2008-E7

Integrated Protection in Viticulture
IOBC/wprs Bulletin Vol. 36, 2008
pp. 369-373

Landscape characteristics influencing pest populations in viticulture

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Abstract. Landscape-scale characteristics can influence pest insects directly, for instance by providing hibernation sites or by creating barriers for migration. We developed a new insect trap (Tri-Δnglué® trap), able to monitor the adult flight periods of all major vine insect pests. Pest insect distribution was sampled at the landscape scale over three years in four French wine growing regions ranging from 60-200 km^2 (Pessac-Léognan, Buzet, Sauternes, Saumur-Champigny). Between 40 and 80 vineyard plots were monitored in each region.

The spatial distributions of the insects varied little between years. L*obesia botrana* and *Scaphoideus titanus*) had clustered distributions at this scale but spatial structure was less pronounced for *Empoasca vitis* and *Eupoecilia ambiguella*.

A geographical information system was used to describe and quantify land cover characteristics at a variety of local and landscape scales, using buffers of increasing diameter (250 to 1000m). Insect abundance was significantly correlated with a number of both local and landscape-scale land cover variables. The two most abundant pest species, *L. botrana* and *E. vitis,* showed very dissimilar distributions. *L. botrana* was more abundant in large continuous monocultures while *E. vitis* was more abundant in heterogeneous landscapes including woodlands.

The strength of these correlations increased with increasing buffer size, up to 750 m, revealing that population levels are indeed influenced by landscape characteristics at this scale. Longer term, landscape-scale monitoring will be continued to try to determine how landscape configuration may influence pest insect movements, so as to better explain underlying mechanisms.

Tri-Δnglué trap networks like this one are being adopted by professional organisations, for example to monitor *Scaphoideus titanus,* vector of the quarantine disease 'flavescence dorée' in areas under imposed sprayings

Key words: viticulture, *Empoasca vitis*, *Lobesia botrana*, *Scaphoideus titanus*, *Eupoecilia ambiguella*, landscape, geographical information system, France.

Introduction

Certain landscape features outside vine plots are considered to be ecological compensation areas able to enhance the beneficial effects of natural enemies (ECA, Boller *et al.* 2004, van Helden *et al.,* 2004). However such features also directly influence pest insects, providing habitat supplementation (alternative host plants) or complementation (hibernation sites) or by acting as physical barriers to dispersion (Decante & Van Helden, 2006).

Vine plots vary in their vulnerability to the pest insects *L. botrana*, *Eu. ambiguella*, *E. vitis* and *S. titanus.* These species have a range of different ecological traits: mono to tri-voltine, pure specialist to generalist, sedentary to highly mobile (Stockel, 2000). To investigate the relationships between pest insect relative abundance and local and landscape characteristics we conducted a 3-year study to compare insect distributions in several "appellations" (areas of origin).

Material and methods

Study sites

Over three years, between 40 and 70 vine plots were sampled per "appellation" (Pessac-Léognan (PL, 2005-6), Saumur-Champigny (SC, 2005-7), Buzet (Bz, 2007) and Sauternes (Sa, 2006). Plot size was > 1 ha and minimum spacing between traps was 500m. Management was entirely left to the owners but was rather homogeneous within each "appellation".

Insect monitoring

Adult insects were trap monitored and larvae were counted three weeks after peak captures as described earlier (Van Helden *et al.,* 2006) using Tri-Δnglué® traps (a yellow delta 2 µg pheromone trap). Second larval generations were not monitored because of insecticide applications.

Geographical Information System

Land use was defined and digitised, using high-resolution ortho-rectified aerial photographs (BDORTHO, IGN) and GIS software (ARCGIS – ESRI). Two different land cover classifications were used, composed of 3 or 12 habitats. Only the results based on the simple habitat classification are presented here. This first step enabled us to calculate the amount of each land cover type (vine, forest, others) around each trap, in a set of buffers of increasing radius (250, 500, 750, 1000 m). The total continuous area of vineyards (CaV) to which each trap belonged was also determined.

