Aphidophagous guilds on nettle (*Urtica dioica*) strips close to fields of green pea, rape and wheat

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Abstract The common nettle (*Urtica dioica* L.) is a perennial and cosmopolitan plant species and is known to be the source of food for a great diversity of insects. To understand the importance of the nettle in agro-ecosystems, a field experiment was carried out in an experimental farm at Gembloux (Belgium) to study the effect of nettle margin strips on aphid and aphidophagous populations in close field crops, namely wheat (*Triticum aestivum* L.), green pea (*Pisum sativum* L.) and rape (*Brassicae napus* L.). The aphids and related beneficial populations were weekly assessed, from March to August 2005, by visual observations in two plots per field crop. A higher abundance of aphidophagous beneficials was collected in nettle strips when compared to the field crops. Particularly, the presence of predatory anthocorids, mirids and green lacewings was observed on nettle only. Nevertheless, the most abundant aphid predatory family, the Coccinellidae, was distributed in both environments, in nettle strips and in crop fields. The field margin supported a significantly higher density of *Harmonia axyridis* than the field crops. In contrast, the field crops, green pea particularly, supported a higher density of *Coccinella septempunctata*. The distribution of the aphidophagous species, mainly the ladybirds, was discussed in relation to the host plant and related aphid species and their potential effect on integrated pest management.

Key words Aphidophagous ladybirds, beneficials, insect diversity, nettle, wheat, green pea, rape, margin strips, integrated pest management, *Microlophium carnosum*, *Acyrthosiphon pisum*, *Sitobion avenae*
DOI 10.1111/j.1744-7917.2007.00169.x

Introduction

Conservation biological control involves environmental manipulations to enhance the fecundity and longevity of natural enemies, modify their behavior and provide shelter from adverse environmental conditions (Wratten *et al*., 2003). These strategies include the maintenance of ecological compensation areas, relying on the increase of plant diversity within or outside crops, and are crucial in enhancing beneficial insects' abundance for pest suppression (Rossing *et al*., 2003). Recently, there have been a number of studies suggesting that the use of non-crop habitats within crops which mimic natural habitats can be used to successfully encourage the influx of natural enemies into fields (Thomas *et al*., 1992).

Among aphidophagous beneficials, ladybird beetles tend to lay their eggs close to their prey. The voracious larvae forage in or close to aphid colonies (Ferran & Dixon, 1993). For this behavior, coccinellid predators were often considered efficient biological control agents of aphids. Among coccinellid predators, the multicolored Asian ladybeetle, *Harmonia axyridis* (Pallas) is a well-known aphid predator from the Asian region (Yasumatsu & Watanabe, 1964; Hukusima & Kamei, 1970; Hukusima & Ohwaki, 1972) that invaded the Nearctic region and has been used in European greenhouses for several years. The

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species appears to have a high ability to track aphid populations in space and time (Osawa, 2000; With *et al*., 2002).

Field margins are currently considered important for maintaining wildlife diversity in agricultural landscapes (Way & Greig-Smith, 1987; Boatman, 1994). The common nettle is a marginal, perennial and cosmopolitan plant (Preston *et al*., 2002). According to Greig-Smith (1948), nettle is the source of food of a great diversity of insects, for example, *Microlophium carnosum* (Buckt) and *Aphis urticata* Kalt. (Homoptera: Aphididae); *Thrips urtica* Fab. (Thysanoptera); *Liocoris tripustulatus* Fab. (Heteroptera: Miridae). Consequently, nettle provides a significant and relatively sure habitat for beneficial insects such as ladybird beetles (Perrin, 1975).

The aim of the current work was to study the effect of planting strips of nettle on field margins on diversity and abundance of aphidopagous predators in crop fields. The study particularly focuses on the predators, *H. axyridis*, *C. septempunctata* and *Episyrphus balteatus*.

Material and methods

Plot setting

This study was carried out in the experimental farm (flatland) located in Gembloux (Belgium). Three field crops were used, namely wheat (*T. aestivum*), green pea (*P. sativum*) and rape (*B. napus*). Marginal nettle (*U. dioica*) strips were planted in plots in November 2004 (200 plants per plot, 6 areas of 10 m × 20 m each) (Fig. 1). *H. axyridis* was voluntarily imported into Belgium and used in biological control for several years by farmers in greenhouses and gardens against aphid pests. Although *H. axyridis* has been used for biological control in Belgium since 1997, no observation in the wild was reported before September 2001. Since then, the number of observations increased steadily especially in the northern part of Belgium (Fig. 2).

