without supplemental food) were individually transferred to a reversed square bean leaf disc (2.5 x 2.5 cm) placed on a polyurethane sponge soaked in tap water and supplied with 15 *F. occidentalis* first instars. The first group of females received only thrips, whereas the second group received thrips supplemented with the same food source the mites were previously reared on. The number of killed thrips larvae was counted after 24 h.

Statistical analysis
Intrinsic rates of increase (r_m) were calculated using the methods described by Birch (1948) and Maia *et al.* (2000). We used one-way-ANOVA analysis to compare the jackknife values of r_m (Meyer *et al.*, 1986) and means were compared using Tukey's (homoscedasticity) or Tamhane's test (heteroscedasticity). Differences in predation rates were analyzed by means of Student's t-tests. The level of significance was set at 0.05.

Results and discussion

Population growth of thrips
Immatures of *F. occidentalis* developed more than one day (10.4 ± 0.1 days) faster when Nutrimite^{TM} was supplemented on bean leaf discs compared to bean leaf discs only (11.5 ± 0.1 days). Both *Artemia* diets did not result in an enhanced development of the thrips larvae (11.5 ± 0.1 and 11.6 ± 0.1 days, respectively). Supplementing leaf discs with pollen increased thrips reproduction considerably above that observed with Artefeed (Figure 1). With Artefeed, oviposition rate was slightly higher than on bean leaf discs alone. Little or no difference to bean leaf alone was observed when *F. occidentalis* was provided with high quality cysts of *A. franciscana.*

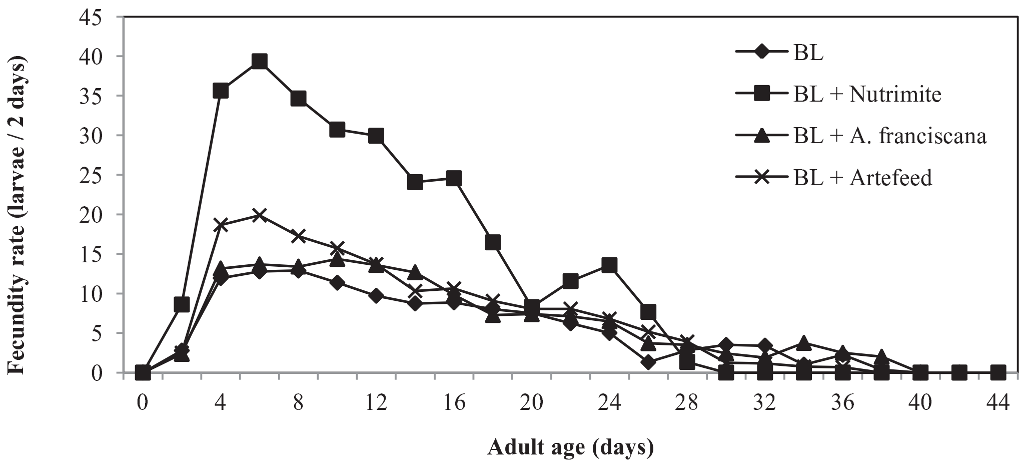

Figure 1: Oviposition rate of *F. occidentalis* fed on different diets at 25 °C. Food supplements were provided on bean leaf discs (BL).

Population growth rates of *F. occidentalis* were higher when Nutrimite™ was provided on the bean leaf discs, whereas both *Artemia* products were less supportive (Figure 2).