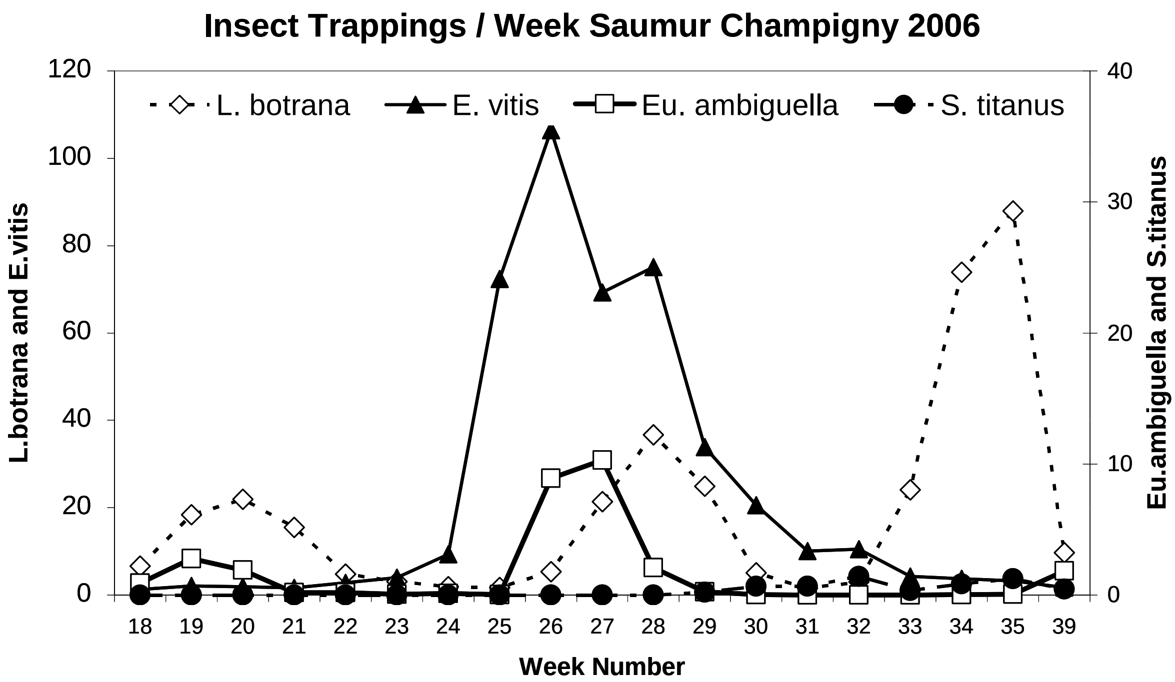

Fig. 1: Example of weekly insect captures on Tri-Δnglué® trap in the Saumur-Champigny area in 2006. Means of 36 traps NB. *Lobesia botrana* and *Empoasca vitis*: left axis, *Eupoecilia ambiguella* and *Scaphoideus titanus*: right axis.

Data analysis

Insect abundances were summed within each generation (*Lobesia botrana* spring adult Generation = *Lb*aG0, first larval generation = *Lb*lG1 etc.) and for each year (*Lb*a2005 etc.).

These were compared with the plot and landscape variables using Spearman rank correlation coefficients (CC).

Results and discussion

Insect dynamics and distribution

Insect trap samples showed ‘classic’ population dynamics (Fig 1). Insecticide treatments on second generation larvae (tortricids, *E. vitis*) sometimes interfered with our observations. Overall, trapping levels and flight periods varied between both “appellations” and years.

Variations between generations within a single year

As during 2005 (Van Helden *et al.,* 2006) strong correlations appeared between successive generations and stages of *L. botrana* for all “appellations” and years (Spearman r ≅ 0.8).

E. vitis often showed significant correlations between immigrating adults (*Ev*aG0) and subsequent larvae (*Ev*lG1) and between G1 and G2 adults. CCs of G1 larvae and adults were nonexistent confirming the hypothesis that many G1 adults migrate (Decante & Van Helden, 2006). *E. ambiguella*, (SC), showed no significant CCs between G0 and G1 but trapping levels were generally low (Fig 1).

Table 1: Spearman rank corr. coefficients (r_s) of total insect capture (data from 29 traps) between three years in the Saumur-Champigny area. Significant values in **BOLD** (α=0.05, bilateral test).

