

# Herbivores and their parasitoids show differences in abundance on eight different nectar producing plants

Karin Winkler<sup>1</sup>, Felix L. Wäckers<sup>2</sup>, Laetitia Buitriago<sup>1,3</sup> & Joop C. van Lenteren<sup>1</sup>

<sup>1</sup>Wageningen University, Laboratory of Entomology, Binnenhaven 7, 6709 PD Wageningen, The Netherlands; <sup>2</sup>Netherlands Institute for Ecological Research (NIOO-KNAW), Heteren, The Netherlands; <sup>3</sup>Ecole Nationale d'Ingénieurs des Travaux Agricoles de Bordeaux, 1, cours du Général de Gaulle, P.B. 201, 33175 Grandignan Cedex, France

Flowering field margins can play an important role in enhancing biological control by providing food for beneficial insects. At the same time herbivorous insects might profit from the flowers, which unintentionally might result in higher pest numbers. Herbivorous and parasitic insects differ in their exploitation of nectar sources. Direct visual observation and sweep net sampling on eight plant species (*Anethum graveolens*, *Borago officinalis*, *Centaurea cyanus*, *Centaurea jacea*, *Fagopyrum esculentum*, *Lobularia maritima*, *Origanum vulgare*, *Tanacetum vulgare*) were used to identify flowers which are selectively visited by beneficial parasitoids, but not by their herbivorous hosts. On two plant species with either exposed nectaries (*A. graveolens*) or extrafloral nectaries (*C. cyanus*) the parasitoid *Diadegma semiclausum* was observed, but none of the herbivores in substantial numbers. Other plant species, like *O. vulgare*, were visited by at least one of the herbivore species, but not or in low numbers by *D. semiclausum*. These findings provide important information for fine-tuning the composition of flowering field edges in order to successfully boost biological control.

*Keywords:* flowering field margin, 'selective food plant', *Diadegma semiclausum*, *Plutella xylostella*, *Autographa gamma*, *Pieris* spp.

Establishing flowering field margins to enhance the availability of nectar and pollen-rich plants for beneficial insects can be an element of agro-ecosystem diversification programs. Many beneficial insects, like for example hoverflies (MacLeod 1999) and parasitoids (Leius 1960, Syme 1975, Heimpel *et al.* 1997) depend during their adult stage on food for maintenance, dispersal and reproduction. However, not only beneficial insects, but also herbivores may feed on floral nectar in their adult stage (Romeis *et al.* 2005). Indiscriminately adding nectar sources to agricultural cropping systems could result in higher pest numbers as pest insects may benefit from these food sources as well (Romeis & Wäckers 2002, Zhao *et al.* 1992, Burleigh 1972).

It is only recently that researchers are paying attention to this herbivore stimulating risk (Baggen *et al.* 1999). It means that with the design of flowering field margins, the needs of beneficial as well as pest species have to be taken into

Table 1. Species, families and food provision of flowers used in this study.

| Plant species               | Colour | Family                  | Provide                    |
|-----------------------------|--------|-------------------------|----------------------------|
| <i>Anethum graveolens</i>   | yellow | Apiaceae (Umbelliferae) | nectar                     |
| <i>Borago officinalis</i>   | purple | Boraginaceae            | nectar                     |
| <i>Centaurea cyanus</i>     | blue   | Asteraceae (Compositae) | nectar, extrafloral nectar |
| <i>Centaurea jacea</i>      | purple | Asteraceae (Compositae) | nectar                     |
| <i>Fagopyrum esculentum</i> | white  | Polygonaceae            | nectar                     |
| <i>Lobularia maritima</i>   | white  | Brassicaceae            | nectar                     |
| <i>Origanum vulgare</i>     | purple | Lamiaceae (Labiatae)    | nectar                     |
| <i>Tanacetum vulgare</i>    | yellow | Asteraceae (Compositae) | nectar                     |

account. Flowering field edges should consist of 'selective food plants' (Baggen & Gurr 1998) that mainly, if not exclusively, promote the performance of natural enemies without supporting the pest species.

Herbivorous and parasitic insects differ in their exploitation of nectar sources. This selectivity can be based on various mechanisms, but generally visual or olfactorial attraction plays an important role (Patt *et al.* 1999, Proctor & Yeo 1973, Wäckers 2004). In the multitrophic system 'cabbage – herbivores – natural enemies' we investigated relative attractiveness of a number of flowering herbs for the most abundant cabbage pests and their associated natural enemies. Direct visual observation and sweep net sampling were used to identify flowers which are selectively visited by beneficial parasitoids, but not by their herbivorous hosts.

