Final report

Study of the control exerted by natural enemies over aphids and scales in apple orchards and the management factors affecting the natural regulation of pests they provide

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Introduction

Meetings with the participation of growers, advisors and researchers in the apple growing region of Skåne (Äppelträffen, 2011, 2012) revealed that the incidence of aphid and scale pests had increased during the past years. Sudden outbreaks of these secondary pests prompted significant additional intervention mainly with chemical insecticides. The reasons underlying more regular and severe outbreaks are unknown but the general assumption is that they are related to the adoption of new insecticides in 2008. In addition, the insecticidal treatments required to control specific outbreaks give short term control of the problem, but eliminate, or greatly reduce, the abundance of their natural enemies thus making subsequent outbreaks more severe (Solomon *et al.* 2000). Participants in Äppelträffen identified the study of natural enemies, and possible management strategies to foster their ecological service, as a research priority. Strategies fall in two categories according to Eilenberg et al. (2001): (1) the protection of natural enemies, and (2) the provision of adequate resources to improve their abundance and fitness. Both strategies require, as a starting point, detailed phenological data on natural enemies and pest's trophic relationships. In the first case it allows for a correct product choice and application (Murchie, Williams & Alford 1997; Wilson, Bauer & Lally 1998). In the second, it is essential to identify which natural enemies, and when, should be provided with additional resources in order to improve their performance. From 2014, integrated production is mandatory in EU apple orchards (91/414/EEC). One of the main objectives of integrated pest management (IPM) is to maximize the effectiveness of natural enemies for pest control. In apple production, biological control promotion is regarded as the main focus of advanced IPM (Blommers 1994). Aphids are along with tortricids the most relevant pests in European apple orchards (Blommers 1994) and other homopteran pests, such as the woolly apple aphid, *Eriosoma lanigerum* Hausmann, and the mussel scale, *Lepidosaphes ulmi* (L.) have increased in the past years and therefore can be locally relevant in Swedish apple orchards demanding additional control to suppress their damage.

Through this project we intent, in the first place, to provide information on the state of the ecosystem service provided by natural enemies through the regulation of these relevant pests in Swedish apple orchards. Secondly, to establish the knowledge required for the development of strategies aiming at the conservation and increase of this pest regulation function allowing, in the long term, for a reduction in insecticidal interventions.

Rosy apple aphid (*Dysaphis plantaginea*)

Experimental sites 2013: The experiment was conducted in 9 different apple commercial orchards in Skåne. Concerning pest management strategies, the experiment included 5 orchards without pesticide sprays (organic) and 4 orchards relying on insecticidal control as sole pest management strategy (conventional orchards). One of the orchards selected could not be used for the experiment due logistic problems. Groups of organic and conventional orchards also differed in landscape complexity in terms of natural habitats and patchiness with locations both in eastern Skåne and in the apple growing region of Österlen in western Skåne.

Experiment 1(2013): The experiment carried out in 2013 focused on *Dysaphis plantaginea* (Passerini), the rosy apple aphid (RAA). This aphid is regarded as the most harmful homopteran pest in apple cultivation, especially in organic orchards where no specific insecticidal products can be used against it.

In each location five 2-yr-old potted apple trees of the variety Aroma were deployed at the borders of the experimental plots at no more than 5 m from the apple tree rows. The trees were transported to the orchards during May, before flowering, in two consecutive weeks to allow natural enemies (NEs) from the orchard to colonize the tree prior to the establishment of aphid colonies. The pots were buried into the soil to prevent them from tipping over and were provided with 5 L of water per week, which, in addition to rainfall proved to be enough to avoid desiccation.

From around midMay and immediately after flowering, all the orchards were weekly scanned for active RAA. The earliest RAA colonies were detected in the western coast of Skåne. In early June, the first adults encountered in Alnarp were used to infest the potted trees. Five RAA colonies were established per tree in all 45 trees part of the experiment (9 orchards) by placing an adult female inside a clipcage and allowing it to reproduce for a week. After this period all the clipcages were removed exposing the colonies to the NEs and this initial number of aphids counted. One RAA colony per tree was placed inside a polyester mesh preventing the access of NEs (control treatment).

