The effect of landscape structure and field margin vegetation on the regulation of crop herbivores

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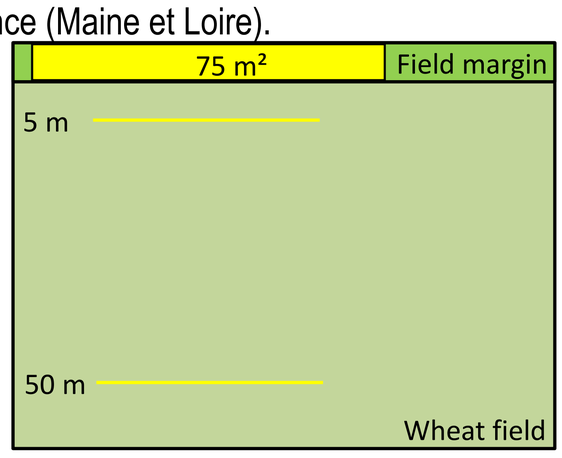
Plant species of non-crop structures such as herbaceous margin strips, hedgerows, forest fragments or wetlands provide important habitat functions for several natural enemies of crop herbivores. Several studies have demonstrated that the density of such structures in agricultural landscapes is positively correlated to herbivore regulation but the role of plant species composition is not well understood so far. We used a correlative approach (1) to test the relation between spontaneous field margin vegetation and infestation of crop plants and (2) to compare the influence of plant species composition and diversity with that of landscape structure

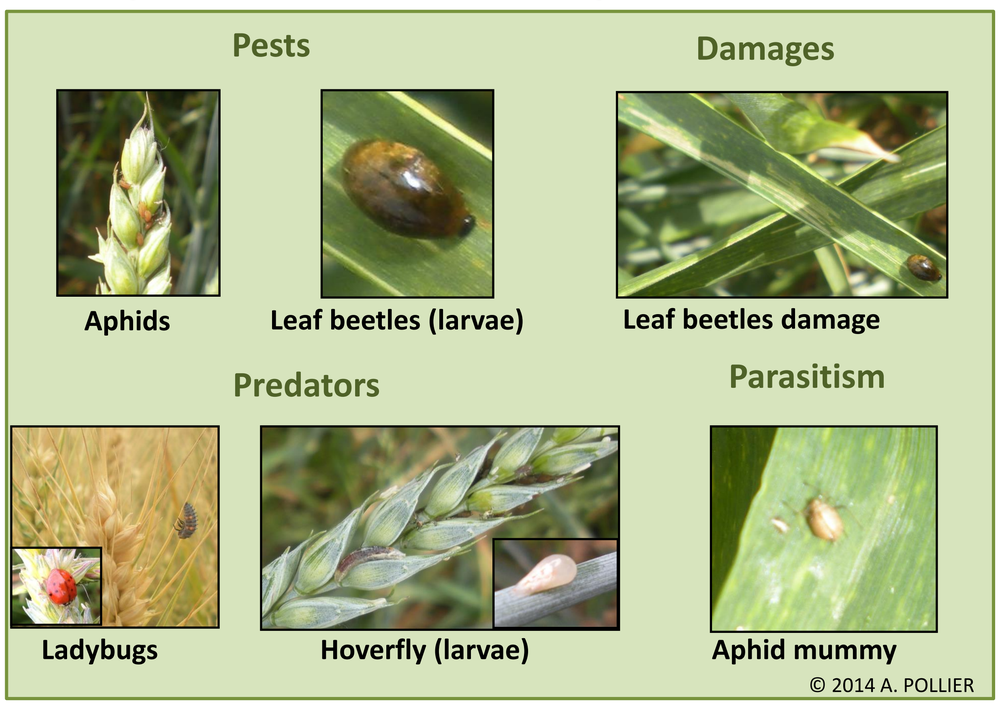
Approach:

• We studied **16 wheat fields** in Western France (Maine et Loire).



• **Vegetation survey**: One survey within the field margin (75 m²) including cover and phenological stage of all vascular plant species. The cover of flowering entomophilous species was calculated by multiplying % cover and % plants in flowering stage.

• **Entomological surveys**: Two surveys analyzing 50 wheat plants at two distances from the field margin: insect abundance, crop damage, herbivore parasitism.



• **Landscape survey:** The surrounding landscape was mapped within a distance of 1000m around the 16 wheat fields.

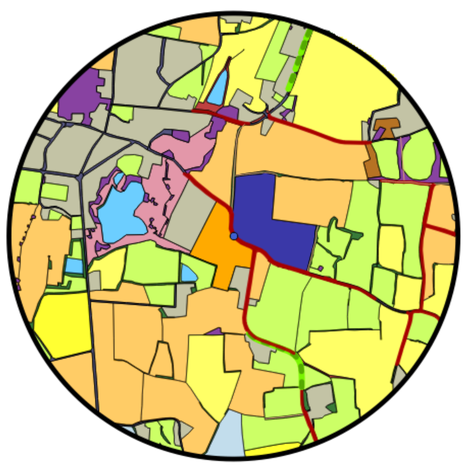


Table 1: Landscape variables used in this study

Landscape variables		
Shannon	Landscape diversity	$H' = -\sum_{i=1}^{R} p_i \ln p_i$
Cereal	Cereal crops	Area
Semi-natural structures	Woodlands, hedgerows	
	Grasslands	
	Other semi-natural structures	

• **Statistical analysis:** Linear models including vegetation data (diversity, cover of flowering entomophilous plants, grass cover) and landscape variables (Table 1) were fitted. A stepwise backward procedure was used to select explanatory variables giving the best model fit (stepAIC using MASS package in R). Different models were calculated landscape variables at a distance of 100, 200, 500 and 1000m.

