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IMPACT OF CLOSE HABITAT ON THE ENTOMOLOGICAL DIVERSITY AND ABUNDANCE IN CARROT OPEN FIELDS

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ABSTRACT

Vegetable open fields areas have been increasing for the last decade in Wallonia (South part of Belgium), mainly in Hesbaye. To be in accordance with quality standards, especially in terms of agrochemical residues (R.M.L.), biological pest control was developed and reduces the insecticide use, leading to have safer fresh products. Carrot represents an important cultivated species in Wallonia. To asses the impact of close habitat on both pest (mainly aphids) and beneficial insects, carrot fields were investigated during all the production duration in 2000. Twelve fields between Waremme and Hannut were visited weekly from June to October. Insects were caught using yellow traps and determined to the family level. Approximately 90.000 insects belonging to 109 families were identified. Significant differences linked to field closed habitat were observed on 31 families. An increase of biodiversity in term of family number near set-asides and woody borders was observed. Evaluation of pest and beneficial diversity and density in vegetable crops was discussed to promote future IPM program.

Key-words: carrot, close habitat, aphids, yellow traps, biological control.

INTRODUCTION

Vegetable cropping has been increasing in importance in Wallonia for 10 years. But, to be in accordance to quality standards, vegetable products must respect to residues limits. I.P.M. allows to reduce chemical sprayings and to produce safe products. Among those new productions, carrot cultivation is one of the most important speculation. In the Hesbaye region, *Psila rosae*, the carrot fly, has caused little problems for some years. As soon as complete no treatment may be considered. But, observations show that some sprayings must be maintained to fight aphid pests, mainly early in the season. After young seedlings germination, first weeks growing constitute a dangerous period during which, a lot of aphid species may infest the crops and lead to important damages. Among aphid pests, seedlings aphid *Cavariella aegopodii* Scop. is the most damageable for carrot. *C. agopodii* life cycle is characterised by host alternation. Winter host are willows. Early in spring, *C. aegopodii* massively switches on its summer host, the *Apiaceae*, for instance carrot. Common pest management consists in a early spraying with an aphicid against *C. aegopodii*. Later, treatments are not necessary because the other aphids are well controlled by natural enemies. The impact of semi-natural vegetation on abundance and diversity of some beneficials and pests is well studied (Cowgill, 1993; Wyss, 1996; Allen-Wardell, 1999). But the effect of field environment on a majority of species remain poorly studied. However, hedges, groves, set-asides and fallows contain a rich entomofauna which participates to agro-ecosystems and contributes to the regulation of pest populations (Pollard, 1968). So agro-ecosystems biodiversity may be separated in two components: the biodivesity bounded to the crop and the associated biodiversity which, assemble all the living organisms colonizing fields from close habitat (Vandermeer *et al.*, 1995). The aim of our study was precisely to asses the impact of close habitat on entomological biodiversity of carrot fields. The final objective was to evaluate and utilise beneficial insects in vegetable open field crops.

MATERIALS AND METHODS

This study was carried in 12 carrot fields between the small Hesbaye towns Hannut and Waremme. They were chosen according the vegetation type surrounding. So, three types of close habitat were selected: crops (4 fields), set-asides (4 fields) and woody areas (4 fields). In set-asides, the vegetation was dominated by a little number of species belonging to the *Poaceae* and *Fabaceae* families. In each field, insects were trapped using six von Moericke's water traps filled with a "teepol" solution (0.1% vol.) and disposed on the corner of a one metre triangle. Traps were weekly emptied and trapping last 19 weeks from June to October (as the crop was present). Caught insects were determined to the family taxonomical level, except for *Thysanoptera* (to order). Statistical analyses were performed using the Minitab® software (12.2 version). ANOVA was realised on data after a log (x+1) transformation (Dagnelie, 1975). Diversity was assessed by *Shannon*'s diversity index.