Abundance of aphids and aphidophagous beneficials was followed weekly between May and August 2005; at that time wheat and rape were harvested and green pea was almost dry, at three field crops (3−5 ha each). A near large stand (1 000 m^2) of spontaneous nettle in a natural reserve was included in the experimental design. Two plots per field were selected, each of 10 m × 20 m; all plots were without insecticide treatment; the distance between each plot was 100 m.

Each week, 10 plants per plot were randomly taken to count and identify the aphids and aphidophagous populations on each plant. To identify the hoverfly and ladybird collected larvae, they were reared in the laboratory until

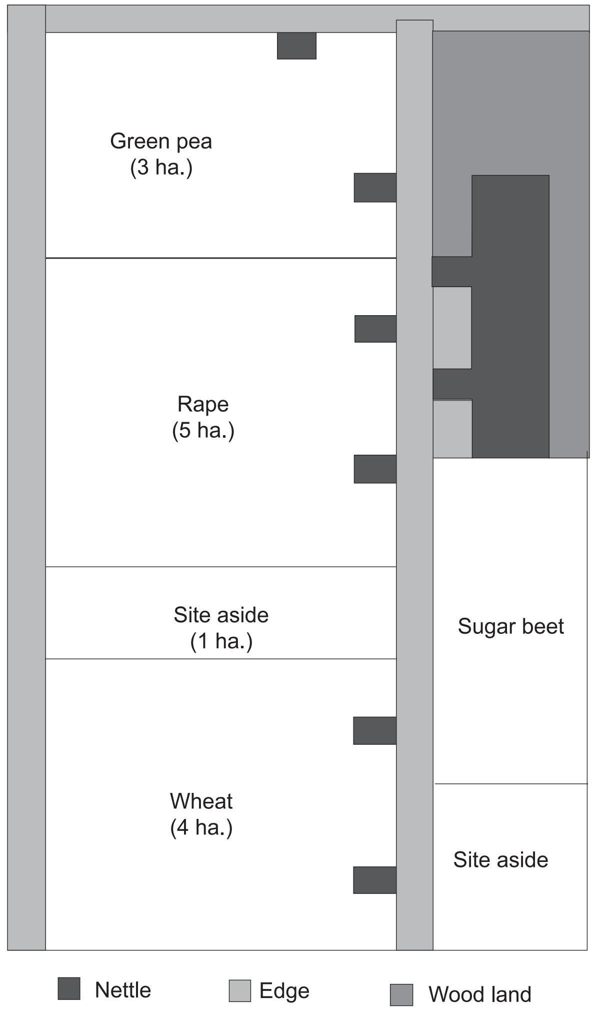

Fig. 1 Description site of observed plots in 2005.

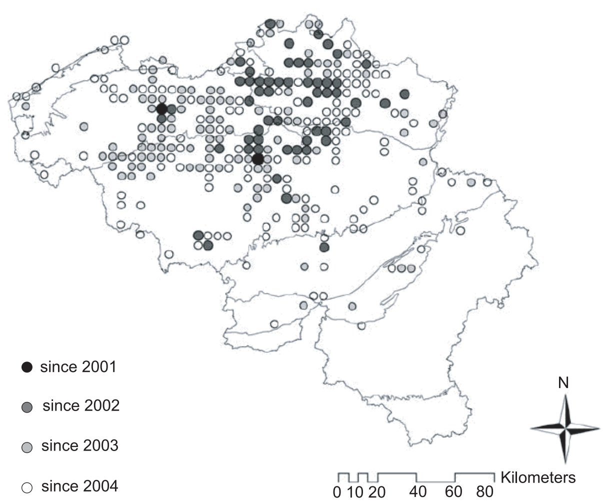

Fig. 2 Repartition of *Harmonia axyridis* in Belgium (Maes, 2005).

adult emergence and the emerged adults were identified.

