UNIVERSITY OF AMSTERDAM

UvA-DARE (Digital Academic Repository)

The significance of floral resources for natural control of aphids

Langoya, L.A.; van Rijn, P.C.J.

Published in:
Proceedings of the Netherlands Entomological Society Meeting

Link to publication

Citation for published version (APA):
Langoya, L. A., & van Rijn, P. C. J. (2008). The significance of floral resources for natural control of aphids. *Proceedings of the Netherlands Entomological Society Meeting*, *19*, 67-74.

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

UvA-DARE is a service provided by the library of the University of Amsterdam (http://dare.uva.nl)

Download date: 27 Feb 2021

The significance of floral resources for natural control of aphids

L.A. Langoya & P.C.J. van Rijn
Centre for Terrestrial Ecology, Netherlands Institute for Ecology, NIOO-KNAW, PO Box 40, 6666 ZG Heteren, The Netherlands, E-mail: l.langoya@nioo.knaw.nl, p.vanrijn@nioo.knaw.nl

The main objective of the Functional Agro-Biodiversity project in the 'Hoeksche Waard' is the creation of favourable conditions both at the farm and landscape level for promoting bio-diversity and the role of natural enemies of pests.
Aphids constitute one of the major crop pests in Dutch arable and vegetable farming. The common syrphid, *Episyrphus balteatus*, is one of the important predators of this polyphagous pest complex. Since only its predatory larval stage subsists on aphids, while the adult live primarily on nectar and pollen, agro-biodiversity enhancement in the form of field margin plants can be particularly essential for syrphid survival and reproduction and for sustaining a viable natural enemy population. Field and laboratory investigations show that selected plant species strongly differ in their suitability as food sources for the syrphid *E. balteatus*, even within specific families. Aphid honeydew is an important supplementary food source. *E. balteatus* can, on the basis of our analyses, be regarded as an effective predator of aphids.

Keywords: conservation biological control, aphids, hoverflies, *Episyrphus balteatus,* nectar, pollen and honeydew.

Functional Agro-Biodiversity (FAB) is a concept that aims at substantially reducing pesticide use in arable and field vegetable farming through exploitation of the potentials of natural control. One of the goals of FAB is the enhancement of natural control by: 1) improving the quality of semi-natural landscape elements such as hedgerows and dykes, 2) creating field margins for food and shelter for entomophagous insects, and 3) minimal and selective use of pesticides based on monitoring pests and natural enemies.

Syrphids (hoverflies) feature conspicuously among the natural enemy populations in field crops. Detailed studies of their contribution to pest management are limited (Schmidt *et al.* 2004). Compared to other natural enemies, *e.g.* lady beetles or lacewings, hoverflies seem to be better equipped in locating aphid colonies, because of their swift flight patterns and ability to hover to quickly assess preys. Worldwide there is a fairly large number of species that are aphidophagous (Bugg 1992). Among these, *Episyrphus balteatus* is one of the most abundant species in arable fields (van Rijn & Smit 2007). Aphidophagous hoverflies alternately feed on plant-derived foods (nectar and pollen) and prey on aphids during different stages of their life cycle. The exploitation of these food sources is of practical significance for realising sustainable pest control strategies. These attributes were relevant for the functional choice of field margin plants in this research.

We examined three key questions: (1) the suitability of flowering plant species for field margins, (2) the importance of nectar, pollen and honeydew for syrphid survival, and (3) the impact of syrphids on aphid populations.

MATERIAL AND METHODS

Field experiments

Field experiments were conducted with both annual and perennial field margin plants. Annual plants produce comparatively large quantities of flowers, while perennials essentially function as sanctuaries for various insects. Careful phenological analysis of these prospective plants provided us with a select group of species capable of guaranteeing a steady supply of nectar and pollen for natural enemies from week 22 to week 40, during which aphids can be present in the field crops. The margins were laid adjacent to the crop fields.

Aphid and syrphid population densities per leaf were monitored on potato crops at 3.5, 15, 40 and 90 metres distances from the perennial margins and annual plant strips.

