Use of nectar resources by *Asocgaster quadridentata* WESMAEL (Hymenoptera, Braconidae), an important egg-larval parasitoid of the codling moth: first evidence from laboratory studies

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Abstract

Functional biodiversity on different trophic levels can provide essential pest control in agroecosystems. Codling moth as a key pest in apple is the target host of several parasitoid species whose efficacy may depend from a diverse environment. For instance, plant-derived food (nectar, pollen) from flowering plants could be crucial for their survival and successful reproduction. In a first attempt, the effect of providing sugar resources and nectar providing plants on survival of males and females of the codling moth parasitod Ascogaster quadridentata Wesmael *was estimated in laboratory studies. Plants were selected by their multifunctional qualities as nectar providers for pollinators and beneficials and as cover crop. Both sexes of* A. quadridentata *increased their survival considerably by access to different sugar sources. From the offered plants, however, only buckwheat could feed* A. quadridentata *successfully. Results will be used to design first field experiments in this ongoing study.*

Keywords: Functional biodiversity, plant provided food, conservation biological control, sustainable fruit growing

Introduction

The involvement of natural regulative processes in pest control is an important prerequisite for sustainable production both in organic and integrated fruit growing. Codling moth, *Cydia pomonella* (Lepidoptera, Tortricidae) is the key pest in apple production due to direct damage of fruits and increasing resistance against insecticides as well as viral biopesticides. Conservation biological control by enhancing natural enemies may help to reduce pest pressure and improve control strategies. The egg-larval parasitoid *Ascogaster quadridentata* (Hymenoptera, Braconidae), a specialist of several Tortricid pests, occurs in most apple-growing regions and can be highly effective, especially in parasitizing the summer generation of the pest. Under laboratory rearing conditions, *A. quadridentata* lives several weeks when honey-fed. Thus, successful location and use of nectar and other sugar resources may also be an essential factor for sufficient survival and reproduction in the field. For active habitat manipulation, floral resource plants which favour the natural enemy but not the pest should be preferably selected (Lavandero *et al*., 2006). Furthermore, establishment of plants with confirmed multifunctional qualities (insectary plants, soil fertilization, use for human or animal food) or the preserving of the biodiversity of natural occuring wild plants may be more acceptable for the grower when aiming on the ecological engineering of the crop system (Fiedler *et al*., 2008; Walton & Isaacs, 2011). We describe laboratory experiments which test the use of sugar sources and nectar providing plants with multifunctional qualtities by *A. quadridentata* as the first step in designing suitable ecological infrastructures.

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Material and Methods

Based on field collections from South-Hessia and Baden-Württemberg, a laboratory rearing of *A. quadridentata* was established in 2010. Parasitoid females were allowed to oviposit into codling moth eggs and hatched host larvae were subsequently reared in individual containers on artificial diet until parasitized host larvae emerged for cocoon spinning. Larvae were collected and added to plastic boxes containing corrugated cardboard rolls for pupation and adult emergence. Development took place within 5 to 6 weeks at 25°C and long day conditions (16:8 h). Plants were sown in pots and grown in the greenhouse until blooming.

For the first experiment, individual caged, freshly emerged parasitoids were offered one of the following options: 1) water, provided in a 5 ml plastic vial with a cotton wick, 2) water (as above) and honey (small drops smeared on pieces of Parafilm®), 3) water and fructose-solution (1 mol, provided in a 5 ml plastic vial with a cotton wick *ad libidum*), 4) water and glucose-solution (1 mol, in 5 ml plastic via with a cotton wick, *ad libidum*), 5) water and one freshly cut, water-immersed inflorescence of buckwheat (*Fagopyrum esculentum* Moench), changed daily, 6) water and one inflorescence of buckwheat, changed every second day. Survival of the wasps was recorded daily and sex was determined after death. For each treatment, 20 wasps were set up within a couple of days.

In the second experiment, wasps were provided with the following treatments: 1) water only, 2) water and honey, 3) water and one inflorescence of wild mustard (*Sinapis arvensis* L., 4) water and one inflorescence of Phacelia (*Phacelia tanacetifolia* Benth.), 5) water and buckwheat, 6) water and wild parsnip (*Pastinaca sativa* L.*)*, 7) water and red clover (*Trifolium pratense* L.*)*. Plants of treatments 3, 4, and 5 were grown in the greenhouse; plants of treatments 6 and 7 were taken from the field every morning. Inflorescences were changed daily. Survival and sex were recorded as above. For each treatment, 20 to 25 wasps were set up within a couple of days.