Results:

• **Importance of spatial scale and scale selection:**

Table 2: Model fit at different spatial scales using the Akaike Information Criterion (AIC)

AIC	1000m	500m	200m	100m
Aphids	-45,46	-46,35	**-53,83**	-46,96
Leaf beetle damage	-111,1	-112,45	-110,4	**-113,44**
Leaf beetle larvae	-46,43	**-54,53**	-47,46	-47,46
Hoverflies	-31,42	-32,75	**-38,01**	-36,46
Ladybugs	-25,14	-25,14	-25,32	**-26,13**
Mummies	-19,27	-19,27	-21,29	**-21,55**
Aphid parasitism rate	-77,4	-77,4	-77,92	**-79,93**

In general, the best model fit was obtained at smaller scales (100 and 200 m, Table 2). Landscape structures relatively close to the observation points had the highest influence on crop herbivores and natural enemies.

Aphid parasitism (rate) = (mummy abundance/(aphid + mummy abundance) X 100

• **Overall influence of vegetation and landscape variables:**

Table 3: Influence of landscape and vegetation variables on crop herbivores and natural enemies (scale with best model fit)

	Plant species diversity	Cover flowering entomophilous plants	Grass cover	Shannon	Cereal crop	Semi-natural structures
Aphids	0	0	0	0	-*	-**
Leaf beetle damage	+*	0	0	-*	0	0
Leaf beetle larvae	-**	-(*)	0	0	-**	0
Hoverflies	0	0	0	0	-(*)	-*
Ladybugs	0	0	0	0	0	0
Aphid mummies	0	+(*)	0	0	-(*)	0
Aphid parasitism rate	0	+*	+(*)	+(*)	0	0

Codes: **+** positive influence; **-** negative influence; **0** not significant; P<0.1: **(*);** <0.05: ***;** <0.01: ****;** <0.001: *******

Landscape variables:

1) The area of semi-natural structures was negatively correlated with aphid abundance suggesting a better aphid control (Table 3). However, contrary to the hypothesis that semi-natural habitats present important resources for hoverflies, the correlation with hoverfly abundance was negative.
2) The abundance of crop herbivores and natural enemies was negatively correlated with the density of cereal crops in the surrounding landscape.
3) Landscape diversity was positively correlated with leaf beetle damage and negatively aphid parasitism.

Vegetation variables:

1) The cover of flowering entomophilous plants had a relatively strong influence on herbivore control. A higher aphid parasitism and a lower leaf beetle abundance was found close to field margins with a high cover of flowering entomophilous plants (Table 3, Fig. 1). However, the control effect was not strong enough to significantly reduce aphid abundance and leaf beetle damage.

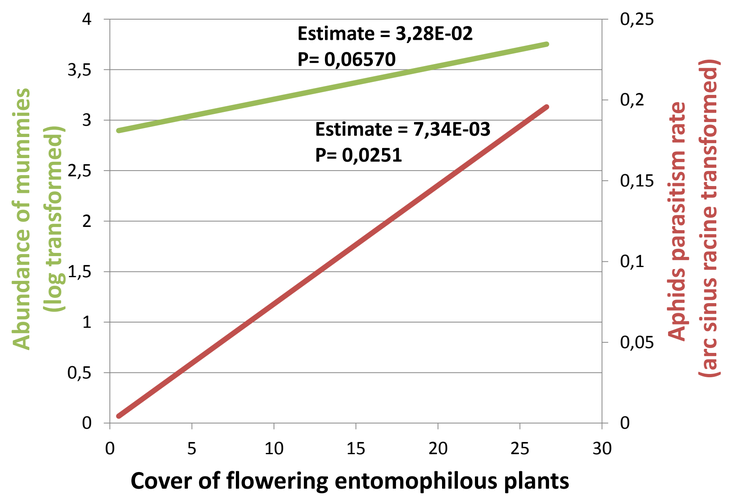


Fig. 1: The influence of flowering entomophilous plants on number and rate of parasitised aphids (mummies) using parameter estimates of multifactorial linear models.

2) The influence of plant diversity was positive for leaf beetle damage but negative for beetle abundance.
3) Grass cover had only a small influence on response variables.

Conclusions:

The results demonstrate the importance of landscape structure and plant species composition at relatively small spatial scales. Interactions between surrounding habitats, crop herbivores and their natural enemies may be limited by the low mobility of the involved insect species. Landscapes dominated by cereal crops were not attractive for natural enemy groups but the abundance of the two most important pest insects species was also lower. Evidence for a contribution of semi-natural structures to biological control was quite poor. However, we found a clearly positive effect of flowering entomophilous plants on the control of crop herbivores suggesting that the presence of related resources (nectar, pollen) is crucial for the activity of natural enemies.

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