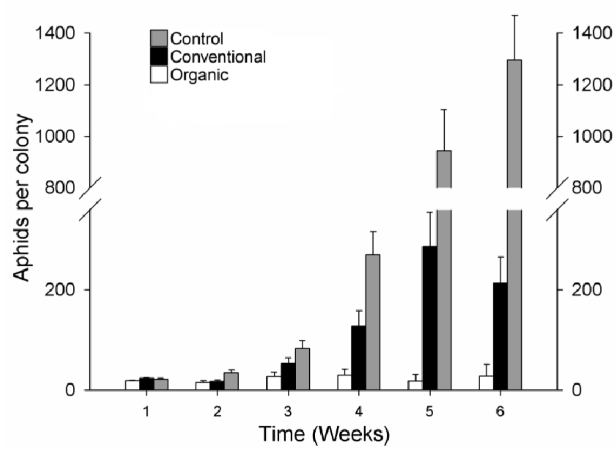

Fig. 1. Mean (± SE) number of RAA adults and nymphs per colony and week in organic and conventional orchards and control colonies.

Recent literature has shown ant-aphid mutualism to be a determinant factor on the reduction of natural enemy presence in apple aphid colonies. Following the advice of a specialist in this relationship, and in order to assess the natural enemy presence regardless of the ant population, we suppressed aphid-ant attendance in all the potted trees by installing an ant feeder per tree. The ant feeder consisted in a plastic bottle introduced in an upright position inside a plastic cup and baited with 20% sucrose solution. All ant feeders were placed before the infestation process.

RAA colonies were monitored weekly recording the total number of aphids and in each sampling occasion, naturally occurring predatory arthropods associated to the RAA colonies were assessed visually in and around the colony. Colonies were monitored for six consecutive weeks.

Results: No differences in initial colony size were observed between control, conventional and organic treatments when the clipcages were removed to initiate the experiment (GLMM, *P* = 0.683, Fig. 1), indicating no discernible effect of the confined control microclimate on aphid reproduction. Control colonies presented a sustained growth until the end of the experiment (Fig. 1). None of them disappeared completely during this period (Fig. 2a). Colonies exposed to NEs decreased in number very quickly and the size of the surviving colonies remained much lower than that of the control colonies (Figs. 1 and 2).

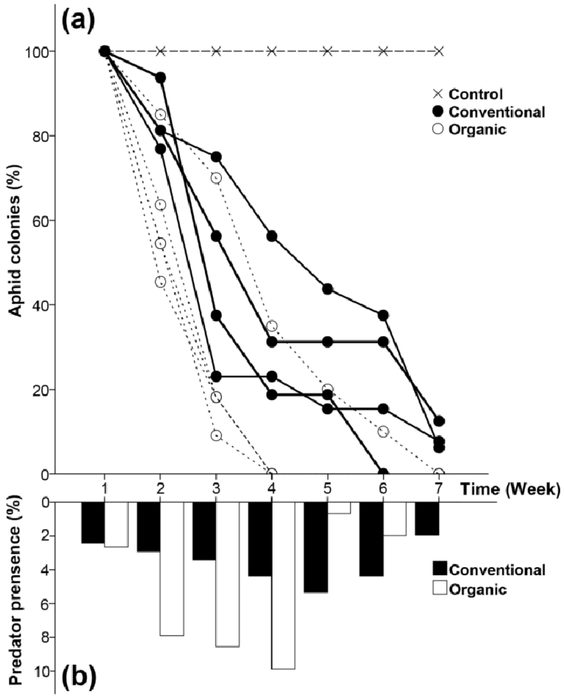

Fig. 2. (a) Active RAA sentinel colonies in percentage of total colonies established at the beginning of the experiment in conventional and organic apple orchards. (b) Percentage of RAA sentinel colonies in which one or more NEs were present in organic and conventional apple orchards.

