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Natural hedges as an element of functional biodiversity in agroecosystems: the case of a Central Italy vineyard

Luigi PONTI[1,3], Carlo RICCI[1], Fabio VERONESI[2], Renzo TORRICELLI[2]
[1]*Dipartimento di Arboricoltura e Protezione delle Piante, Università di Perugia, Italy*
[2]*Dipartimento di Biologia Vegetale e Biotecnologie Agroambientali, Università di Perugia, Italy*
[3]*Department of Environmental Science, Policy and Management, University of California at Berkeley, USA*

Abstract

In a vineyard of Central Italy surrounded by two hedges, one composed of bramble, *Rubus ulmifolius* Schott, and one of elm, *Ulmus minor* Miller, the green grape leafhopper, *Empoasca vitis* (Göthe), and the Italian grape leafhopper, *Zygina rhamni* Ferrari (Homoptera Cicadellidae), did not reach economically important population levels. Although *E. vitis* and *Z. rhamni* were found on bramble, this plant is not a major source of colonising grape leafhoppers. Rather it hosts three non-pest leafhoppers: *Ribautiana tenerrima* (Herrich-Schäffer), *Arboridia parvula* (Boheman) (Homoptera Cicadellidae), and a species of the genus *Zygina*. Mainly *R. tenerrima* serves as an early season food source to parasitoids of the *Anagrus* complex (Hymenoptera Mymaridae), the most important natural enemies of grape leafhoppers in Italy. This enabled the parasitoid wasps to build up their populations to later colonise the adjacent vineyard. We documented a clear movement of *Anagrus* from the bramble hedge to vineyard. *Anagrus* did not exhibit a spring peak on elm, although this plant contributed to continued survival of parasitoids throughout the season by harbouring several leafhopper species: *E. vitis*, *Z. rhamni*, *A. parvula*, *Ribautiana ulmi* (L.) and a species of the genus *Alebra*.

Key words: biological control, hedges, vineyard, leafhoppers, *Anagrus*.

Introduction

Hedges have been considered a key component of agroecosystem biodiversity (Altieri, 1991) and can be functional for pest management. In many cases natural vegetation around crop fields harbours alternate hosts or preys for natural enemies, thus providing seasonal resources to bridge gaps in the life cycles of entomophagous insects and crop pests (Altieri and Whitcomb, 1979; Burgio *et al.*, 2004).

The influence of such hedgerows on grape pest management has been investigated (Doutt and Nakata, 1973; Boller *et al.,* 1988; Cerutti *et al.,* 1991). For example, the effectiveness of the egg parasitoid wasp *Anagrus epos* Girault (Hymenoptera Mymaridae) in regulating the grape leafhopper *Erythroneura elegantula* (Osborn) (Homoptera Cicadellidae) within Californian vineyards was increased greatly in vineyards near areas invaded by bramble (*Rubus* sp.) (Doutt and Nakata, 1973) and became a classic (Delucchi, 1994) example of habitat management (Delucchi, 1997; Letourneau and Altieri, 1999). *E. elegantula* overwinters as adult, but bramble supports another leafhopper, providing an alternative host to *A. epos* during the winter. This allows an early and effective control of the grape leafhopper by the parasitoid, which colonises vineyards from hedges in the following growing season.

In Europe analogous studies have focused on the green grape leafhopper *Empoasca vitis* (Göthe) (Homoptera Cicadellidae). This insect is considered a serious problem in vineyards of Northern Italy (Pavan *et al.* 1992), but it is not a major pest in Umbria (a region of Central Italy), where the agricultural landscape is still dominated by fields surrounded by hedges. These hedges, many of which contain *Rubus* spp. and other plant species, support populations of the egg parasitoid *Anagrus atomus* (L.) (Ponti, 2000), the most important natural enemy of the *E. vitis* (Arzone *et al.,* 1988). The only literature available on leafhoppers in Umbria was an investigation listing 387 species records of Rhynchota (Mancini, 1953).