Laboratory experiments

Complementary to field observations, laboratory experiments were conducted with the aim of understanding the extent to which flowering plants in farming environments can contribute to the survival and reproduction of natural enemies.

The role of floral resources of the different plant species in the life history of *E. balteatus* was investigated. Cage experiments in climate chambers were carried out under controlled conditions (22°C and 80% RH). Each cage (130 dm^2) was provided with a flowering plant, two freshly emerged males and females of *E. balteatus* and a bottle with wet cotton wool for water supply. *E. balteatus* pupae were provided by Koppert B.V. (Berkel and Rodenrijs, The Netherlands). The survival of the syrphids was checked every other day.

For studying the impact of honeydew and for reproductive studies a six weeks-old Brussels sprout plant (bearing 5-7 leaves), initially infested with 10 cabbage aphids (*Brevicoryne brassicae*), was added to each cage. The honeydew produced by aphids is known to be essential for stimulating syrphid oviposition (Scholz & Poehling 2000).

RESULTS

Field Experiments

The results of field observations of 2007 in potato fields can be summarised by the following:

1) *Aphis nasturtii* was the most observed aphid species, followed by *Macrosiphum euphorbiae*.

2) In the potato crop the eggs and larvae of hoverflies were the most numerous of all natural enemies, followed by lacewings (esp. *Chrysoperla* spp.). Lady beetles (*Coccinella* spp.), predatory bugs (*Orius* spp.) and parasitoids (*Aphidius* spp.) were of minor importance.

3) Among the adult hoverflies visiting the flowering strips *Melanostoma mellinum* and *E. balteatus* were the most numerous.

4) The mean total aphid density was always below 1 per (compound) leaf; well below economic threshold levels. No pesticide applications were needed.

5) In June and July the aphid densities were never higher than 0.3 per leaf, clearly lower than in the previous two years on these farms. The predator-to-prey ratio was clearly higher compared to previous years, indicating an increasing effectiveness of local natural enemy populations since field margins and integrated pest management schemes were incorporated.

6) Only at the field with the highest aphid numbers spatial relations with field margins were observed that are similar to the results from the previous year (LTO 2007).

Laboratory experiments

Syrphid survival on different plant species

Survival studies show that for four out of 16 plant species tested (Table 1), longevity of *E. balteatus* males and/or females is not significantly higher than with water only (1.9 days at 22°C). For the other 12 selected species, longevity is higher than with water only, with the averages ranging from 8 to 14 days. The performance of this group of plants did not differ significantly ($P>0.05$) compared to the 1M sucrose control, which resulted in an average of 11.9 days.

Syrphids forage especially on plants with easily accessible nectar. The flowering plants tested as food plants for *E. balteatus* are hence broadly represented in a number of plant families, particularly Asteraceae, Apiaceae and Fabaceae. Even within these selected families, plant species strongly differ in their suitability as food source (Table 1). Within the family of Apiaceae, *Carum carvi* clearly underperformed, whereas within the family of Asteraceae, *Calendula officinalis* was unsuitable as food source for this syrphid species. These differences are associated with the compatibility of the floral morphology with the size and structure of the insect mouthparts. Within Fabaceae, only *Vicia sativa* is suitable, but this is explained not by differences in floral attributes but by the presence of extrafloral nectaries on the stipulae, which are readily accessible for hoverflies.

Table 1. The effect of flowering plants on the longevity of *E. balteatus* compared to a control with water only (P<0.05). Plant species in order of decreasing syrphid longevity.

Food plant species	Plant family	n	Impact on longevity
Pastinaca sativa	Apiaceae	16	+
Borago officinalis	Boraginaceae	44	+
Daucus carota	Apiaceae	10	+
Matricaria recutita	Asteraceae	15	+
Fagopyrum esculentum	Polygonaceae	49	+
Achillea millefolium	Asteraceae	15	+
Vicia sativa	Fabaceae	33	+
Malva sylvestris	Malvacaeae	12	+
Centaurea cyanus	Asteraceae	39	+
Coriandrum sativum	Apiaceae	46	+
Foeniculum vulgare	Apiaceae	21	+
Chrysanthemum segetum	Asteraceae	22	+/0
Medicago sativa	Fabaceae	18	0
Vicia cracca	Fabaceae	13	0
Calendula officinalis	Asteraceae	20	0
Carum carvi	Apiaceae	12	0

The importance of pollen, nectar and honeydew for syrphid longevity

A preliminary assessment of adult *E. balteatus* survival when reared exclusively on pollen shows only half the life span of one reared on sucrose.