Survival data of wasps in the different treatments were analyzed using ANOVA with PROC GENMOD (SAS software version 9.2, 2008: Poisson distribution with logit link), followed by the LSD Multiple Range test or survival analysis with the Product-Limit method (PROC LIFETEST; SAS, 2008). No significant differences in longevity between sexes or interaction of sex with food were found and subsequent analysis was performed with pooled results of males and females in the different food treatments. Survival curves were compared between treatments using a log rank test and multiple comparisons between treatments were made using Šidák-corrected p-values (SAS, 2008).

Results

Food had a significant effect on survival of *A. quadridentata* in the first (χ^2 = 112.5, df = 5, $P < 0.0001$) and the second experiment (χ^2 = 123.9, df = 6, $P < 0.0001$) as well. Access to sugar sources as honey or sugar solutions significantly increased the longevity (Figure 1). In the first experiment, wasps died after 3.9 days when offered water only, but lived nearly ten times longer (34.3 days) when having access to pure honey. Those wasps which were fed with glucose or fructose lived on average 19 and 25 days respectively. Offering buckwheat also clearly prolonged the survival of the wasps (16 days). However, changing the inflorescence only every second day had no significant effect in comparison to the water control and wasps died after 5.8 days in this treatment.

In the second experiment, overall survival was generally shorter in all treatments (Figure 2). In the water control, the wasps died after 3.3 days, but lived three times longer (10.5 days) when fed with honey. Having access to buckwheat also significantly increased the longevity of the wasps (5.4 days) in comparison to water. The other plants were obviously not used or not suitable to feed *A. quadridentata* as their provision did not prolong survival. Flower-visiting by individuals was observed only on buckwheat and wild parsnip, not in the other treatments.

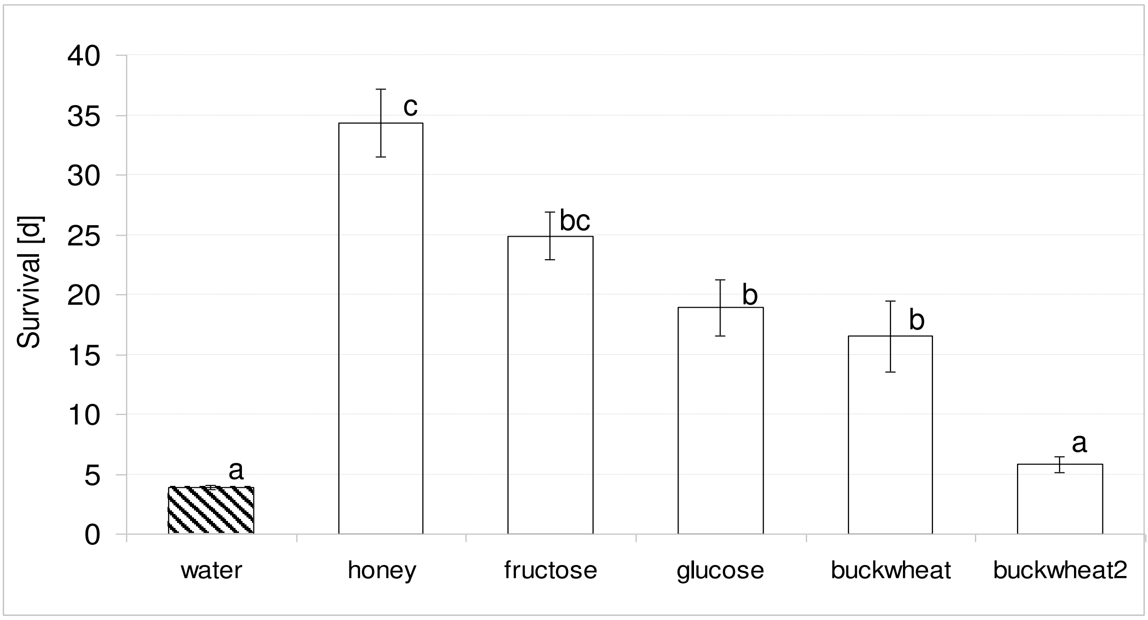

Figure 1: Longevity (mean ± SE) of *A. quadridentata* when provided with different sugar resources (1 mol solution) or buckwheat flowers, cut daily or every second day in comparison to water only. Significant differences between treatments are indicated by different letters at $p \leq 0.05$.