Colony suppression differed significantly between management systems (Frailty model, Hazar Ratio = 2.4, *P* = 0.002) with higher colony survival in conventional orchards (Fig. 2). Landscape complexity (simple – complex) was borderline significant (Frailty model, HR = 0.6, *P* = 0.066), indicating a trend towards higher survival in simple landscapes. The amount of colonies with NEs presence was higher in organic orchards until most of the colonies disappeared (Frailty model, *P* = 0.032, Fig. 2b). The most recorded NEs were *Anthocoris nemorum* (45.7 % of observations), nymphs of the common European earwig, *F. auricularia* (12.2%) and larvae of the predatory midge *Aphidoletes aphidimyza* (16.7 %). Predatory mirids accounted for 9.2 % and lacewing larvae for 5.3 %. Cantharid beetles and ladybirds were also observed. *A. aphidimyza* and syrphid fly larvae were more frequently observed in late, well-developed colonies unlike the rest of the predators that appeared earlier in the colony development. No parasitoid mummies were observed in the sentinel colonies.

Mussel scale (*Lepidosaphes ulmi*)

Experimental sites 2014: A mussel scale survey was carried out in 18 orchards, 6 conventional and 12 organic (6 unsprayed and 6 using sulfur for disease control). The potted tree experiment in 2014 was carried out in a total of 13 apple orchards. Six of the orchards were conventional and 7 organic. As in 2013, no insecticides approved in organic management were applied against aphids and/or scales. Orchards with different management schemes were situated in both simple and complex landscapes in terms of heterogeneity and natural habitat composition.

Experiment 1(2014): In each orchard, four 3-yr-old potted apple trees of the variety Aroma were deployed and maintained as described above for 2013. In April, more than 300 scale shells with overwintering eggs underneath were collected from known hot-spots in a single orchard. Scales were obtained from 1-year shoots from the previous season to make sure that scale shells were not old. The scales were selected and prepared for infestation under the microscope by cutting small sections of the shoots with just one scale each. During week 19, the potted trees were infested with the mussel scale. Shoot sections carrying a single scale each were attached to fresh shoots of the potted apple trees using wire. Three scales were established per tree (a total of 156 scales in 13 orchards). One of them was placed inside the control mesh bag. For the second one, a smaller mesh bags was arranged to protect early instars against NEs. This second protective mesh bag was removed in week 27 to expose the hatched scales to NEs. The third scale was attached to a shoot without protection. The shoots where scales were established were monitored weekly looking for small hatchlings. However, it was not possible to record the occurrence of the scales due to their microscopic size. Later on, bigger instars were observed already settled on the young shoots. This allowed no observation on their possible NEs as early instars. After the trees were returned from the field the 20th of November, all shoots used in the experiment were removed from the trees and taken to the laboratory to record the amount of scales that survived in each of the treatments (control *vs*. exposed). After assessment, scales from each shoot were kept separately in Petri dishes until October 2015 when they were checked for parasitism. The parasitic wasps collected were identified by a scale parasitoid taxonomy expert. In addition, the mussel scale population was surveyed in orchards under different management strategies. The presence of scales on the tree trunk was checked in 50 trees per orchard and on 20 new shoots per tree in a total of 30 trees per orchard.

Results: There was a clear difference between the number of scales that survived within the control bags and those exposed from the beginning of the experiment (Fig. 3a). However, the scale nymphs that were exposed later in the season (week 27) had the same survival rate as the control individuals indicating no predation after older instars settled. Overall, predation contributed to a 56.0 % reduction of the total potential population. Comparing management strategies, no differences were observed in number of scales per shoot between conventional (2.1 ± 0.4, mean ± SE) and organic orchards (1.8 ± 0.5) (GLMM, $P = 0.421$).