The relative importance of sucrose (a substitute for nectar for this experiment) and honeydew as food sources are shown in Figure 1. A strong positive impact of honeydew on adult longevity was observed when compared to a treat-

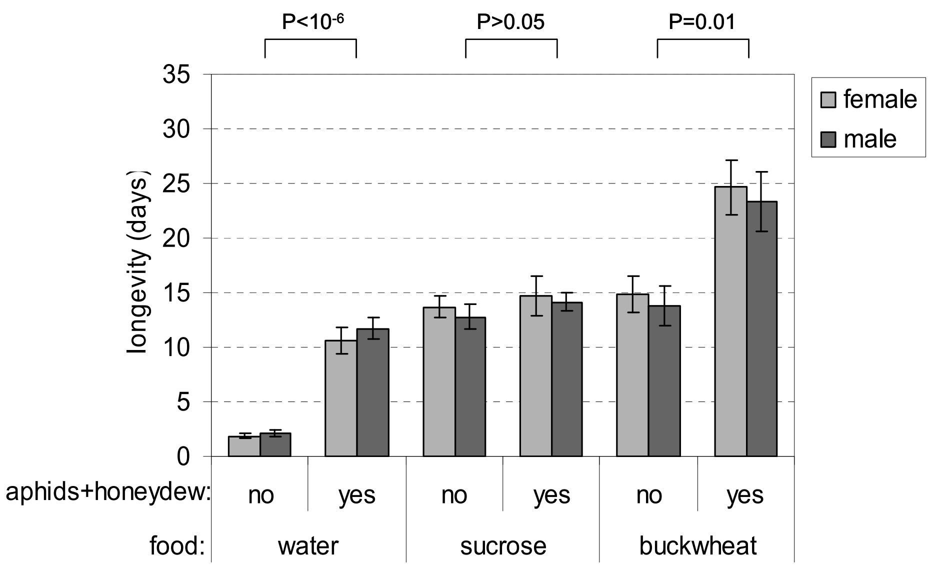

Figure 1. Effect of honeydew in different combinations with other food sources on adult longevity (22°C and 80% RH) ANOVA indicates significant effects of food-source ($P<10^{-6}$) and prey (aphid/honeydew) (P=0.003) and their interaction (P=0.045).

ment with water only ($P<10^{-6}$). A parallel result was seen when honeydew was added to a treatment with flowering buckwheat (*Fagopyrum esculentum*) (P=0.01). This indicates that honeydew is used by the adult syrphids and directly impacts on their longevity. In the presence of sucrose, however, no effect of honeydew is observed. The lack of synergy in the latter combination can be explained by both substances functioning mainly as energy sources.

Syrphid reproduction and aphid control

In a small scale experiment egg production is observed for four out of eight surviving females in cages with cabbage aphids on Brussels sprout plants and pollen and nectar providing plants (of four different plant species – buckwheat, cornflower, coriander and borage). The results (Fig. 2A) show that oviposition commences one week after emergence of females from pupae and continues until the end of the third week.

The larvae of viable eggs normally emerge within 2 to 3 days after oviposition. The predator-prey population dynamics on cabbage plants show that aphid infestation is effectively compromised and diminishes substantially in the presence of syrphid larvae (Fig. 2B). In their absence, the pest population increases unabated to an extent that the cabbage plants no longer can sustain them. Wilting eventually ensues, marking the subsequent decline in aphid numbers (Fig. 2B).