Concerning predatory bug and green lacewings larvae, the observed adults were collected and identified in the laboratory.

Statistical analysis

The software SAS was used in statistic analyses. All data were summarised per plot: analysis of variance (ANOVA) and Student and Newman Keuls test were used, following transformation of data to log $(n + 1)$ if necessary to stabilise the variance, to determine the effects of the differently vegetated plots in the selected fields.

Results

Aphid abundance and diversity

Three aphid species were abundant on field crops and nettle; no aphid infestation was observed on rape. Consequently, aphidophagous insects were also absent on rape through the 2005 season. The most abundant species in each plant were: *Microlophium carnosum* on nettle (with 97%), *Acyrthosiphon pisum* on pea (with 99%) and *Sitobion avenae* on wheat (with 76%). A list of aphid species and relative abundances were presented in Table 1.

Table 1 Abundance and diversity (mean number/m^2 /week) of aphids and related aphidophagous predators in 2005.

	Pea		Wheat		Rape					
	In nettle	In field	In nettle	In field	In nettle	In field	Natural nettle	Total	%†	%‡
Aphididae										
Microlophium carnosum Buckton	174.3	0.0	266.1	0.0	587.0	0.0	5256.7	6284.0	63.7	
Aphis urticata Gmelin	132.1	0.0	54.1	0.0	3.0	0.0	0.0	189.0	1.9	
Acyrthosiphon pisum Harris	0.0	1365.3	0.0	0.0	0.0	0.0	0.0	1365.3	13.8	
Macrosiphon euphorbiae Thomas	0.0	8.0	0.0	0.0	0.0	0.5	0.0	8.5	0.1	
Metopolophium dirhodum Walker	0.0	0.0	0.0	475.4	0.0	0.0	0.0	475.4	4.8	
Sitobion avenae F.	0.0	0.0	0.0	1545.8	0.0	0.0	0.0	1545.8	15.7	
Coccinellidae										62.5
Coccinella septempunctata L.	14.6	35.5	3.8	4.7	5.2	0.0	15.3	79.1	41.0	
Harmonia axyridis Pallas	2.0	0.5	1.4	0.0	5.4	0.0	92.0	101.3	52.5	
Adalia 2-punctata L.	0.2	0.0	0.0	0.0	0.0	0.0	5.0	5.1	2.6	
Propylea 14-punctata L.	0.0	0.0	0.0	2.0	1.0	0.0	3.0	6.2	3.2	
Adalia 10-punctata L.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7	0.3	
Anatis ocellata L.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7	0.3	
Syrphidae										7.6
Episyrphus balteatus De Geer	0.0	3.0	0.0	9.0	1.0	0.0	7.0	20.1	85.8	
Metasyrphus latilunulatus Collin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	
Sphaerophoria scripta L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	
Metasyrphus nitens Zetterstedt	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7	2.8	
Metasyrphus luniger Meigen	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7	2.8	
Melanostoma mellinum L.	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.6	2.6	
Platycheirus scutatus Meigen	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.9	3.7	
Anthocoridae										21.0
Orius minutus L.	6.0	0.0	3.0	0.0	10.0	0.0	38.0	57.4	88.7	
Anthocoris nemorum L.	0.6	0.0	0.0	0.0	0.0	0.0	3.0	3.7	5.7	
Anthocoris nemoralis F.	0.4	0.0	0.0	0.0	1.0	0.0	3.0	3.7	5.7	
Miridae										8.5
Deraeocoris ruber L.	1.2	0.0	2.8	0.0	3.0	0.0	15.0	22.0	83.7	
Heterotoma meriopterum Scop.	0.2	0.0	0.2	0.0	0.2	0.0	3.7	4.3	16.3	
Chrysopidae										0.4
Chrysoperla carnea Stephens	0.2	0.0	0.4	0.0	0.6	0.0	0.0	1.2	100.0	

†Relative proportion of each species in family.

‡Relative proportion of each family in aphidophagous predators.

