Summary

Aphis spiraecola Patch. (Hemiptera: Aphididae) is a key pest of clementines in the Mediterranean basin. This aphid colonizes tender clementine shoots in spring and causes important economic losses. Integrated management of *A. spiraecola* in clementines is currently based in chemical control because Biological control of *A. spiraecola* is still poorly known and efforts were based on the use and conservation of parasitoids but it did not success. On the other hand, the predator complex of *A. spiraecola* is well known but its impact on populations of this aphid has not been documented. With all this said, the aims of this thesis were: i) to disentangle the reasons behind the low parasitism of *A. spiraecola*; ii) to determine when and how predators can control *A. spiraecola* populations; and, finally, iii) to evaluate whether a ground cover of Poaceae plants can enhance the biological control of this aphid in clementines by improving the establishment of its predators.

The studies were carried out in clementine orchards located in "Provincia de Valencia" and "Provincia de Castellón" from 2011 to 2013.

In the first objective we sampled four orchards and determine the parasitoid complex and parasitism (and hyper-) rates weekly. Parasitism percentages were low (below 5%) and *Binodoxys angelicae* Haliday (Hymenoptera: Braconidae) was the unique primary parasitoid emerged from mummies of *A. spiraecola*. At least six hymenopteran hyperparasitoid species were identified by classical means attacking this primary parasitoid: *Syrphophagus aphidivorus* (Mayr) (Encyrtidae), *Alloxysta* sp. (Forster) (Figitidae), *Asaphes* sp. (Walker) (Pteromalidae), *Pachyneuron aphidis* (Bouché) (Pteromalidae), *Dendrocerus* sp. (Ratzeburg) (Megaspilidae) and *Phaenoglyphis villosa* (Hartig) (Figitidae). In addition, we developed a DNA-based approach to untangle the structure of the aphid-parasitoid food web in citrus. This methodology confirmed that all six species hyperparasitized *B. angelicae*. The most abundant hyperparasitoids were *S. aphidivorus* and *Alloxysta* sp. Both dominated this food web and they were abundant from the beginning of the season, and hyperparasitism percentages remained high around 40% throughout both seasons. Finally, hyperparasitoids also increased the secondary sex ratio of *B. angelicae*. Thus, hyperparasitism probably explains the low impact of *B. angelicae* on *A. spiraecola* populations.

For the second objective we sampled three clementine orchards to determine the effect of aphid predators on *A. spiraecola* colonies and damage over a three-year period. Life parameters of *A. spiraecola* colonies (maximum number of aphids, longevity and colony phenology) varied among the orchards over the three years. Predators attacked one third of the colonies, and it did not significantly differed among orchards any year. However, the maximum number of aphids and the longevity of *A. spiraecola* colonies were negatively correlated with the time of first attack by predators. More importantly, the percentage of shoots occupied by *A. spiraecola* (damages) remained below or close to the intervention threshold when colonies were attacked prior to ~200 degree days (DD) since the beginning of the aphid colonization. These results suggest that: i) the presence of predators at the beginning of the season should be considered to develop new intervention thresholds and ii) biological control programs should promote the early presence of predators in clementine orchards.

To promote the early presence of predators in clementine orchards, in the third objective we evaluated ground cover management, as strategy of conservation biological control. This ground cover management may provide alternative preys to natural enemies. The effect of a sown ground cover (based on *Poaceae* plants) on the biological control of *A. spiraecola* was evaluated in four orchards with ground cover management compared with four orchards with bare soil management. This sown Poaceae cover coexists with a complex of wild plants that might also affect biological control of *A. spiraecola*. Therefore, the ground cover plant composition and their inhabiting aphids were also described. Finally, we compared the presence of *A. spiraecola* and its natural enemies in these orchards. While Poaceae plants represented ~66% of the ground cover, the rest of the cover comprised mainly *Malva* sp. (13%), *Oxalis* sp. (5%) and *Sonchus* sp. (2%). Poaceae plants and *Oxalis* sp. harbored stenophagous aphids and *Macrosiphum euphorbiae* Thomas (Hemiptera: Aphididae), respectively, which appeared sooner in the system than citrus aphids. These aphids serve as alternative prey/hosts for natural enemies, thus enhancing the biocontrol of *A. spiraecola*. By contrast, *Malva* sp. and *Sonchus* sp. harbored the potential citrus pest *Aphis gossypii* Glover (Hemiptera: Aphididae) and other aphids that appear simultaneously with *A. spiraecola*. Therefore, by attracting them to the cover, this latter group could relieve the attack of natural enemies on *A. spiraecola* in the canopy. Although these wild plants may act as reservoirs for *A. spiraecola* as well as other aphid species that can disrupt the biocontrol services of natural enemies, overall, the sown cover was effective in terms of biological control of *A. spiraecola* in the citrus canopy. It promoted the early presence of predators in citrus canopies but did not promote the early presence of parasitoids. Predators attacked *A. spiraecola* colonies in the canopies before their exponential increase. These attacks resulted in satisfactory aphid control, because citrus orchards with ground cover never exceeded the aphid economic threshold.