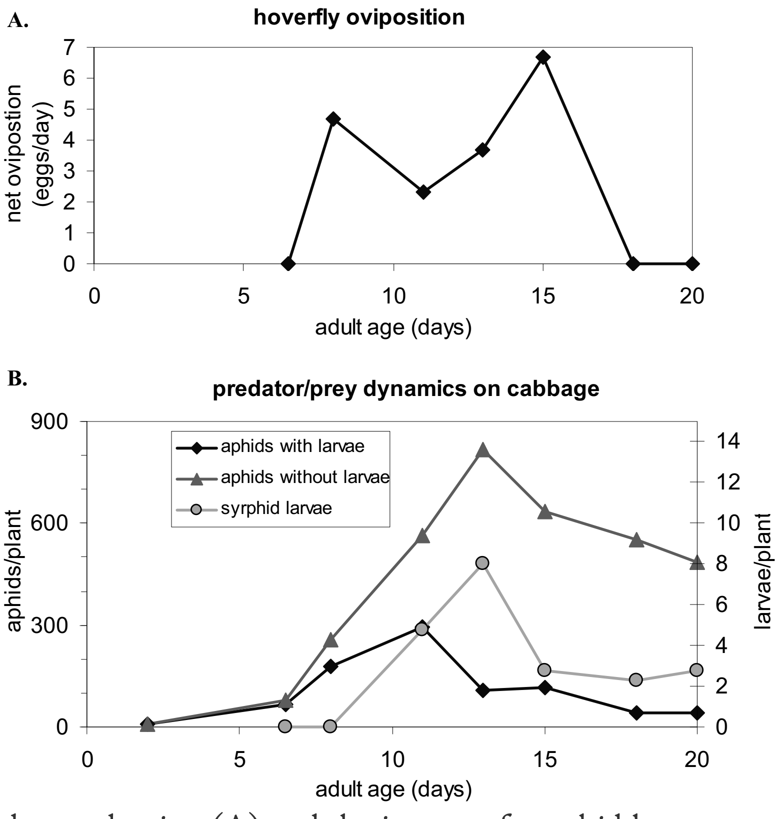

Figure 2. Syrphid reproduction (A) and the impact of syrphid larvae on cabbage aphids (B). Offspring of one female per cage (n=4). Brussels sprout plants infested with cabbage aphids (*Brevicoryne brassicae*) two days after adult emergence.

The observed population dynamics indicate that the offspring of a single female syrphid can check the growth of a colony of about 500 aphids during 3 weeks. Coupled with controlling aphid infestation we witness a corresponding decline in larval predator numbers.

DISCUSSION

The complexity of the trophic interactions under semi-natural conditions necessitated that we take a closer look at the mechanisms behind field observations. We came to the following conclusions: (1) both pollen and nectar are essential for syrphid survival and reproduction, (2) diverse field margins are important in providing a stable supply of food for syrphids and other natural enemies, (3) selected plant species strongly differ in their suitability as food sources for the syrphid *E. balteatus,* even within selected families, (4) aphid honeydew is an important supplementary food source, and (5) *E. balteatus* is potentially an effective predator of aphids. These conclusions are briefly discussed below.

The availability of plant provided food is inevitable for the completion of the life cycle of natural enemies such as syrphids. The females in particular require pollen during the adult stage. Pollen is primarily a source of proteins and amino acids. In addition, it contains lipids, steroids and carbohydrates (Wäckers *et al.* 2007).

Diverse field margins provide additional food for sustaining a viable aphidophagous natural enemy population. Plant species that flower at different times of the season offer a continuous availability of floral resources in the vicinity of crop fields throughout the farming season, facilitating continued presence of natural enemies as long as pest control is required in the field.

Plant species strongly differ in their suitability as food sources for *E. balteatus.* Suitability is partially determined by the morphological match between the mouthparts and flowers. The short tongue of *E. balteatus* as compared to other flower visiting insects, limits it to plant species with short or open corollas (van Rijn & Wäckers 2007). But even within the group of plants with accessible nectar, some species appeared unsuitable, indicating that other factors such as food quality are important as well. When nectar is not available, syrphids may rely on the more easily accessible pollen. Preliminary experiments, however, indicate that pollen is not equally significant in sustaining adult longevity.