## MATERIAL AND METHODS

### Plants

Fourteen flower species commonly used in commercially available seed mixtures were sown in three replicates at two experimental locations in the vicinity of Wageningen, the Netherlands. Plots were 3 × 3 m in size, arranged in three rows and separated with a 1 m wide grass strip within and between the rows. Grass was mown regularly and plots were hand weeded. As not all 14 plant species were flowering during the same period, the data presented here are restricted to those eight species that were flowering simultaneously (*Anethum graveolens*, *Borago officinalis*, *Centaurea cyanus*, *Centaurea jacea*, *Fagopyrum esculentum*, *Lobularia maritima*, *Origanum vulgare* and *Tanacetum vulgare*).

### Monitoring insects

We walked around each plot once to count the larger lepidopteran species like *Autographa gamma* and *Pieris* spp. in the flowering vegetation. Small species like *Plutella xylostella* and parasitoids were caught by sweep net sampling. A standard-

ized number of 12 sweeps was used in each plot. To minimize disturbance in the plots, a neighbouring plot was not sampled immediately but later. Sampling was done from week 28 until week 32 on sunny and dry days between 10:00 and 15:00 h.

#### Statistical evaluation

The data for presence of insects on eight different flower species were pooled over weeks and locations. As data were not normally distributed, non-parametric statistics were used to check for significant differences between the groups. When the Kruskal-Wallis test indicated that there are differences among the eight flower species, the Mann-Whitney-U test was used for pair wise comparison between flower species ( $\alpha=0.05$ ).

## RESULTS

Some insect species like *Mamestra brassicae*, *Cotesia glomerata* and *Microliptis* spp. were observed only in low numbers and were therefore excluded from statistical analysis. The average number of *Pieris* spp, *A. gamma*, *P. xylostella* and *Diadegma semiclausum* individuals observed per plant species is presented in Figure 1 a-d.

*Pieris* spp. were observed on two plant species only, *O. vulgare* and *C. jacea*. On *O. vulgare* significantly more individuals were observed than on *C. jacea*. *A. gamma* was observed on four out of the eight plants included in this study. Besides *O. vulgare* and *C. jacea* these were *B. officinalis* and, to a lower extent, *C. cyanus*. *P. xylostella* was observed in low numbers on any plant involved in this study. Highest numbers were caught on *L. maritima*, and this was significantly more than on *A. graveolens*, *B. officinalis*, *C. cyanus* and *T. vulgare*.

The parasitoid *D. semiclausum* was caught on any of the eight plant species except *O. vulgare*. Highest numbers were caught on *C. cyanus*, and this was significantly more than on *C. jacea*, *F. esculentum*, *L. maritima* and *T. vulgare*.

## DISCUSSION

Our observations indicate that herbivorous and parasitic insects differ in their relative attraction to nectar sources. There are three plant species (*A. graveolens*, *C. cyanus* and *T. vulgare*) on which *D. semiclausum* was observed, but none of the herbivores in substantial numbers. Other plant species, like *O. vulgare*, were visited by at least one of the herbivore species, but not or in low numbers by *D. semiclausum*. Even though additional aspects like nectar accessibility play a role as well, these findings provide important information for fine-tuning the composition of flowering field edges in order to successfully boost biological control.

*Diadegma semiclausum* was caught in highest numbers on *C. cyanus*. Besides hidden floral nectar, this plant species also has extrafloral nectaries (Stettmer 1993). In addition, *C. cyanus* plants were heavily invested with aphids during the sampling period. Like extrafloral nectar, aphid honeydew can be an important source of carbohydrates for parasitoids with short, unspecialized mouthparts. It