Traditionally, *Anagrus* spp. associated with leafhoppers on grapes have been placed in a single species within the same geographic region. This is the case of *A. atomus* in Italy (Arzone *et al.* 1988) and *A. epos* in California (Doutt and Nakata, 1973). However, the systematics of *Anagrus* are poorly understood; members of this genus that inhabit vineyards are a complex of species and biotypes (Chiappini, 1987; Trjapitzin and Chiappini, 1994). For this reason, the *Anagrus* spp. of the present study, which is likely a complex of species and biotypes (Chiappini E., personal communication), is hereafter referred to simply as *Anagrus*, as in recent studies on the same topic (Corbett and Rosenheim, 1996; Williams and Martinson, 2000).

This paper is a case study on the well-known "*Anagrus*-leafhopper system", conducted in a low-input vineyard in Umbria. Preliminary studies conducted in this vineyard have been presented to several national and international meetings (Ponti and Ricci, 2000, 2002; Ponti *et al.*, 2002; Ponti *et al.*, 2003).

The aim of the present study was to assess whether hedges surrounding such vineyard, comprise an element of plant biodiversity that can be functional for grape pest management, exerting a positive influence on population dynamics of the most important natural enemy of grape leafhoppers in Italy. This study reports population trends of pestiferous and alternatives leafhoppers, and associated natural enemies, in both the vineyard and the adjacent vegetation.

Materials and methods

This study was conducted in a 2 ha vineyard located in Sant'Enea (289 m a.s.l.), 10 km south of Perugia (Umbria), during 1998 and 1999. The vineyard was located on a hilly area bordering the valley of the Tiber River. This area is a typical vine growing region, where fields are surrounded by perennial hedgerows. The vineyard under study was surrounded by two hedges, one composed by bramble, *Rubus ulmifolius* Schott, and the other dominated by elm, *Ulmus minor* Miller, which are common plant species in the hedges of Umbria.

No insecticides were applied to the vineyard during the survey. The only fungicides used were Bordeaux mixture and sulphur, which have been found to be selective for phytoseiid mites (Duso and Girolami, 1985), important to avoid tetranychid mite outbreaks.

Leafhopper and *Anagrus* adults were monitored using yellow sticky traps (20 × 15 × 0.3 cm) made of yellow PVC (Repsol Glass®, type SE-1011 3520 GUL, Repsol, Denmark), and coated with Temo glue (Kollant S.p.A., Padova, Italy). Yellow sticky traps are valid instruments for sampling both *E. vitis* (Picotti and Pavan, 1991) and *Anagrus* populations (Kido *et al.*, 1983; Picotti and Pavan, 1991; Williams and Martinson, 2000). Traps were observed with a Zeiss stereomicroscope. *Anagrus* catches were divided into males and females, according to morphological characteristics (Chiappini, 1987; Viggiani, 1988).

In 1998 a preliminary monitoring was carried out to investigate the composition of leafhopper species in the vineyard under study, and to properly plan the procedures for more intensive sampling conducted in 1999.

In the 1999 growing season, nine traps were replaced weekly from May to August: three in grapes, three in the bramble hedge and three in elm hedge. Traps inside the vineyard were suspended at 1.5 m high in the middle of the central rows. Traps in hedges were suspended to the vegetation at 1.5 m height. All traps were oriented North to South to standardise the influence exerted by environmental factors such as wind. Owing to the relatively small scale of this agroecosystem, three traps in each of the three habitats were considered sufficient for statistical analysis of the collected data.

Leafhopper nymphs were monitored by direct count on leaves. Six middle-basal grape leaves were randomly collected weekly in June and July in the same rows monitored by traps. Six leaves were randomly collected weekly from the bramble hedge from March to August. Leaves were observed under a Zeiss stereomicroscope.

We focused on bramble because it is an evergreen plant, showing a notably early arthropod activity in the season, while elm has a phenology similar to grape, being colonised much later by insects. Specimens of *Anagrus* and leafhoppers were collected and prepared for identification.

