21 SPIDERS IN THE LANDSCAPE OF ITALIAN VINEYARDS: LANGA ASTIGIANA

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INTRODUCTION

A spider community can undergo rapid changes in species composition due to its quick reaction to any variation in vegetation structure (Asselin and Baudry, 1989). It is strongly influenced by agricultural practices (Luczak, 1979) and chemical treatments (Chant, 1956; McCaffrey and Horsburgh, 1980; see Marc *et al.*, 1999 for an overall review). Moreover, landscape ecology gives many examples of the influence of landscape heterogeneity and spatial structure on species distribution and community composition (Zonnenveld and Forman, 1990; Burel and Baudry, 1999; Gibb and Hochuli, 2002). However, it seems that agricultural practices affect pitfall-collected spider community composition more than landscape heterogeneity (Jeanneret *et al.*, 2003). The aim of this study is to evaluate the influence of landscape heterogeneity and agricultural practices on spider communities in the vineyards of Langa Astigiana (NW Italy). The extended version of this research, adding numerous data and analysis, has been recently published in Isaia *et al.* (2006).

STUDY AREA AND METHODS

The study area is located in the so-called Langa Astigiana (NW Italy), a region with a high density of vineyards (Fig. 1) where woods represent the only diverse patch.

Figure 1: Different cultural practices often reflects different landscapes. Organic (A and B) and intensive farms (C and D).

The sampling sites are characterized by different agricultural practices and levels of human disturbance: from farms with certified organic production (the only treatment is spraying with sulphur) to intensive farms with heavy chemical treatments with herbicides, insecticides, anti-mould and anti-rot compounds. All “intensive” vineyards chosen for this study are located in very homogeneous landscapes and, on the other hand, the landscape of organic vineyards is much more heterogeneous. Spider assemblages were collected from April 2002 to July 2003 with pitfall traps 6 cm in diameter filled with glycol-ethylene and water (50%) and by hand-sampling of 30 minutes each using a pooter in sample areas of 9 m^2. Pitfall traps were replaced every three weeks. Twenty-three sites were randomly selected over a total study area of 5 sites of approximately 2 km^2 each and sampled at least four times each for a total of ninety-five samples.

The environmental characterization of the sampling sites was based on the following metrics: (1) distance from the closest wood (in m); (2) distance from the closest hedgerow (in m); (3) mean height of the herbaceous layer between vine rows (this variable is related to agricultural practices: in intensive vineyards no, or much reduced, herbaceous layer is found). Landscape diversity was measured by means of Shannon Index, calculated on a circle area of 200 m around each sampling station. Relationships between spider communities and environmental factors were examined using canonical correspondence analysis (CCA, Ter Braak, 1986). Ordinations were performed using the PC-ORD software (version 4, McCune and Mefford, 1999). Pitfall-trapped and hand-collected samples were treated separately. Spider species with less than 3 specimens were excluded from the analysis. A Monte Carlo test of significance was performed to test the null hypothesis of no linear relationship between matrices, using 1000 randomisations.

To better investigate the relationship between single species and each environmental metric, we applied Indicator Species Analysis following the method proposed by Dufrene and Legendre (1997), *i.e.* grouping the sampling sites according to the CCA diagram ordination. Two groups (A and C) consisted of sampling sites with, respectively, axis 1 and axis 2 scores greater than the mean value ± standard deviation. A third group (group B) included all the remaining sampling sites. The composition of each group was then analysed in terms of spider hunting strategies. Four hunting strategies (Jones, 1984; Roberts, 1985, 1995) were considered for pitfall sites: specialised predators, sheet web weavers, nocturnal wanderers and diurnal wanderers. For hand collecting sites, we considered wandering and ambush spiders, sheet and tangle web weavers, and orb web weavers.

RESULTS

In total, 891 spiders belonging to 74 species, 61 genera and 20 families were collected: 502 spiders were collected by hand, 389 in pitfall traps (Table 1). A significant, high correlation (-0.959 Pearson) was found between Shannon index applied to each sampling station and their distance of woods.

Table 1: Synopsis of spider sampling data referring to species (a) and specimens (b). Valid data refers to data used in the analysis. Y refers to young specimens not determinable at species level, R refers to rare species (less than 3 specimens).