RESULTS

Amount of 83.586 insects belonging to nine orders and 109 families were caught and determined on the carrot cultivation. More than 99% of them belong to 56 families while 53 families were represented only by 491 individuals (Appendix 1). *Diptera* (35.262 indiv.) was way the most abundant order. *Hymenoptera* (20.007 indiv.), *Hemiptera* (5.887 indiv.), *Coleoptera* (3.455 indiv.) and *Thysanoptera* (1.035 indiv.) represent each one from 23.6% to 1.2%. The five other orders *(Lepidoptera, Neuroptera, Mecoptera, Orthoptera* and *Ephemeroptera*) corresponded to only 2% of the captures.
During the entire season, the mean insect number (125) per trap was significantly ($0.001<P<0.026$; $3.31<t<4,31$) lower in fields near crops (woody areas: 136; set-asides: 147). Set-asides favoured the highest density, but no significant difference was found with ($P=0,58$; $t=0,99$) woody areas. Results about insect diversity are similar. Insect diversity was significantly ($0.001<P<0.004$; $3.21<t<4.77$) lower in traps of fields surrounded by crops (20.8 families/trap) in comparison with woody areas (22.9 families/trap) and set-asides (24.0 families/trap). But, no significant difference

(P=0.271; t=1.54) was found between these types of habitat. Fields edged by woody areas were richer in term of family listed (102). They were followed by fields near set-asides (96) and by fields surrounded by crops (85). Shannon's index value was similar for the three types of habitats (crops: 0.73; set-asides: 0.73; woody areas 0.72). Closed habitat modified significantly the abundance of 31 families in which nine families of carrot pests and beneficials (Table 1). So, set-asides favoured predatory bugs (*Anthocoridae*), *Syrphidae*, *Elateridae* and *Tenthredinidae*. Parasitoid *Aphididae*, predator *Stapylinidae* and *Ichneumonidae* were more present in traps close to woody areas, while *Hemerobiidae* were more abundant near crops.

Table 1: Mean insect number per week and per trap in relation with the close habitat (Means followed by the same letter are not significantly different)