Data on the number of *Anagrus* on grape, bramble, and elm were statistically processed using a parametric *t* test.

Results

Two leafhopper species were able to reproduce on grape in 1998 and 1999: *Empoasca vitis* and *Zygina rhamni* Ferrari (Homoptera Cicadellidae). In 1999, during the peak abundance period, nymph population levels of both species on grape leaves remained below economic threshold values proposed in Europe for grape leafhoppers (Pavan *et al.,* 1998) (figure 1).

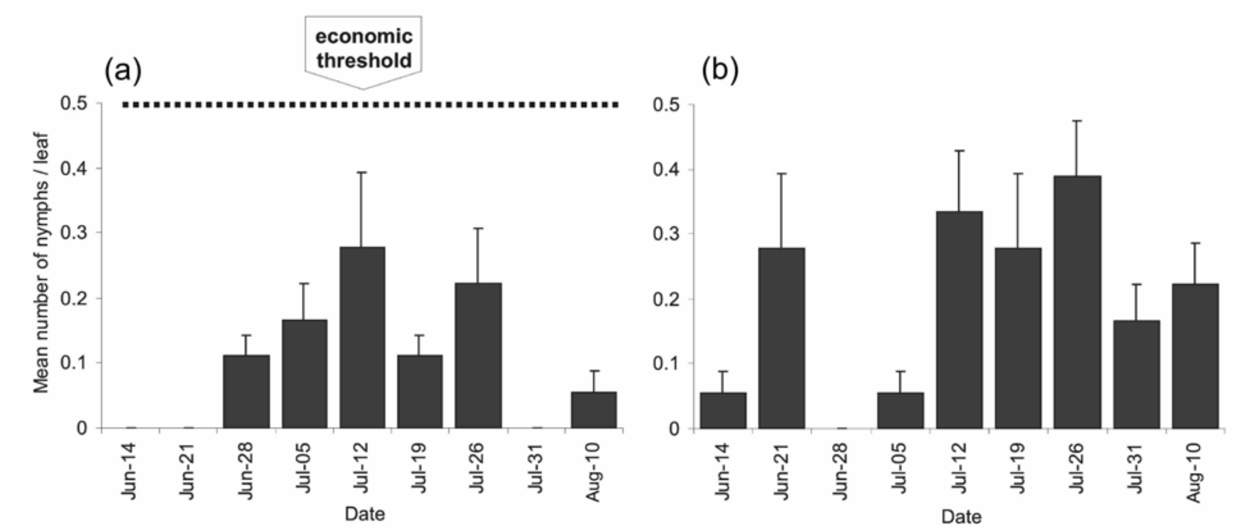

Figure 1. Nymphal population densities (mean ± se) of *Empoasca vitis* (a) and *Zygina rhamni* (b) in 1999 on grape leaves during peak abundance period (the lowest value among the different economic thresholds proposed for *Empoasca vitis* in Europe is 0.5 nymphs per leaf).

Although densities were slightly higher on bramble at the beginning of the season, cumulative trap captures of *E. vitis* adults in the bramble hedge and in vineyard showed a parallel trend, increasing in number as the season progressed; but after July 12, *E. vitis* was clearly more abundant in grapes than in bramble (figure 2). Cumulative numbers of *Z. rhamni* showed a similar trend, although in bramble *Z. rhamni* densities built up at a lower rate than *E. vitis* (figure 2).

Two non-pestiferous leafhopper species were able to reproduce on bramble throughout the observation period: *Ribautiana tenerrima* (Herrich-Schäffer) and a species of the genus *Zygina*, while *Arboridia parvula* (Boheman) was found on bramble only in the spring. The adults of *R. tenerrima*, the dominant species in bramble, were particularly abundant in spring, and nymph densities were high since early spring (figure 3).