A) SPECIES	VALID DATA	EXCLUDED		TOTAL
Pitfall traps	20	22		42
Hand collecting	18	20		38
Both methods	2	4		6
Total	36	38		74
B) SPECIMENS		Y	R	
Pitfall traps	304	57	28	389
Hand collecting	474	4	24	502
Total	778	61	52	891

CCA with pitfall data

The first axis of ordination evaluated with a Monte Carlo test with 1000 permutations was significant ($p<0.05$). Fig. 2 shows the ordination of species and sites based on LC scores (linear combination of environmental variables). Intraset correlations values (*sensu* Ter Braak, 1986) of environmental variables indicate that the distance from the closest woods (*i.e.* landscape heterogeneity) was the main environmental variable influencing the ordination. The other three variables showed a lower correlation with the first axis of ordination (see Table 2). The approximate ranking of the centres of the distributions of species along the distance from the closest wood suggests that *Dyplostyla concolor*, *Floronia bucculenta*, *Dysdera crocota*, *Tegenaria nemorosa* and *Phrurolithus festivus* are not negatively affected by large distances from wooded areas, while *Trochosa terricola*, *Aulonia albimana*, *Zelotes praeficus* and *Arctosa personata* are typical of sites near woods. These species are also associated with a high layer of natural herbaceous vegetation. The proximity of hedgerows seems to favour the presence of *Zodarion italicum*, *Aulonia albimana* and *Trochosa terricola*.

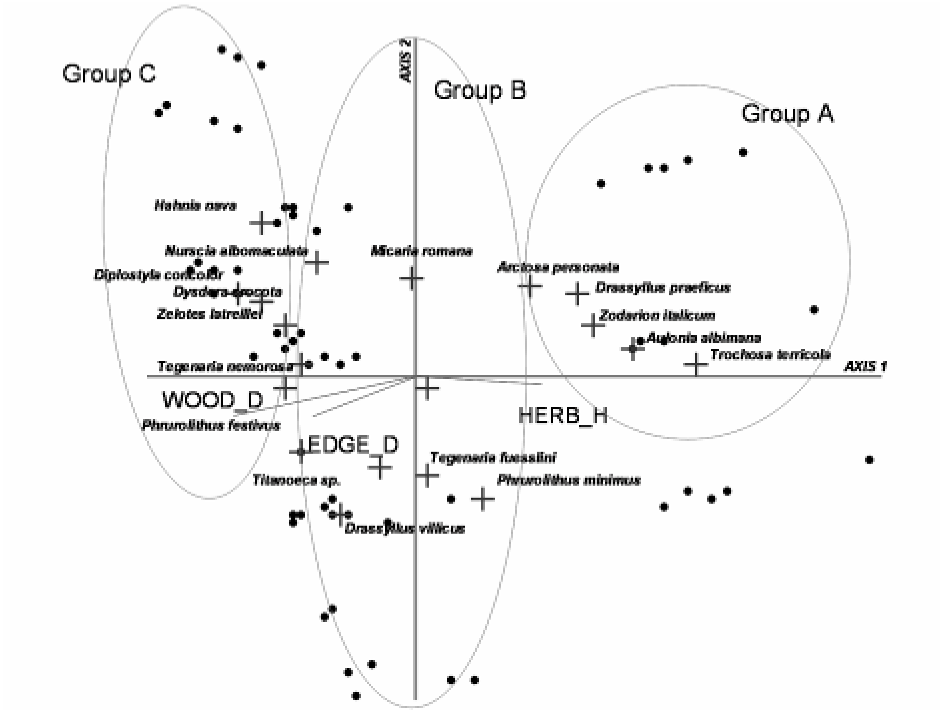

Figure 2: Ordination of sites in environmental space as defined by CCA, using LC scores for pitfall trapped. Circles are sites, + symbols are species.

CCA with hand-sampled data

The total variance of species data explained by the three axes is higher than with the pitfall data. (Table 2). The first axis accounts for most of the variation. Fig. 3 shows the ordination of species and sites based on LC scores. The approximate ranking of the centres of the distributions of species along the distance from the closest wood indicate that *Aulonia albimana*, *Heliophanus cupreus*, *Heriaeus mellottei*, *Micrommata virescens* and *Enoplognatha ovata* are mainly found in vineyards near woods (*i.e.* in vineyards in heterogeneous landscapes). For the variable herb_h, the order of ranking goes from *Thomisus* sp. and *Nuctenea umbratica* to *Aulonia albimana*, *Heliophanus cupreus* and *Heriaeus mellottei*. The presence of *Achaearanea* sp. and *Lepthyphantes tenuis* seems not to be associated with the distance from hedgerows.