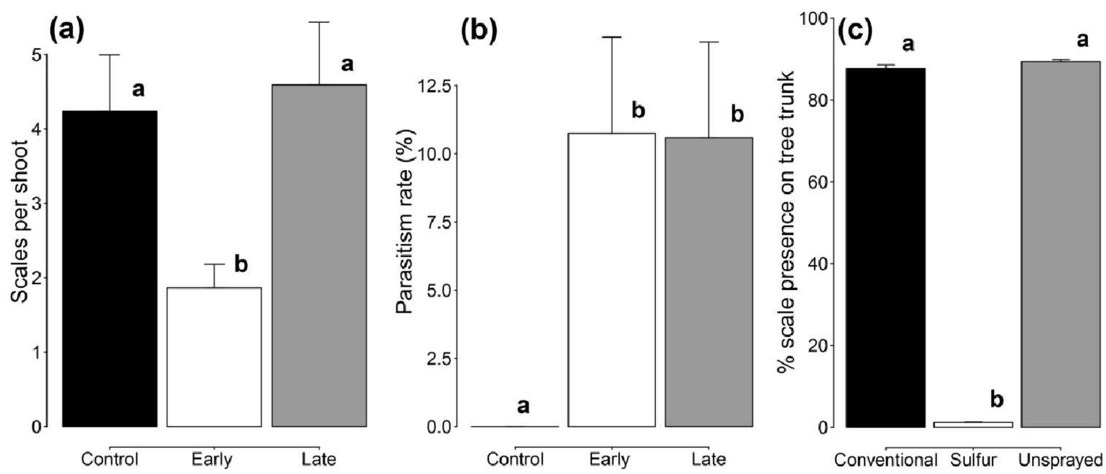

Fig. 3. (a) Mean (± SE) *L. ulmi* scales per shoot and (b) mean (± SE) percentage of parasitized *L. ulmi* in control exclusion, early exposure, and late exposure treatments. (c) Percentage (± SE) of tree trunks with *L. ulmi* presence . Different letters indicate statistically significantly different values (GLMM-Tukey test).

No difference in parasitism rate was observed between early and late exposure treatments (GLMM, $P = 0.406$) indicating that parasitism occurs mostly on settled nymphal instars (Fig. 3b). As observed for predation, no difference was obtained in parasitism rates between conventional (7.2 ± 2.1) and organic orchards (11.5 ± 5.6) (GLMM, $P = 0.327$). Three parasitoid species were collected: *Aphytis mytilaspidis* (Aphelinidae) (40.9%), *Zaomma lambinus* (36.7%) and *Epitetracnemus intersectus* (11.3%) (both Encyrtidae). There was no difference in mussel scale occurrence between unsprayed and conventional orchards while sulfur applications were found to contribute very significantly to reduce *L. ulmi* infestation levels (Fig. 3c).

Woolly apple aphid (*Erisoma lanigerum*)

Experiment 1(2014): Woolly apple aphid (WAA) colonies were established on the potted trees with a similar methodology as described for *L. ulmi*. However, establishment did not succeed for this pest. Biological control potential could not be measured in unmanaged organic orchards, as initially planned, because the pest was not present or the populations were extremely low. Tree canopy sampling (Experiment 2, page 6) revealed that in 2014 WAA incidence in conventional orchards (1.71 ± 0.28, mean individuals per sample ± SE) was much higher than in organic orchards (0.09 ± 0.03) (GAMM, $P < 0.001$) despite insecticide treatments. No WAA presence was detected in 2013.

Additional experiment (2015): During 2015 all 14 experimental sites were scouted for WAA. Observations made the previous year revealed that infestation levels appeared to be higher on pollenizer trees (apple varieties that produce high quantities of pollen used to increase apple pollination) present in conventional orchards. We tested the hypothesis of whether pollenizer trees, as a structural element in management options, could be more susceptible to the pest affecting infestation levels, pest distribution and biological control. In the two conventional orchards where the pest was present at its peak in July-August, a total of 8 plots with 140 trees each were sampled. Four plots had pollenizer trees and 4 relied on mixed varieties for pollination. The varieties Ingrid Marie and Aroma were present in the two plot categories considered. In each tree, 30 shoots were observed for presence or absence of the pest. In each colony detected, the amount of alive and parasitized WAAs was recorded as well as the presence of predators.

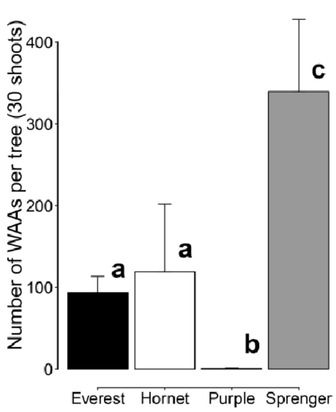

Fig. 4. Mean (± SE) number of WAA per tree (30 shoots per tree) in different pollenizer tree varieties. Different letters indicate statistically significantly different values (GLMM-Tukey test, P < 0.05).