The leafhoppers detected in the elm hedge were *E. vitis*, *Z. rhamni*, *A. parvula*, *Ribautiana ulmi* (L.) and a species of the genus *Alebra*.

More *Anagrus* females than males were detected on April 26 and May 3 on bramble and only females were detected in the vineyard in May. As populations of

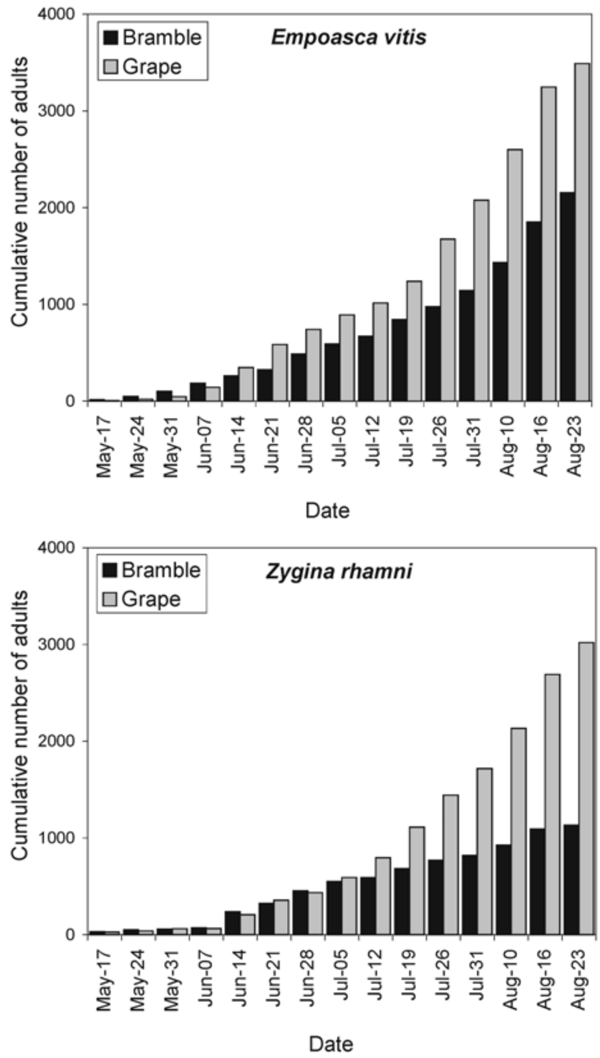

Figure 2. Cumulative number of adults of *Empoasca vitis* and *Zygina rhamni* on yellow sticky traps on bramble and grape in a vineyard of Central Italy in 1999.

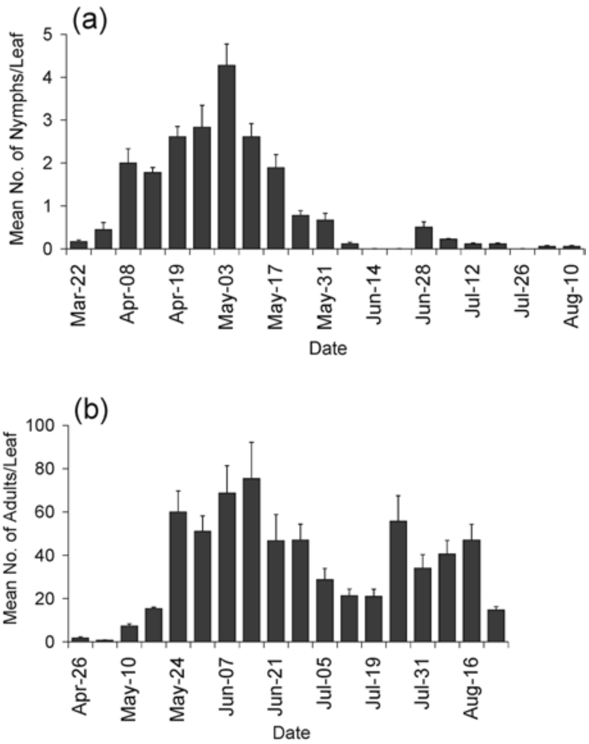

Figure 3. Population levels of *Ribautiana tenerrima* on the bramble hedge of a vineyard of Central Italy in 1999: (a) nymphal densities (mean ± se) on leaves and (b) number of adults per trap (mean ± se).