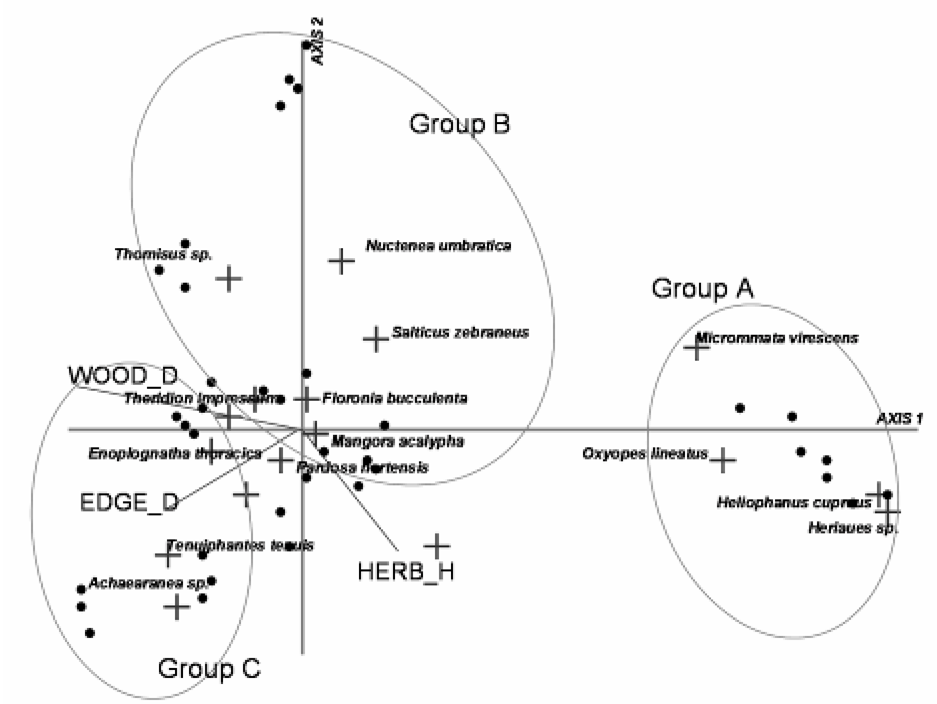

Figure 3: Ordination of sites in environmental space as defined by CCA, using LC scores for hand sampled spiders. Circles are sites, + symbols are species.

Table 2: Summary Statistics for Pitfall data set (a) and for hand sampling data set (b).

A) AXIS SUMMARY STATISTICS FOR PITFALLS DATA SET			
Number of canonical axes: 3			
Total variance ("inertia") in the species data: 8.7527			
	AXIS 1	AXIS 2	AXIS 3
Eigenvalue	0.423	0.293	0.210
VARIANCE IN SPECIES DATA			
% of variance explained	4.8	3.4	2.4
Cumulative % explained	4.8	8.2	10.6
Pearson Correlation, Spp-Envt	0.810	0.759	0.666
Kendall (Rank) Corr., Spp-Envt	0.455	0.483	0.418
B) AXIS SUMMARY STATISTICS FOR HAND SAMPLING DATA SET			
Number of canonical axes: 3			
Total variance ("inertia") in the species data: 3.3116			
	AXIS 1	AXIS 2	AXIS 3
Eigenvalue	0.453	0.175	0.130
VARIANCE IN SPECIES DATA			
% of variance explained	13.7	5.3	3.9
Cumulative % explained	13.7	19.0	22.9
Pearson Correlation, Spp-Envt	0.872	0.759	0.727
Kendall (Rank) Corr., Spp-Envt	0.338	0.570	0.556

Indicator species analysis (ISA)

The main features of group A are the vicinity of woods and the presence of a high herbaceous layer, while group C sites are far from woods and have a very low herbaceous layer as a consequence of agricultural practices. Group B includes the remaining stations. According to ISA's results in the pitfall community, five species are significant indicators of group A: *Aulonia albimana*, *Phrurolithus minimus*, *Arctosa personata*, *Drassyllus praeficus*. Only *Diplostyla concolor* is a significant indicator of group C, which is composed of the most disturbed sites. In the hand-collected community, four species (*Aulonia albimana*, *Enoplognatha ovata*, *Heriaeus mellottei*, *Micrommata virescens*) are significant indicators of group A, while only *Frontinellina frutetorum* is a significant indicator of group C. *Aulonia albimana* was collected by both sampling techniques and is a significant indicator of group A in both data sets.