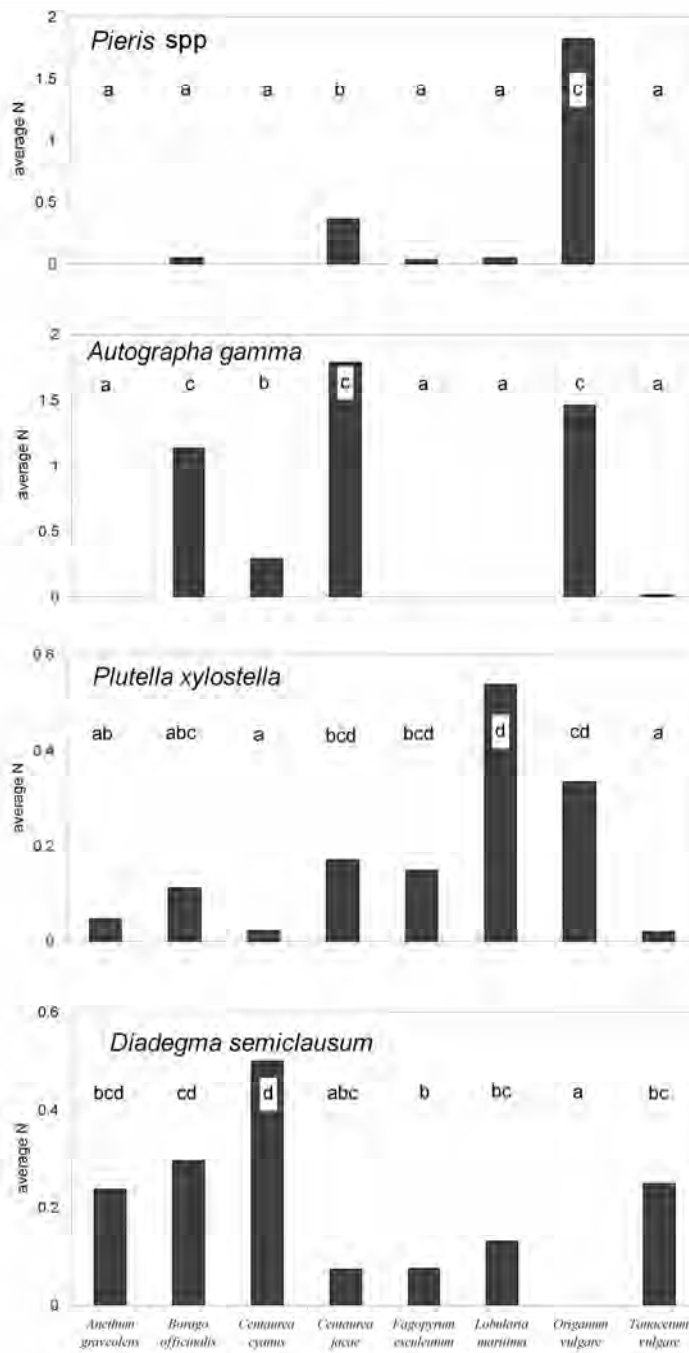


Figure 1. Average number of individuals visually observed ((a) *Pieris* spp. and (b) *Autographa gamma*) and collected by sweep net sampling ((c) *Plutella xylostella* and (d) *Diadegma semiclausum*) per 3 × 3m plot on eight different nectar plants during 5 weeks. Different letters indicate significant differences between plant species (Mann-Whitney-U test, alpha=0.05).

is quite likely that this supply with easy accessible food caused high parasitoid catches on *C. cyanus*.

Earlier studies already stated the importance of Apiaceae as nectar source for hymenoptera (Leius 1960, Kopvillem 1960). *A. graveolens* provides nectar on exposed nectaries, which is in general more concentrated than hidden nectar (Kevan & Baker 1983). While parasitoids can deal with a wide range of nectar concentrations (Siekman *et al.* 2001), herbivores with their extended proboscis are restricted to less concentrated nectar (Daniel *et al.* 1989). This might explain why *D. semiclausum*, but none of the lepidopteran herbivores was found on *A. graveolens* in substantial numbers.

In case of *T. vulgare*, an Asteraceae (Compositae) species, nectar is hidden in small corolla tubes. As we could not observe individual parasitoids feeding on this plant species (in contrast to *C. cyanus* and *A. graveolens*), it might be that *D. semiclausum* was looking for something else than food in the *T. vulgare* plots, like a 'comfortable' microclimate.

The herbivore species *Pieris* spp. and *A. gamma* were found on *O. vulgare* and *C. jacea*, two plant species on which *D. semiclausum* was not present or caught in low numbers. As both plants have tubular flowers with hidden nectar, exploitation of the nectar is restricted to insects with longer tubular mouthparts. Exclusion of these plant species, which are selectively suitable for and visited by the herbivores, might reduce the risk of unintentionally increasing pest numbers.

The herbivore *P. xylostella* was caught in highest numbers on *L. maritima*. This plant species does not only provide accessible nectar (Winkler, unpublished) but is also a host plant of *P. xylostella*. Its parasitoid *D. semiclausum* was found in only moderate numbers on this plant. While the suitability of this plant as nectar source for *D. semiclausum* is questionable (Winkler, unpublished), recent studies indicate the potential of this plant species as a trap crop for *P. xylostella* (De Groot *et al.* 2005).

In order to shift insect composition and numbers to our benefit, we should particularly promote plant species like *A. graveolens* and *C. cyanus*, which were visited by the parasitoid but not by the herbivores. At the same time we should exclude plant species, which were selectively visited by herbivores. In this way the establishment of flowering field edges can be optimised in order to increase their impact on sustainable pest control in agricultural cropping systems.

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