Syrphid oviposition in or near aphid colonies is advantageous for the female that benefits from the available honeydew. This can otherwise be seen as a prudent strategy to avail emerging larvae easy access to aphids. Still, aphid honeydew appears to have a strong impact on adult longevity. As a supplementary food source it is valuable not only for being rich in carbohydrates, but can provide some amino-acids as well (Wäckers *et al.* 2008). Hogervorst *et al.* (2007) showed that honeydew specific sugars can be traced in field-collected *E. balteatus*. Even second and third instar larvae of syrphids appear to feed on honeydew and sucrose too (Bargen *et al.* 1998). More research in the reproductive physiology of *E. balteatus* could probably provide us with valuable information about the importance of honeydew in the predator-prey interrelationship.

The practical implications of the above observations for biological control can best be viewed against the background of three sets of realities: 1) A good natural enemy does not exclusively rely on a single prey species under field conditions. Being a facultative omnivore that feeds on the nymphs of scale insects (Bargen *et al.* 1998) and on other homopterous taxa (personal field observations), *E. balteatus* can survive on alternative preys; 2) Aphids are under natural conditions ephemeral resources due to their susceptibility to a wide range of biotic and other influences such as predation, parasitism, declining host qualities, changes in weather and dispersal (Bugg 1992). Polyphagy apparently has suited them for their relative success in agrarian environments. A successful aphid pest management must therefore embrace the use of efficient predators. Whereas the relatively slower natural enemies such as coccinelid beetles, chrysophids and anthrocorids may be preferred in augmentative bio control (ABC) in covered crops, the highly mobile and effective *E. balteatus* appears to be suitable for conservation bio control (CBC) under open field conditions; 3) The presence of natural enemies in field margins should be well synchronised with the earliest onset of crop infestations in order to realise the practical benefits of timely biological pest control.

Acknowledgments The authors would like to thank Jurgen Kooijman and Anita Dulos for their valuable contributions to laboratory experiments and André Kamp for practical assistance in field monitoring. We are particularly grateful to the department of Multitrophic Interactions (MTI) of the NIOO for providing the opportunities for accomplishing this work.

REFERENCES

Bargen, H., Sandhof, K. & Poehling, H.-M. 1998. Prey finding by larvae and adult females of *Episyrphus Balteatus*. Entomologia Experimentalis et Applicata 87 (3): 245-254.

Bugg, R.L. 1992. Habitat manipulation to enhance the effectiveness of aphidophagous hoverflies. Sustainable Agricultural Technical Reviews. University of California.

Hogervorst, P.A., Wäckers, F.L. & Römeis, J. 2007. Detecting nutritional state and food source use in field-collected insects that synthesize honeydew oligosaccharides. Functional Ecology 21 (5): 936-946.

LTO. 2007. Rapportage FAB 2006. Functionele AgroBiodiversiteit. www.lto.nl/fab.

Rijn, P.C.J. van & Smit, J.T. 2007. Zweefvliegen (Diptera: Syrphidae) voor de natuurlijke bestrijding van bladluizen. Entomologische Berichten 67(6): 253-256.

Rijn, P.C.J. van & Wäckers, F.L. 2007. Bloemrijke akkerranden voeden natuurlijke vijanden. Entomologische Berichten 67(6): 226-230.

Schmidt M.N., Thewes U., Thies, C. & Tscharntke, T. 2004. Aphid suppression by natural enemies in mulched cereals. Entomologia Experimentalis et Applicata 113: 87-93.

Scholz, D. & Poehling, H.-M. 2000. Oviposition site selection of *Episyrphus balteatus*. Entomologia Experimentalis et Applicata 94(2): 149-158.
Wäckers, F., Rijn, P. van & Heimpel, G. 2008. Honeydew as a food source for natural enemies: Making the best of a bad meal? Biological Control (in press).
Wäckers, F.L., Römeis, J. & Rijn, P.C.J. van 2007. Nectar and pollen feeding by insect herbivores and implications for multitrophic interactions. Annual Review of Entomology 52: 301-23.