Family	Crops	Set-asides	Woody areas	F	P
*Aphidoidea**	3.98 ± 8.31(a) (b)	3.32 ± 6.46 (a)	6.44 ± 12.72 (b)	3.46	0.032
*Anthocoridae***	0.64 ± 1.41 (a)	0.93 ± 1.61 (b)	0.77 ± 1.65 (a)	3.27	0.039
*Hemerobiidae***	0.13 ± 0.49 (a)	0.04 ± 0.19 (b)	0.09 ± 0.38 (a) (b)	3.21	0.041
Scatophagidae	1.11 ± 2.77(a)	2.05 ± 3.42 (b)	0.96 ± 2.12 (a)	9.80	< 0.001
Sarcophagidae	0.15 ± 0.95 (a)	0.30 ± 2.04 (a)	0.71 ± 2.69 (b)	6.47	0.002
*Syrphidae***	3.29 ± 6.18 (a)	6.66 ± 8.55 (b)	3.17 ± 4.93 (a)	20.23	< 0.001
Anthomyiidae	13.66 ± 27.64 (a)	11.64 ± 12.77 (a)	17.98 ± 23.82 (b)	6.03	0.003
Chironomidae	2.47 ± 7.17 (a)	2.30 ± 4.89 (a)	5.41 ± 12.14 (b)	10.99	< 0.001
Coelopidae	0.04 ± 0.19 (a)	0.09 ± 0.29 (a) (b)	0.16 ± 0.43 (b)	7.82	< 0.001
Dolichopodidae	0.45 ± 1.32 (a)	0.66 ± 1.46 (a) (b)	1.36 ± 2.88 (b)	13.85	< 0.001
Drosophilidae	8.55 ± 10.58 (a)	9.73 ± 7.71 (b)	8.65 ± 8.68 (a)	3.12	0.045
*Empididae***	4.48 ± 0.37(a)	5.67 ± 7.77 (b)	3.80 ± 4.02 (a)	4.09	0.017
Muscidae	2.76 ± 4.73 (a)	5.54 ± 8.62 (b)	3.97 ± 5.96 (c)	13.89	< 0.001
Calliphoridae	7.67 ± 12.11 (a)	10.85 ± 11.02 (b)	15.72 ± 17.21 (b)	17.45	< 0.001
Lonchopteridae	0.38 ± 1.86 (a)	0.45 ± 0.81 (b)	0.26 ± 0.57 (a)	4.07	0.017
Opomyzidae	0.07 ± 0.28 (a)	0.18 ± 0.47 (b)	0.17 ± 0.42 (b)	4.64	0.010
Phoridae	6.21 ± 7.34 (a)	7.07 ± 8.45 (a)	5.12 ± 6.97 (b)	3.74	0.024
Sepsidae	1.44 ± 3.76 (a)	3.98 ± 5.57 (b)	1.33 ± 2.02 (a)	39.40	< 0.001
Stratiomyiidae	0.19 ± 0.55 (a)	0.69 ± 1.35 (b)	0.34 ± 0.84 (a)	16.82	< 0.001
Tephritidae	0.14 ± 0.43 (a)	0.22 ± 0.59 (a)	0.04 ± 0.20 (b)	8.93	< 0.001
*Tenthredinidae**	18.14 ± 47.79 (a)	20.44 ± 39.71 (b)	6.61 ± 13.85 (a)	10.24	< 0.001
*Ichneumonidae***	3.34 ± 4.13 (a)	4.75 ± 5.32 (b)	5.21 ± 8.94 (b)	3.80	< 0.001
*Apoidea***	0.52 ± 1.09 (a)	1.08 ± 1.46 (b)	0.68 ± 1.06 (c)	16.02	< 0.001
Cynipidae	1.91 ± 2.55 (a)	2.47 ± 3.37 (a)	3.38 ± 5.43 (b)	6.12	0.002
Pteromalidae	4.91 ± 9.38 (a)	4.28 ± 6.06 (a)	2.47 ± 5.66 (b)	11.64	< 0.001
Sphecidae	0.07 ± 0.26 (a)	0.13 ± 0.41 (a) (b)	0.15 ± 0.40 (b)	3.01	0.050
Vespidae	0.06 ± 0.38 (a)	0.07 ± 0.30 (a)	0.35 ± 0.76 (b)	23.74	< 0.001
Cantharidae	0.31 ± 0.91(a)	0.13 ± 0.43 (b)	0.11 ± 0.37 (b)	6.63	< 0.001
Chrysomelidae	0.91 ± 1.63 (a)	2.62 ± 5.26 (b)	1.16 ± 2.06 (a)	11.06	< 0.001
*Elateridae**	0.05 ± 0.22 (a)	0.18 ± 0.52 (b)	0.14 ± 0.44 (b)	5.82	0.003
*Staphylinidae***	1.49 ± 5.14 (a)	1.61 ± 2.70 (a) (b)	2.62 ± 5.60 (b)	3.99	0.019
*Thysanoptera**	2.08 ± 7.46 (a) (b)	1.78 ± 3.12 (a)	1.07 ± 2.07 (b)	3.38	0.035

DISCUSSION

The insect diversity may be assessed by the total number of taxa present. But, it may be completed by diversity indexes such as Shannon's one (Daget, 1976). In our case, the equitability measures the repartition of captures between families and so, the insect population equilibrium. Tough, it's common knowledge that diversified insect populations are more stable and less subject to pest infestations. The values of this index on the 109 families registered in our fields are comprised between 0.72 and 0.73. These results are relatively high in comparison with typical values (from 0.4 to 0.7) of poor diversified agro-ecosystems (Bartlett *et al.*, 1973). Tested habitats don't modify perceptibly the insect populations structure because the equitability values are very similar. Nevertheless, significant differences show that set-asides and woody areas enhance insect density and mean diversity of carrot fields. Theses results confirm previous works (Colignon *et al.*, 2002; Colignon *et al., 2001*). The high density observed near woody vegetation is due to the increased presence of *Staphylinidae* and *Aphidoidea*. Aphids abundance results from *C. aegopodii* attraction for willows (*Salix* spp.), very numerous around prospected fields. Indeed, 93% of the aphids belong to *C. aegopodii*. Close habitat significantly modifies the abundance of many families present in carrot fields. Semi-natural areas surrounding crops are attractive to some families (set-asides to *Syrphidae*, *Apoidea* and *Tenthredinidae*) or constitute refuges for others (wood for *Staphylinidae, Aphidoidea*). Syphids are the most preponderant group among aphidophagous predators (they represent about 90%). These results show the importance of this family in the natural control of aphid populations. With regard to this, the best control would be expected near set-asides. Indeed, the ratio aphids on aphidiphagous at the time of *C. aegopodii* peak is lower for set-asides (2.81) than for woody areas (3.66) and crops (3.87).