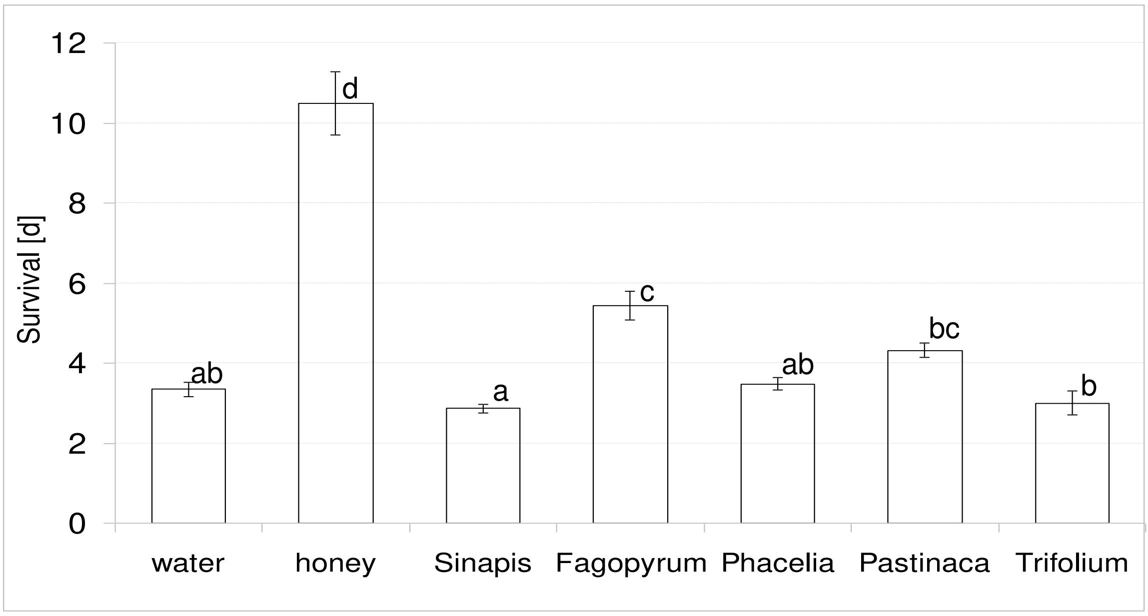

Figure 2: Longevity (mean ± SE) of *A. quadridentata* when provided with different sugar resources (1 mol solution) or buckwheat flowers, cut daily or every second day in comparison to water only. Significant differences between treatments are indicated by different letters at $p \leq 0.05$.

Discussion

Lifespan of *A. quadridentata* increased to several weeks by feeding on honey or sugar solutions. Honey was the best food, suggesting that beside sugars other components (pollen, minerals etc.) may support the parasitoid`s survival. Wasps did also well from feeding on fructose and to some lesser extent from glucose and freshly cut buckwheat flowers. Changing buckwheat only every second day obviously leads to the starvation of the wasps, suggesting that the nectar provision was insufficient. Also Lee & Heimpel (2008) reported decrease in survival of *Cotesia glomerata* (L.) when buckwheat flowers were changed every second or third day instead of daily change. Methodology of presenting flowering plants (number of flowers, excised or intact inflorescences), plant quality *per se* as well as overall fitness of the parasitoids certainly affects the results of such experiments (Wade & Wratten, 2006).

Mustard, *Phacelia* and red clover had no enhancing effect on the wasps which died as quickly as those in the water control. Flowers of wild parsnip usually attract many insects with unspecialized mouthparts and were therefore expected to feed also this parasitoid. However, lifespan of *A. quadridentata* was only marginally prolonged by this plant. Flowers were collected from outside and their nectar might have already been exhausted and it may be valuable to repeat the test with greenhouse grown plants. According to these preliminary results, buckwheat can be considered as suitable cover crop in orchards for promoting *A. quadridentata*. This plant was already shown to be a suitable nectar resource for many beneficial insects also in other crop systems. It is usually planted due to its soil protecting and weed suppressing properties especially in vineyards, where *A. quadridentata* may be also active in parasitizing grape moths (Thiéry *et al.*, 2011), thus presenting a cover plant with multifunctional qualities. Nevertheless, the need for additional plant-provided food for enhancing survival, but also fertility of this important parasitoid of tortricid pests will be studied in subsequent experiments. Also selectivity of buckwheat and other flowering plants in increasing fitness of natural enemies but not of the pest, e.g. the codling moth, needs to be clarified.

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