

## **Influence of ecological infrastructures on the increase of biodiversity and conservation of beneficial arthropods in citrus orchards**

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**Abstract:** We performed a study in nineteen citrus plots representative of the agricultural landscape of the municipality of Altea (100 km south of Valencia, in eastern Spain) in order to determine the influence of ecological infrastructures on biodiversity and conservation of beneficial arthropods. The landscape was dominated by small citrus orchards mixed with low density urban areas, a consequence of touristic urban pressure. We have considered five factors: pest management system (zero residues vs. conventional), size of the plot, distance to nearest natural habitat, presence/absence of cover crop, and presence/absence of other non-citrus fruits in the plot. Four of the five factors showed a positive influence on biodiversification and conservation of beneficials: small plot size, short distance to natural habitat, presence of vegetation cover and presence of other fruits. These are the factors to promote in order to develop biological strategies alternative to traditional pesticide use in the management of citrus pests. Only the factor “pest management system” does not show a significant influence on biodiversity or on abundance of biological control agents.

**Key words:** landscape, ecological infrastructures, biodiversity, biological control, conservation

### **Introduction**

The literature stresses the importance of strategies that support effective natural pest control on a landscape scale (Duelli *et al.*, 1990; Dennis and Fry, 1992; Bugg and Pickett, 1998; Nentwig, 1998). We performed a study in nineteen citrus plots representatives of the agricultural landscape of the municipality of Altea (100 km south of Valencia, in eastern Spain) in order to determine the influence of ecological infrastructures on biodiversity and conservation of beneficial arthropods. The landscape was dominated by small citrus orchards mixed with low density urban areas, a consequence of touristic urban pressure. We have considered five factors: pest management system (zero residues or conventional), size and shape of the plot, distance to the nearest natural habitat, existence of a cover crop, and presence of other non-citrus fruits in the plot. These factors are related to landscape structure and thus influence the following aspects: facilitate food for insects (as nectar or pollen) (Bugg and Pickett, 1998; Nentwig, 1998; Wäckers, 2004; Winkler *et al.*, 2006), improve winter habitat and provides attractive microclimate (Duelli *et al.*, 1990; Dennis and Fry, 1992; Dyer and Landis, 1996; Nentwig, 1998) and give prey and alternative hosts after crop harvest.

## Material and methods

The study was carried out in a significant area of the agricultural landscape of the municipality of Altea (100 km south of Valencia, eastern Spain). The area analyzed was of 23.57 ha and included 19 plots, thus giving an average surface area per plot of 1.3 ha. To determine richness of beneficial insects, two vertical yellow sticky traps of 10 x 10 cm was placed on each orchard and sampled monthly during May, June and July, 2011. All species of beneficial were identified and counted, and the average species richness per trap and month was used as species richness index of the plot.

We analyzed the influence of the following five variables in the richness of beneficial insects: 1) Area: surface area (ha) of the plot, 2) Distance: distance (m) from the plot to the closest natural habitat, with four levels of distance, 0-50 m, 50-75 m, 75-125 m and more than 125 m, 3) Loquat: other fruits present in the citrus orchards (a categorical variable indicating the presence or absence of loquat or other trees in the plot), 4) Management: management strategy for pest control applied in the plot (categorical variable indicating if the plot is zero residues or not (conventional)) and 5) Cover crop: (categorical variable indicating if the plot ground is covered by spontaneous vegetation in more or less than 50% of its area). A multiple linear regression model approach was applied and the equation to estimate the single effects and interactions between the variables was obtained.

## Results and discussion

Distance and Loquat were the only significant single factors influencing natural enemies' richness. Else, we found four significant interactions: Distance x Cover, Distance x Area, Distance x Loquat and Area x Management (Table 1). The following equation was obtained to estimate the relationship between the variables for a significance level of < 8%:

$$\text{Richness of beneficial insects} = 9.19 - 0.06 * \text{Distance} + 4.07 * (6.78 * \text{Loquat} = \text{"presence"}) - 4.60 * \text{Area} * (\text{loquat} = \text{"presence"}) + 0.01 * \text{Distance} * \text{Area} + 0.03 * \text{Distance} * (\text{Management} = \text{"zero residues"}) + 0.04 * \text{Distance} * (\text{Cover \%} = \text{"50 - 100"})$$

Table 1. Significance levels of single and interacting factors in the analysis of the influence of ecological infrastructures on richness of beneficial insects.

Variables	Distance	Loquat	Area * Loquat	Distance * Area	Distance * Management	Distance * Cover %
Significant p - values	0.0043	0.0045	0.0148	0.0097	0.0756	0.0098

The distance of a plot to the nearest natural habitat is the factor that has the greatest influence on beneficial species richness (p = 0.0043). The greater the distance to natural habitat, the lower the diversity of beneficial insects (Figure 1).

The presence of other fruit trees (mostly loquat) in the plot, apart of the citrus crop, is the second single factor significantly influencing the beneficial fauna richness (Figure 2). Loquat trees flower at the end of autumn or early winter, representing an important source of pollen

and nectar in this period of the year when there is scarcity of these resources in the habitat. The availability of nectar may be an important limiting factor for the parasitoids. Without access to carbohydrates, many parasitoids live only a short time and produce few offspring (Irvin *et al.*, 1999; Johanowicz and Mitchell, 2000; Leatemia *et al.*, 1995). The availability of food for adult parasitoids is essential for survival, and therefore plays an important role in the efficacy of parasitoid biological control agents (Berndt and Wratten, 2005).