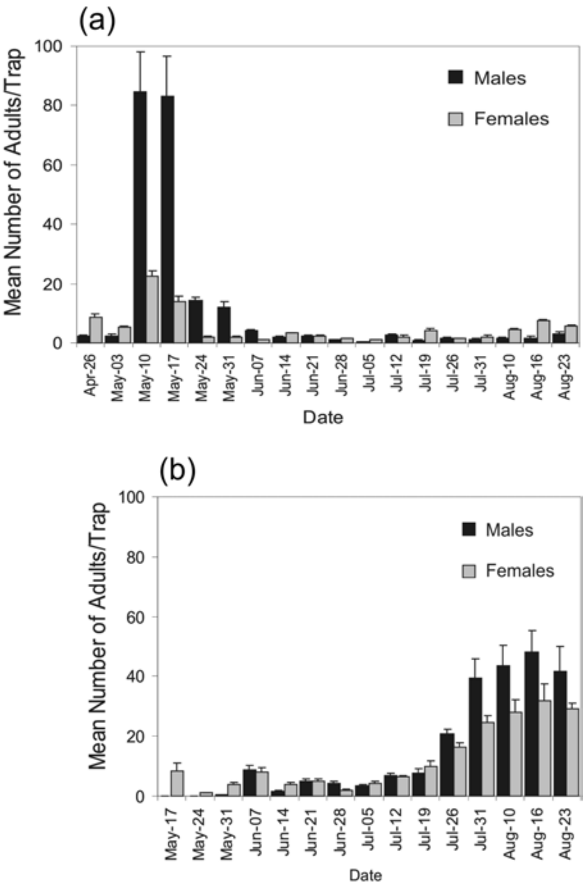

Figure 4. Number of *Anagrus* males and females per trap (mean ± se) on bramble (a) and grape (b) in a vineyard of Central Italy in 1999.

Anagrus decreased in bramble in mid May, its densities increased in the adjacent vineyard, suggesting that *Anagrus* moved from the hedge to the vineyard. In mid July *Anagrus* peaked in the vines, and remained in low numbers on bramble throughout the summer (figure 4).

Anagrus captures in bramble were significantly higher than in vineyard in May, when they reached their seasonal peak. During the summer, *Anagrus* were significantly more abundant in the vineyard, suggesting movement of the wasps form the hedge to the vines (figure 5a). No spring peak of *Anagrus* was evident in the elm hedge and few parasitoids were detected until late May on this plant (figure 5b). Apparently elm is not a source of colonising *Anagrus*.

Discussion and conclusions

The bramble-dwelling leafhopper species observed are not grape pests, but they serve as alternative hosts of *Anagrus* (Arnò *et al.,* 1988).

Compared to the evergreen bramble hedge, the deciduous elm hedge seems to play a minor ecological role, not being able to provide *Anagrus* with early-season alternative leafhoppers. Therefore, the presence of *Anagrus* in the vineyard since early spring is to be related to the bramble hedge.

E. vitis and *Z. rhamni* colonised the vineyard every season predominantly from distant sources, but they did not reach economically important population levels on the studied vineyard, as they normally reach in vineyards of the region. During their peak abundance period on grapes, their population levels were below the lowest economic threshold value proposed in Europe (0.5 nymphs per leaf) and well below the current threshold values for Italy, which vary from 1 to 3 nymphs per leaf (Pavan *et al.,* 1998). This suggests that the densities of these two pests were regulated by natural enemies (especially *Anagrus*) harboured by the bramble hedge.