Insect	*L. botrana*			*E. ambiguella*			*E. vitis*			*S. titanus*		
Year	2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
2005	1			1			1			1		
2006	**0.90**	1		**0.64**	1		**0.50**	1		**0.75**	1	
2007	**0.91**	**0.94**	1	**0.54**	**0.64**	1	**0.41**	**0.51**	1	**0.49**	**0.55**	1

Between-year comparisons

Strong to very strong correlations were found when comparing *L.botrana, Eu.ambiguella* or *S.titanus* plot total population levels for 29 plots *among years* (Table 1). For *E. vitis* these correlations are slightly weaker but still significant, in spite of its hibernation outside the plot. Each species presents a rather comparable spatial distribution between years, in spite of differences in insecticide applications among plots. This distribution therefore seems to be related to some perennial factor of the plot or its surroundings

Insects and landscape characteristics for different buffer sizes

As in Van Helden *et al.* (2006), abundance of *L. botrana* was always positively correlated with the % surface area of the buffer planted with vines (though not always significantly, Table 2). The size of the vine patch (CaV) correlated more strongly. This may relate to direct attraction of pests or to natural enemy exclusion. One management solution to be tested would be fragmentation of vineyards through hedgerow planting. Grape load (food density) is clearly correlated with *Lobesia* population density.

Immigrating *E. vitis* (G0) and first generation (G1) adults correlate negatively with these same variables (Table 2). For spring immigrants (G0), this is probably due to the proximity of hibernation sites (winter hosts) hosts in the nearby vegetation (Decante & van Helden 2006). For summer adults (G1) we were unable to identify alternative summer hosts (Van Helden & Decante 2001, 2002). Long distance passive migration, resulting in homogeneous deposition and subsequent dispersion towards vine plots can also explain higher population levels in plots surrounded by non-habitat. Damage (known as hopperburn) was often observed at plot borders, which could represent a barrier for migrating individuals, reluctant to leave the plot. For *E. ambiguella* and *S. titanus,* there were no significant results.

Increasing buffer size generally increased correlation strength (with % of vine) up to 750 m (Table 2), indicating that landscape composition has an influence at this scale. This diameter is larger than expected considering the adult mobility of *L. botrana* (Torres-Vila *et al*. 1997).

Table 2: Spearman rank correlations with % of vine (for different buffer sizes), total continuous area of vines around the trap (CaV) and grape load of the plot. – Significant values in **BOLD** (a=0,050, bilateral test).

	% vine in buffer of X m				CaV	Grape
Insect	250	500	750	1000		Load
EvaG0	-0,12	-0,26	-0,20	**-0,35**	-0,10	0,24
EvaG1	-0,29	**-0,34**	**-0,42**	**-0,35**	**-0,40**	-0,09
LbaG0	0,25	0,25	0,25	0,14	**0,41**	**0,33**
LbaG1	0,15	0,15	0,21	0,18	**0,33**	**0,35**
LbaG2	0,14	0,13	0,24	0,20	0,24	**0,38**
EvlG1	-0,19	-0,20	-0,25	-0,15	-0,21	0,23

Future observations

From this preliminary work we can identify the major landscape-scale factors influencing pest abundance and develop hypotheses with regard to underlying mechanisms. Longer term, landscape-scale monitoring will be continued to try to determine how landscape configuration may influence pest insect movements or natural enemy impact. In addition, the apparently opposite responses of major pest insects (*L. botrana* versus *E. vitis*) to some parameters (CaV) need to be taken into account. In the Buzet region we will try to include disease monitoring in this landscape ecology study.

A new application for the trap network

The new Tri-Δnglué® trap has been adopted by professional organisations to monitor insects for different surveillance networks (Fulchin & Van Helden, 2007). This trapping system is now also accepted by the French plant protection services (SRPV) for the monitoring of the 'flavescence dorée' vector *S. titanus* in areas under imposed sprayings (quarantine disease). Trap networks have made it possible to demonstrate the near absence of adults after a single larvicide application, thus avoiding the usual subsequent adult treatment. This can lead to a substantial reduction in pesticide use.

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