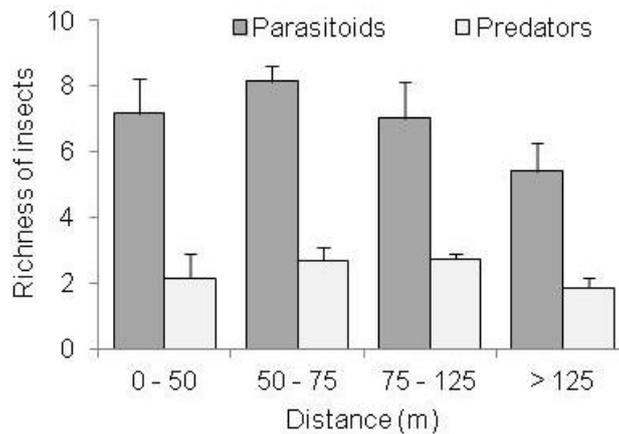


Figure 1. Influence of the distance of the plot to the nearest natural habitat on the richness of beneficial fauna of insects (parasitoids and predators). Vertical bars represent standard error of the mean.

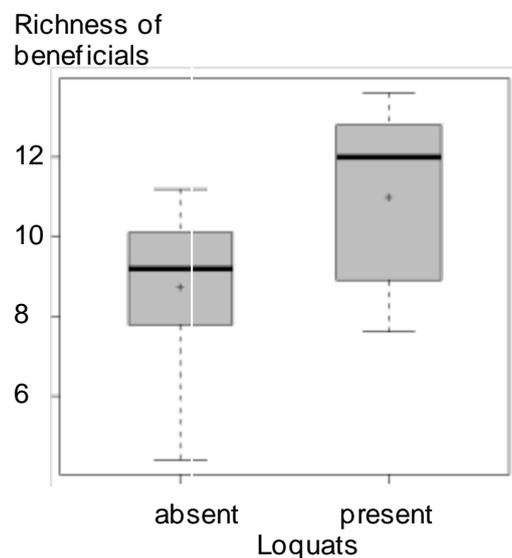


Figure 2. The presence or absence of loquat in the citrus plots is a factor that influences the beneficial species richness ( $p = 0.0045$ ). Vertical bars represent standard error of the mean.

The percentage of cover crop that exists in a plot is a non significant factor ( $P > 0.05$ ), but there is interaction of cover crop with distance to natural areas ( $P = 0.0098$ ). Insect richness of the plots with cover crop  $> 50\%$  is not influenced by their distance to natural

habitat. However, the percentage of cover crop in the orchard has a significant influence on beneficial fauna richness when distance to natural habitats is high ( $> 75$  m) (Figure 3).

The factor "management system" is not significant ( $P > 0.05$ ). However, there is interaction of it with the "distance to natural habitat" ( $P = 0.0756$ ). There is no influence of management system in plots located close (distance  $< 75$  m) to natural areas, but plots managed with "zero residues" have higher richness of beneficial insects than conventionally managed plots when distance to natural areas is high ( $> 75$  m) (Figure 4).

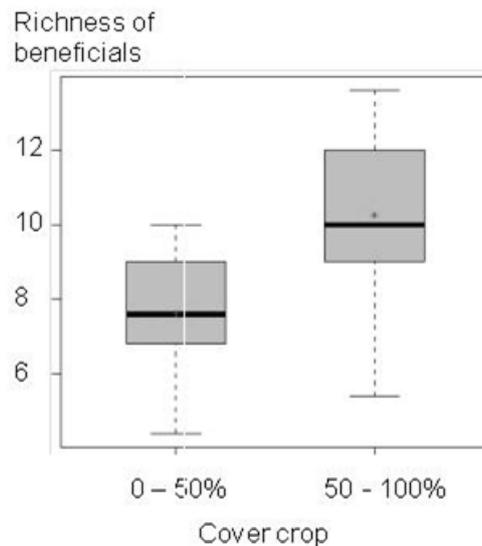


Figure 3. Influence of cover crop in beneficial fauna richness in the plots located at high distance ( $> 75$  m) from natural habitats. Vertical bars represent standard error of the mean.

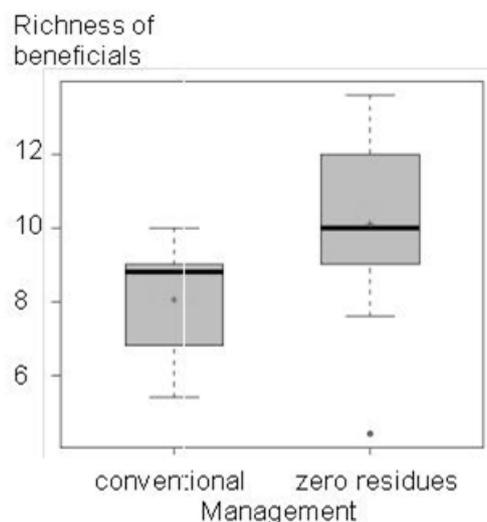


Figure 4. Influence of management system on beneficial fauna richness in plots located at high distance ( $> 75$  m) from natural areas. Vertical bars represent standard error of the mean.

In conclusion, two factors have shown significant influence on biodiversity of beneficial arthropods in citrus plots, the presence of alternative fruits trees (loquat) in the plot and the distance to natural habitats. Else, there are two significant interactions, the distance of natural habitat vs cover crop, and the distance of natural habitat vs management system. This implies that cover crop and management system influence in beneficial fauna only in citrus plots located far from natural habitats.

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