Although *E. vitis* and *Z. rhamni* can be observed on bramble, this plant is not a major source of colonising grape leafhoppers. Rather it hosts 3 non-pest leafhoppers (mainly *R. tenerrima*), which serve as an early-season food source to *Anagrus*, enabling the wasps to build up their populations to later colonise the adjacent vineyard.

The data suggests that *Anagrus* move from the bramble hedge to the vineyard. As *Anagrus* numbers decline on bramble, they start to quickly build up in the vineyard, probably in response to the density of *E. vitis* and *Z. rhamni* on the vines.

Colonisation of the vineyard was carried out mainly by *Anagrus* females. The *t* test provides statistical significance to the seasonal abundance pattern of *Anagrus*, indicating a population shift from the bramble hedge to the vineyard as the season progressed.

The bramble hedge surrounding this Central Italy vineyard appears to be an element of plant biodiversity functional for grape pest management, as it enables an early population build-up of the most important natural enemy of grape leafhoppers. Maintenance of such hedges is therefore advisable to promote early *Anagrus* colonisation leading to an effective control of grape leafhoppers.

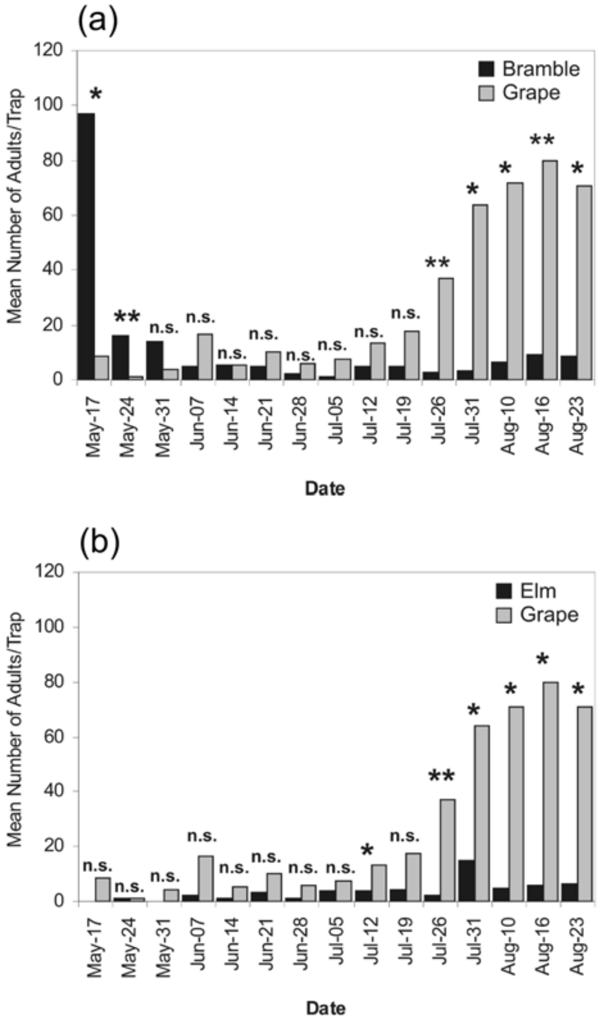

Figure 5. Mean trap captures of *Anagrus* on bramble and grape (a) and on elm and grape (b) in a vineyard surrounded by bramble and elm hedges in Central Italy in 1999 (*t* test: n.s. means are not significantly different; * means are significantly different, $P \leq 0.05$; ** means are significantly different, $P \leq 0.01$).

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Authors' addresses: Luigi PONTI (corresponding author, lponti@nature.berkeley.edu, current address: Department of Environmental Science, Policy and Management, University of California at Berkeley, 137 Mulford Hall-3114, Berkeley, CA 94720-3114, USA), Carlo RICCI, Dipartimento di Arboricoltura e Protezione delle Piante, Università degli Studi di Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy; Fabio VERONESI, Renzo TORRICELLI, Dipartimento di Biologia Vegetale e Biotecnologie Agroambientali, Università degli Studi di Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy.

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