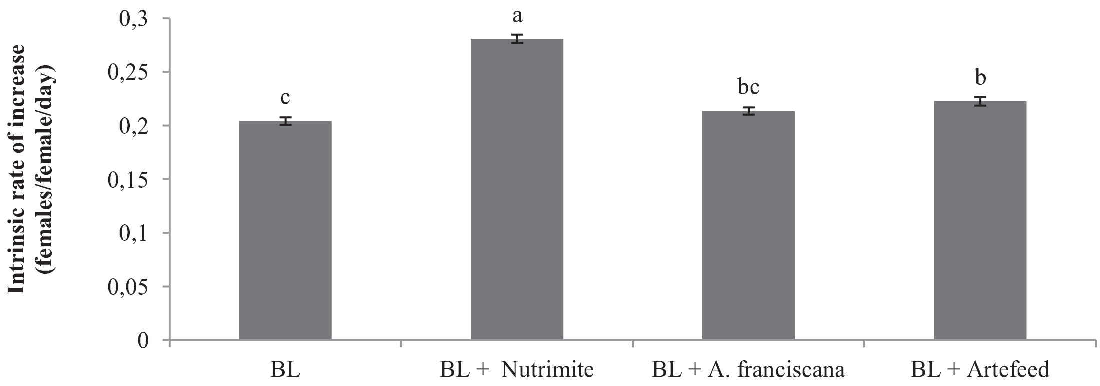

Figure 2: Effect of food supplements on the population growth of *F. occidentalis* fed on different diets at 25 °C. Food supplements were provided on bean leaf discs (BL) (one-way ANOVA: $F = 78.2$; $df = 3, 82$; $p < 0.001$; means were separated using Tukey tests).

Population growth of A. swirskii

Based on intrinsic rates of increase, Nutrimite™ was found to be an excellent food source for *A. swirskii* (Figure 3). Moreover, when the pollen was combined with *F. occidentalis* larvae, no additional effect was observed. For both *Artemia* diets, lower population growth rates were observed. However, when combining *Artemia* cysts with thrips, population growth rates were higher than on a thrips only diet.

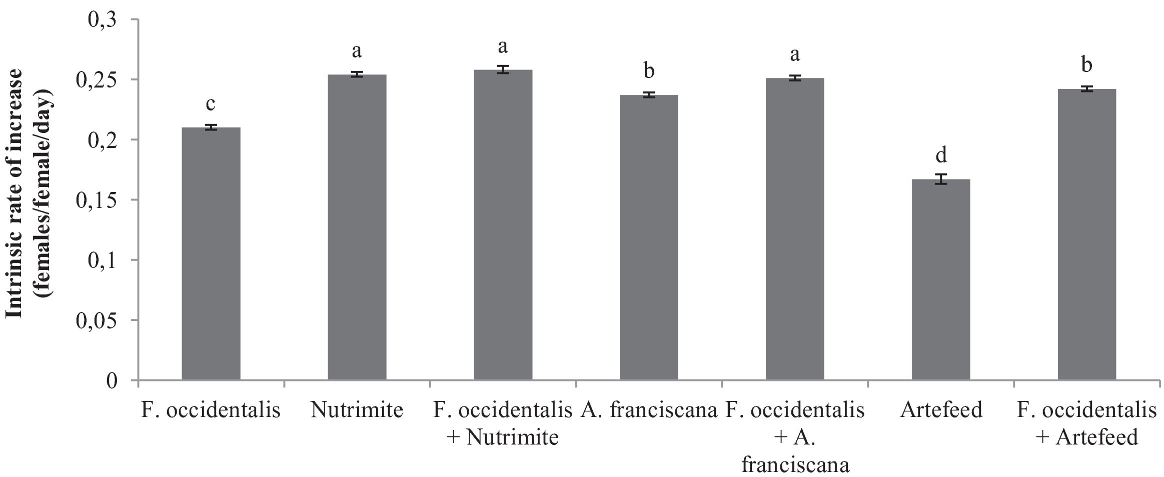

Figure 3: Intrinsic rates of increase of *A. swirskii* fed on different diets (one-way ANOVA: $F = 189.2$; $df = 6,225$; $p < 0.001$; means were separated using Tamhane tests)

Influence of supplemental foods on predation capacity of A. swirskii

Adding food supplements significantly reduced the number of killed thrips, but different foods yielded different levels of reduction. Whereas Nutrimite^{TM} yielded a 45% decrease in consumption rate of *A. swirskii* females, providing Artefeed resulted in a less pronounced reduction in predation of ca. 20%.

The results of our laboratory study indicate that *Artemia* cysts have the potential to support *A. swirskii* populations in the crop. Moreover, the beneficial effect of *Artemia* products on the omnivorous *F. occidentalis* was minimal, whereas thrips fecundity was more than twice as high when *T. angustifolia* pollen (Nutrimite^{TM}) were provided. The reduction in predation capacity of the predatory mite in the presence of *Artemia* cysts is less pronounced than with a supplement of Nutrimite^{TM}. More research should be conducted on the combination of both high and lower quality food supplements, at the same time minimizing benefits for thrips and boosting the population growth of the predators. Field tests will have to elucidate whether lower quality (i.e., cheaper) foods can be used to maintain a population of predatory mites to a level which allows them to effectively control thrips in the crop.

Acknowledgements

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