CONCLUSION

Our results show that close habitat modifies entomological density, diversity and family abundance of carrot fields. These impact concerns the most important pest and beneficial families too. Therefore, the close habitat parameter should be taken in account in a future IPM program in carrot fields. Set-asides attraction may be optimised by introducing more melliferous flowers which enhance syrphids presence. Massive beneficial insects introduction is actually out of cost. But, the management of close field environment appears as a low cost solution to favour biological control in vegetable open field crops.

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Appendix 1: insect total number according to families

Family	Number	Family	Number	Family	Number
Tenthredinidae	9437	*Noctuidae*	308	*Otitidae*	5
Anthomyiidae	9000	*Coccinellidae*	258	*Oedemeridae*	4
Calliphoridae	7032	*Silvanidae*	257	*Simuliidae*	4
Drosophilidae	5586	*Stratiomyiidae*	246	*Hydrophilidae*	4
Limoniidae	4225	*Sarcophagidae*	237	*Ephydridae*	3
Sciaridae	3990	*Lonchopteridae*	225	*Scarabaeidae*	3
Phoridae	3822	*Chrysopidae*	188	*Eumenidae*	3
Empididae	2890	*Curculionidae*	140	*Chrysidae*	3
Aphididae	2851	*Ceraphronidae*	135	*Culicidae*	3
Ichneumonidae	2737	*Cantharidae*	117	*Tabanidae*	3
Syrphidae	2685	*Vespidae*	97	*Limnephilidae*	3
Muscidae	2510	*Opomyzidae*	86	*Liodidae*	3
Pteromalidae	2446	*Tephritidae*	82	*Papilionidae*	2
Chironomidae	2101	*Elateridae*	77	*Nymphalidae*	2
Psychodidae	1895	*Sphecidae*	73	*Pipunculidae*	2
Scatopsidae	1727	*Carabidae*	67	*Sphaeroceridae*	2
Cynipidae	1597	*Eupelmidae*	61	*Eucharitidae*	2
Braconidae	1384	*Coelopidae*	58	*Acanthosomatidae*	2
Sepsidae	1370	*Tineidae*	57	*Pentatomidae*	2
Psyllidae	1231	*Hemerobiidae*	55	*Acrididae*	2
Staphilinidae	1181	*Dryomyzidae*	38	*Conopidae*	2
Chrysomelidae	952	*Cercopidae*	35	*Lycaenidae*	2
Scatophagidae	844	*Nabiidae*	35	*Cerambycidae*	2
Aphidiidae	764	*Mycetophilidae*	33	*Bruchidae*	2
Cicadellidae	672	*Psilidae*	33	*Leucospidae*	1
Cecidomyiidae	635	*Formicidae*	33	*Eurytomidae*	1
Miridae	576	*Pieridae*	31	*Reduviidae*	1
Ceratopogonidae	516	*Rhagionidae*	30	*Geometridae*	1
Dolichopodidae	505	*Silphidae*	24	*Coenagrionidae*	1
Anthocoridae	482	*Proctotrupidae*	23	*Tettigonidae*	1
Apoidea	465	*Panorpidae*	22	*Tachinidae*	1
Bibionidae	412	*Pompilidae*	21	*Xylophagidae*	1
Diaprididae	363	*Heleomyzidae*	20	*Pipunculidae*	1
Nitidulidae	353	*Micropezidae*	14	*Tortricidae*	1
Mymaridae	352	*Mordellidae*	10	*Pterophoridae*	1
Tipulidae	351	*Torymidae*	9	*Anobiidae*	1
Chloropidae	326	*Anisopodidae*	8	Total number	83,634
				families	109