Aphidophagous predator abundance and diversity

A total of 4 630 aphidophagous predator individuals was recorded in all plots, and the majority of insects (62.5%) belonged to Coccinellidae. Anthocorids, mirids and chrysopids occurred on nettle only. Three species represented the Anthocoridae family; *Orius minutes* was more abundant (with 88.7%) than *Anthocoris nemoralis* and *Anthocoris nemorum*. The Miridae family was represented by only two species, namely *Deraeocoris ruber* (with 83.7%) and *Heterotoma meriopterum*. The green lacewings were less abundant, only one species was observed, namely *Chrysoperla carnea*. Highly significant differences between predator populations on nettle and in field crops were observed. The most abundant aphidophagous beneficials are presented in Table 2.

The recorded ladybirds were more abundant on nettle than in field crops (Table 2). While six ladybird species were observed in the crops, three more species were collected on nettle: *Adalia 2-punctata*, *A. 10-punctata* and *Anatis ocellata* were only collected on nettle. The relative proportion of each species widely varied from one host plant to another: *C. septempunctata* and *H. axyridis* the most abundant species, (41.0% and 52.5% of the total ladybirds respectively), had specific distributions. More than 70% of *C. septempunctata* was found in field crops ($F = 17.95$, $P < 0.001$). *H. axyridis* was significantly more abundant on nettle with 86.0% of the total collected individuals ($F = 36.72$, $P < 0.001$) (Tables 2, 3).

Predatory syrphids were weakly present in all plots through the 2005 season. Only seven predatory hoverfly species were recorded on the different plots (Table 2). *E. balteatus* was the major syrphid species with 85.8% of the observed hoverflies; it was more frequent on wheat and nettle than on green pea (Tables 1, 3).

Discussion

Nettle was shown to shelter a dense presence of aphids, represented mainly by *M. carnosum*, and aphidophagous predators belonging to the Anthocoridae, Miridae, Chrysopidae, Syrphidae and Coccinellidae families. The importance of the latter in biological control was clearly pointed out by Hodek and Honek (1996) and Iperti (1999), as it appears to track populations of its prey, although with a degree of lag (Leather & Lehti, 1982; Leather & Owour, 1996).

Table 2 Abundance of aphidophagous predators, ladybirds and hoverflies (mean number ± SE) collected from wheat, green pea, rape and nettle plots in 2005.

Crops	All aphidiphagous predators			Ladybird			Hoverfly		
	Field		Nettle	Field		Nettle	Field		Nettle
Wheat	19.6 ± 55.0 a	*	6.6 ± 14.7 c	4.7 ± 24.4 b	*	3.1 ± 10.4 c	4.7 ± 24.4 ab	*	0.0 ± 0.0 b
Green pea	16.9 ± 30.6 ab		11.3 ± 20.6 bc	18.7 ± 45.3 a		9.1 ± 20.8 bc	2.9 ± 14.0 bc	*	0.2 ± 2.5 b
Rape	0.0 ± 0.0 c	*	14.3 ± 22.8 bc	0.0 ± 0.0 c	*	6.7 ± 21.1 c	0.0 ± 0.0 c	*	0.7 ± 6.2 b
S. nettle[†]			88.7 ± 107.9 a			62.0 ± 139.4 a			6.7 ± 27.5 a

Different letters corresponds to significant differences in column among crops (at least $P < 0.05$). *Significant difference between field and nettle (at least $P < 0.05$).
[†]Spontaneous nettle at the natural reserve.

Table 3 Abundance of *C. septempunctata*, *H. axyridis* and *E. balteatus* (mean number ± SE) recorded on wheat, green pea, rape and nettle plots in 2005.

Crops	*C. septempunctata*			*H. axyridis*			*E. balteatus*		
	Field		Nettle	Field		Nettle	Field		Nettle
Wheat	2.3 ± 18.9 b	*	2.2 ± 7.8 c	0.0 ± 0.0 a	*	0.7 ± 5.2 b	5.25 ± 33.15 a	*	0.00 ± 0.00 b
Green pea	17.9 ± 45.2 a		8.3 ± 19.6 ab	0.3 ± 3.3 a		0.8 ± 4.8 b	1.87 ± 16.58 a		0.20 ± 2.45 b
Rape	0.0 ± 0.0 b	*	2.4 ± 8.9 c	0.0 ± 0.0 a	*	2.6 ± 17.3 b	0.0 ± 0.0 b		0.40 ± 3.45 b
S. nettle[†]	7.0 ± 28.1 bc					46.7 ± 129.7 a			3.33 ± 19.75 a

Different letters corresponds to significant differences in column among crops (at least $P < 0.05$). *Significant difference between field and nettle (at least $P < 0.05$).
[†]Spontaneous nettle at the natural reserve.