Prey capture strategies

The three groups of sites based on the CCA ordination were analysed in terms of the prey capture strategies of their species (Jones, 1984; Roberts, 1985, 1995). The three pitfall groups differ mainly in the specialised predators/sheet web weavers ratio, with group A having the highest value. In the hand-collected data, sheet and tangle web weavers are highly dominant in group C (Fig. 4).

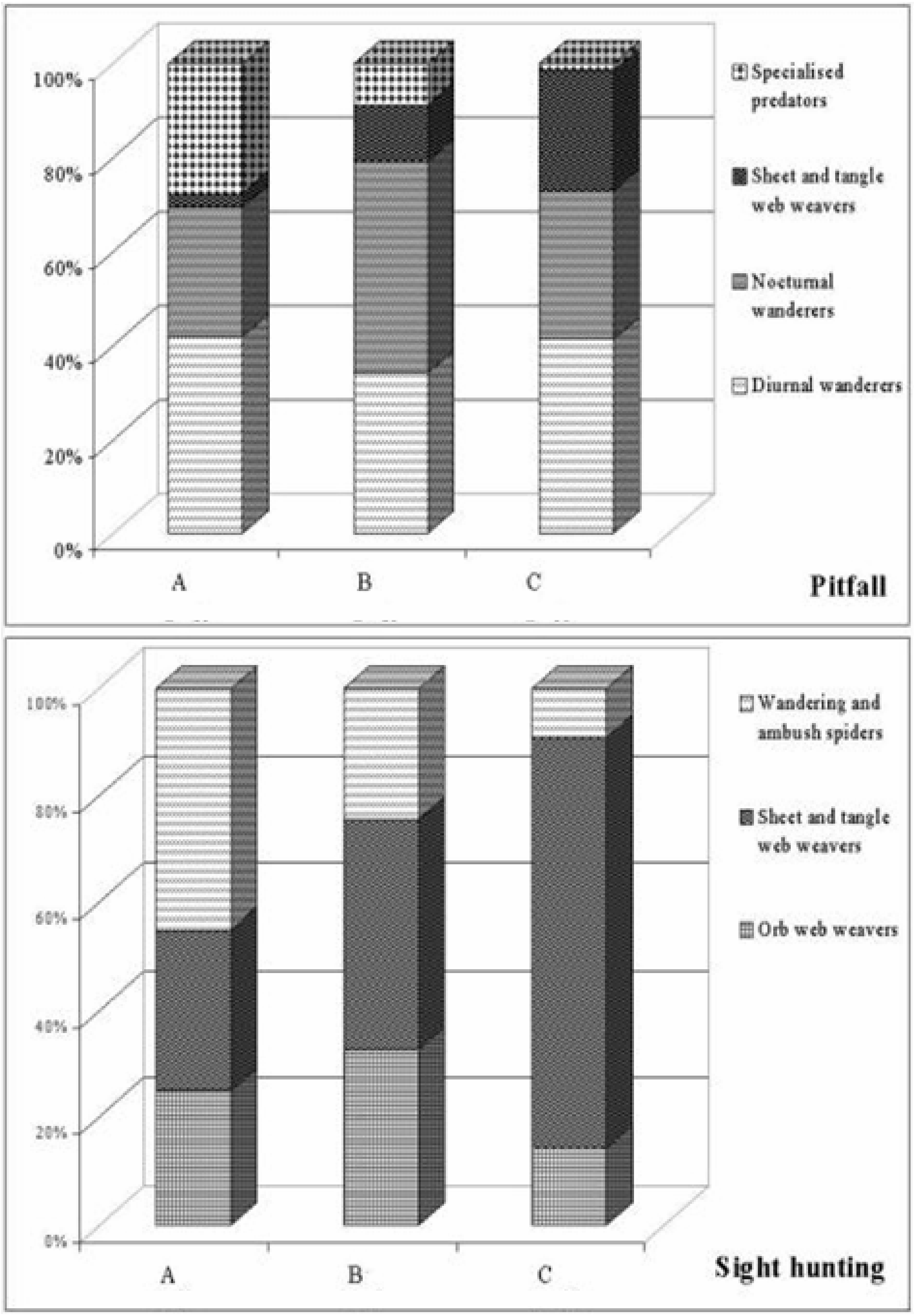

Figure 4: Species grouped by ecological preferences in the three groups defined by CCA.

DISCUSSION

Compared to other agroecosystems like apple orchards (52 species), beans fields (21 species), swiss chards (19 species) and cereals fields (46 species) (see Marc *et al.*, 1999), the high number of species (74) indicates the potential role of vineyards in maintaining high levels of biodiversity in agroecosystems.

