UNIVERSITEIT GENT
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Developmental and reproductive fitness of *Adalia bipunctata* on factitious and artificial diets

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Introduction

The two-spotted ladybird *Adalia bipunctata* (L.) is indigenous to Europe and a commercialized aphidophagous predator. In Europe, this predator may be an alternative to the compromised harlequin ladybird *Harmonia axyridis* (Pallas) as a biological control agent of aphids. In order to stimulate the use of *A. bipunctata,* production could be rationalized. The main reason for the high production cost is the use of expensive foods such as eggs of the Mediterranean flour moth *Ephestia kuehniella* Zeller or live aphids.

In the present study the nutritional value of different alternative foods to sustain development and reproduction of *A. bipunctata* was compared. Both insect and non-insect animal foods, as well as plant foods were tested.

Cysts of the brine shrimp *Artemia franciscana* (Kellogg) are commonly used in fish larviculture. *Artemia* cysts and the artificial meat and liver diet used in this experiment have been proposed as alternative foods for predatory bugs like *Orius* and *Macrolophus* species. Pollen alone does not to sustain development of *A. bipunctata* but may constitute a useful supplementary food source.

Materials & Methods

A colony of *A. bipunctata* was acquired from Biobest NV (Westerlo, Belgium) and fed a 50:50 (w/w) mixture of *E. kuehniella* eggs and pollen. The colony was maintained and the experiments were carried out in incubators set at 23 ± 1°C, 65 ± 5% RH and a 16h photoperiod.

In the experiment 8 diets were tested: (1) live pea aphids *Acyrthosiphon pisum* (Harris), (2) *E. keuhniella* eggs plus moist honey bee pollen, (3) dehydrated and (4) hydrated decapsulated *A. franciscana* cysts, (5) lyophilized meat and liver diet, (6) dehydrated and decapsulated *A. franciscana* cysts supplemented with pollen, (7) lyophilized meat and liver diet supplemented with pollen and (8) a mixture of pollen, dehydrated and decapsulated *A. franciscana* cysts and lyophilized meat and liver diet.

For each diet 60 hatchlings were individually placed in Petri dishes (9 cm diameter; 2 cm high) lined with absorbent paper and furnished with a paper plug as a source of free water. All foods were replaced on Mondays, Wednesdays and Fridays except for the live pea aphids which were replenished on a daily basis. Larval development and survival were monitored daily and newly emerged adults were weighed, fed the same diet as in the larval stages and allowed to mate. Mating couples were transferred to a new Petri dish. Eggs were collected and counted daily.

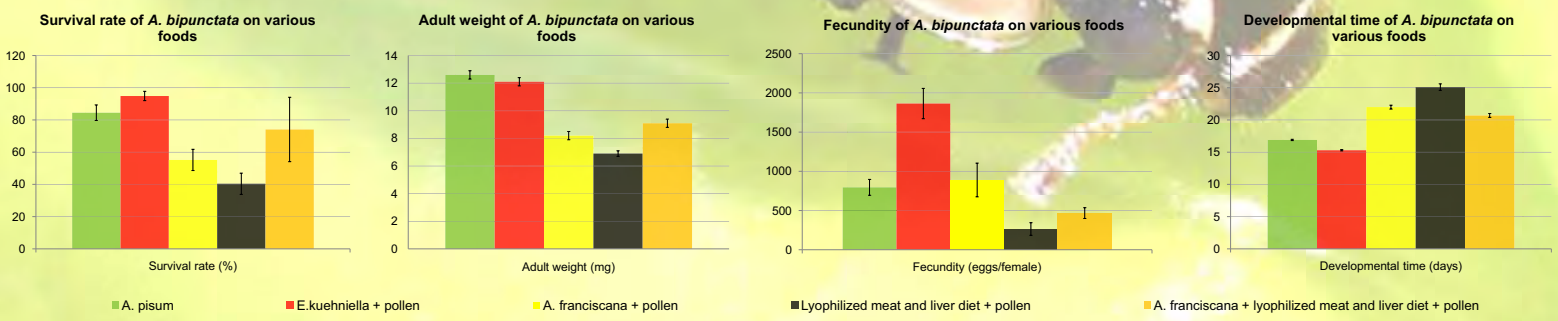
All data except survival rates were subjected to one-way analysis of variance (ANOVA) followed by a Tukey test or, in case of heteroscedasticity, by a Tamhane test. Survival rates had a binomial distribution and were compared by means of a logistic regression.

Results

Larvae of *A. bipunctata* could not reach adulthood when offered only dehydrated or hydrated decapsulated cysts of *A. franciscana*, or only the lyophilized meat and liver diet.

Immature survival on *E. kuehniella* eggs and pollen (94.9%) was similar to that on live aphids (84.5%) but superior to that on the other diets (40.1-74.1%). Survival on the mixture of lyophilized diet, *A. franciscana* cysts and pollen did not differ from that on aphids. Diet also affected total larval and pupal period ($F = 233.21$; $df = 4, 194$; $P < 0.001$), which was ca. 10 days shorter on *E. kuehniella* eggs plus pollen (15.3 days) than on artificial diet supplemented with pollen (25.1 days). Adult weights ($F = 68.29$; $df = 4, 194$; $P < 0.001$) on moth eggs plus pollen or on aphids (12.6 and 12.1 mg, respectively) were almost twice those on the lyophilized artificial diet plus pollen (6.9 mg).

Diets affected lifetime oviposition ($F = 18.61$; $df = 4, 67$; $P < 0.001$). The number of eggs laid on *E. kuehniella* eggs plus pollen (> 1800 eggs per female) was superior to that on the other diets but no significant differences were found among aphids and the other unnatural diets tested, with mean values ranging from 265 to 890 eggs per female.



Discussion

Larvae of *A. bipunctata* were unable to reach adulthood when reared solely on hydrated or dry decapsulated cysts of the brine shrimp *A. franciscana* or on the lyophilized meat and liver diet. This implies that these foods are nutritionally inadequate or its nutrients are at least in part physiologically inaccessible. When bee pollen were added to dry *Artemia* cysts or lyophilized diet larval survival increased up to 40-55 %. Mixing pollen with dry brine shrimp cysts or lyophilized artificial diet ensures a continued hydration of latter materials, making them easier to be processed by the predator. Besides this hydrating effect, pollen may also provide essential nutrients for the predator. The nutritional value of pollen for insects varies greatly among and even within plant species, but particularly zoophilous pollen is known to contain high amounts of proteins, amino acids, starch, lipids, and sugars and traces of vitamins and minerals.

Besides supplying the predator with extra nutrients or water, mixing pollen with the unnatural foods tested in our study may also have stimulated the ingestion of those foods. Developmental performance of *A. bipunctata* was improved when *A. franciscana* cysts, lyophilized artificial diet and pollen were mixed together as compared to combining pollen with cysts or artificial diet alone. The three-component mix probably provides the predators with a sufficiently broad range of physiologically accessible nutrients to complete development.

Offering mixed foods of animal and plant origin may contribute to increasing the cost-effectiveness of mass production by reducing the input of natural prey like aphids, or of nutritionally superior but highly expensive unnatural foods like lepidopteran eggs. In order to rationalize the use of such mixed foods the minimal amount of the optimal food should be determined and the ideal proportion of the different components assessed. Moreover, using several components in an insect diet makes the rearing process less dependent on a single food source.