The analysis of species abundance and frequency in nettle and in field crops, showed a dense presence of *H. axyridis* and low presence of *C. septempunctata* on nettle. In contrast, in green pea fields, a high frequency of *C. septempunctata* was observed, whereas *H. axyridis* was recorded only in low frequency. The oviposition preference related to preferred host-prey and host-plant is an important factor to explain specific distribution of beneficial insects. In addition, the intraguild interactions more frequently studied now, is an important factor influencing the predatory species occurrence in fields. The latter may explain the lower abundant of *C. septempunctata* in presence of *H. axyridis*, and the lower abundance of hoverflies in presence of aphidophagous ladybirds. The overall conversion efficiency of cannibalistic and intraguild prey relative to aphid prey is expected to be somewhat higher for *H. axyridis* than for other coccinellid species such as *C. septempunctata* (Yasuda & Ohnuma, 1999; Michaud & Grant, 2003). Ladybird larvae may frequently become victims of intraguild predation by the aggressive larvae of *H. axyridis* if they do not drop from a plant when attacked by this predator (Sato *et al*., 2005) as do larvae of *C. septempunctata* that are often observed on the ground in the field (Yasuda & Shinya, 1997). Thus, it is important to take into account intraguild behavior of ladybird larvae when considering the potential interactions among species in distribution of aphidophagous guilds.

Aphidophagous predators observed on nettle were generalists and much more diverse than in field crops. Specific aphids, *M. carnosum* and *A. urticata*, and related aphidophagous guild, such as *E. balteatus*, *C. septempunctata*, had considerable presence on nettle in June and May respectively, confirming earlier observations (Banks, 1955; Mills, 1981), before aphid occurrence on green pea and wheat, which were observed to be dense in July. This frequency may demonstrate the presumed movement of aphidophagous predators from nettle to adjacent field crops. Stands of stinging nettles host large numbers of coccinellid adults and larvae (Banks, 1955; Perrin, 1975; Honek, 1981). However, this presumed movement needs to be confirmed by preference oviposition and consumption tests in relation to host prey-plant associations. Another proposed strategy to increase this movement from nettle to field crops could be first to cut out nettle vegetation at the arrival of aphids in crops to allow predation and oviposition by predatory beneficials already present in closed nettle strips. Secondly, a small number of semiochemical releasers could be used in the fields to attract the aphidophagous predators from the nettle to the field crops. One particular molecule, the (*E*)-β-farnesene, a well known aphid alarm pheromone also displayed an attractive kairomonal effect on *A. bipunctata* (Francis *et al*., 2004), *E. balteatus* (Francis *et al*., 2005) and *C. septempunctata* (Al Abassi *et al*., 2000) ladybird species. Both the nettle cut-out and the use of kairomone releaser strategies will be investigated in our experimental design in Gembloux next year.

According to Perrin (1975), nettle provided a high quality habitat for beneficial insects such as *C. septempunctata* and *Platycheirus albimanus* that were the main predatory species on nettle in France. Our current study realized in Belgium showed that *H. axyridis* was more abundant than *C. septempunctata* and *E. balteatus* that were all the main predators in nettle. Therefore, further work is needed to determine the interspecific interactions between *C. septempunctata*, *H. axyridis* and *E. balteatus*. The competition between predatory larvae stages and oviposition preference has to be assessed at both field and laboratory levels. The role of host plant-aphid associations on the specific distribution of aphidophagous predators at open fields has to be determined to be able to enhance optimal biolgical control of aphids.

Acknowledgments

We would like to thank the two reviewers for their comments on the paper, Prof. Thierry Hance and Mr. Jacques Mignon for their helpful comments and suggestions that improved insect identification. I am also grateful to Dr. Yves Brostaux for his suggestions concerning the statistical analysis. Our work has been funded by FNRS (Fonds national de la Recherche scientifique) grant (M2.4.586.04.F).

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Accepted June 13, 2007