The correlations between the environmental variables and the first canonical axis are high, ranging from –0.405 to –0.945 (respectively herb_h and wood_d in the hand-collected data, tab. 2), indicating that the selected environmental variables account for residual variation in the species data, even if not for the main variation. However, the null hypothesis of no influence of landscape matrix on the spider communities living in the vineyards can be rejected. In general, environmental variables seem to have a stronger influence on the hand-collected spider community, as seen by comparing the two percentages of variance explained. The presence of woods and the related landscape heterogeneity appear to be the most important environmental factors for both sub-communities. The presence of an herbaceous layer also plays an important role. These factors influence both the community structure and species composition of spider assemblages. The Indicator Species Analysis applied to the pitfall data indicates that three species are particularly influenced by the considered environmental variables: *Aulonia albimana*, *Arctosa personata* and *Drassyllus praeficus*. These results are in accordance with the species autoecology. In the hand-sampled data, the influence of the variable “distance from the closest wood” suggests that all species found to be significant indicators are mainly found in wooded areas. *Aulonia albimana* is one of the few species collected by both sampling techniques, and in both cases is an indicator of group A, *i.e.* sites with more heterogeneous landscape. Despite the scarcity of ecological data on Italian spiders, we can draw some conclusions concerning the potential use of spiders as bioindicators. The presence of *Aulonia albimana*, *Arctosa personata*, *Enoplognatha ovata*, *Heriaeus mellottei* and *Micrommata virescens* indicates the vicinity of woods and so landscape heterogeneity. As already pointed out, *Aulonia albimana* is often associated with a well developed herbaceous layer. The *Linyphiids Diplostyla concolor* and *Frontinellina frutetorum* are associated with high levels of human disturbance in vineyards; these species are reported in the literature as euryecious species with strong pioneering habits.

The analysis of prey capture strategies highlights the importance of the considered environmental factors. At least in the study area, the presence of woods close to the vineyard is synonymous with landscape heterogeneity, since woods are the only diverse patches in a very homogeneous matrix (vineyards). The vicinity of woods to pitfall traps (group A) seems to favour the presence of specialized predators (such as Zodariids – ant spiders), while sheet and tangle web weavers (mostly Linyphiids) dramatically replace specialized predators as the distance to woods increases and cultural practices intensify.

Sheet and tangle web weavers (again, mostly Linyphiids) present the same trend when the hand-collected samples are considered. Since their propensity to engage in aerial dispersal by ballooning can be considered one of the main reasons for their association with disturbed habitats (Richter, 1970; Greenstone, 1982), their abundance in group C is a sign of a certain degree of human disturbance.

CONCLUSIONS

The analysis of prey capture strategies highlights the importance of the considered environmental factors. The results lead to the following interpretations concerning landscape heterogeneity. At least in the study area, the presence of woods close to the vineyard is synonymous with landscape heterogeneity, since woods are the only diverse patches in a very homogeneous matrix (vineyards). The landscape diversity seems to encourage the presence of ambush prey spiders and specialized ones (such as Zodariids – ant spiders) in hand collecting. Sheet and dome web weavers (mostly Linyphiids) seem to replace ambush prey and specialized predators as landscape diversity decreases.

Sheet and dome web weavers (again, mostly Linyphiids) present the same trend when the pitfall samples are considered. Their propensity to engage in aerial dispersal by ballooning can be considered one of the main reasons for their association with homogeneous landscapes (Richter 1970, Greenstone 1982).

Although it may be easier to interpret data for pitfall trapped spider assemblages, we suggest that future studies maintain both sampling methods in order to provide complete data sets of spider assemblages.

The high number of species found indicates that vineyards represent, in general, suitable habitats for a high number of species and thus our work could represent a necessary starting point for biocontrol purposes in this kind of agroecosystem. In relation to this, landscape diversity can be considered as an important factor in determining spider assemblages.

As pointed out in the discussion (and according to Halley *et al.*, 1996), sheet web and dome web weavers seem to be influenced by landscape structure and management regimes. Their dominance can thus be considered a symptom of a certain degree of increase in landscape homogeneity.

Further developments of this research will include additional environmental variables closely related to agricultural practices. Spider assemblage data will be compared with other response indicators such as soil in fauna, which will help to clarify the role of spiders as bioindicators. In this regard, we are studying a bioindicator system for agroecosystems which will include the use of spider webs as a reliable and feasible tool of investigation, following the approach described in Groppali (2000) and first applied by Isaia *et al.* (2003).

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