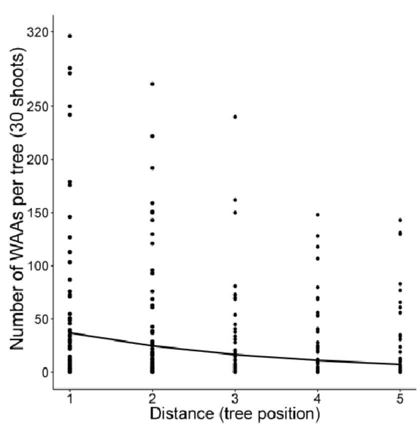

Fig. 5. Relationship between distance to pollenizer tree (tree position) and WAA infestation in commercial apple trees (GLMM, P < 0.001).

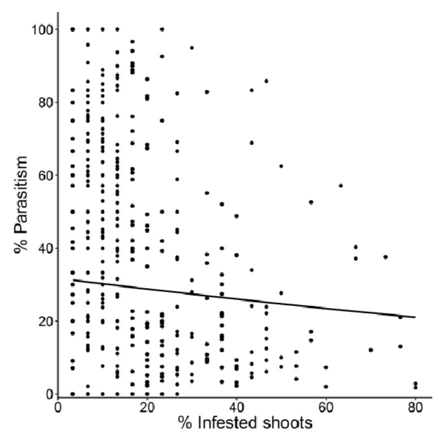

Fig. 6. Relationship between parasitism rate (% parasitized WAAs per tree) and tree infestation (% infested shoots) (GLMM, P < 0.001).

Results: The average infestation levels were considerably higher on pollenizer trees (182.6 ± 3.5, mean aphids per tree ± SE) compared to commercial apple trees (15.0 ± 1.3) (GLMM, *P*

< 0.001). WAA infestation levels varied between pollenizer tree varieties (Fig. 4) being *Malus* 'Professor Sprenger' the most susceptible variety. *Malus* 'Everest' and 'Golden Hornet' also showed high levels of susceptibility compared to commercial trees. The infestation of commercial apple trees in plots where pollenizer trees were present (25.7 ± 2.5) was much higher than in plots with no pollenizer trees (4.2 ± 0.5) (GLMM, $P < 0.001$). This result was consistent with the positive correlation observed between proximity to a pollenizer tree and infestation in commercial trees situated in plots with pollenizer trees (Fig. 5, GLMM, $P < 0.001$). Parasitism rates measured in both commercial and pollenizer trees were lower at higher levels of infestation (Fig. 6). It was common to observe small WAA colonies totally parasitized that were therefore inactive. *Aphelinus mali*, an introduced classical biological control agent in Sweden, was the only parasitoid species observed attacking WAA. A number of predators were observed feeding from WAA although their densities were very low with just 2.8% of the colonies with predator presence. Hoverfly larvae accounted for 39.4% of the individuals observed, *A. nemorum* for 30.4%, ladybirds (*Coccinella septempunctata*, *Adalia decempunctata*, *Propylea quatuordecimpunctata* and *Harmonia axyridis*) for 17.4% and the mirid *Heterotoma planicornis* for 8.7%. Hoverflies and ladybirds were observed in heavily infested plots while predatory heteroptera (*A. nemorum* and *H. planicornis*) were present in plots without pollenizer trees as well. *Chrysoperla carnea* s.l. and *Hemerobius humilis* larvae were observed on pollenizer trees in 2014 but not during the additional experiment carried out in 2015.

Natural enemies

Experimental sites 2014-2015: The experiment was conducted in all the experimental sites described previously for experiments involving potted trees plus an additional site each year where potted trees were not allowed. A total of 10 sites were sampled in 2013 and 14 sites in 2014.

Experiment 2: The NEs present on the tree canopy were sampled using an insect aspirator InsectaZooka (Bioquip Products, USA). In each orchard, 15 suction samples in 2013 and 10 in 2014 were collected with a minimum separation of 10 m between them. Each suction sample consisted in 2 minutes aspiration covering inner and outer branches up to a height of 2 m of up to 5 apple trees depending on the tree sizes. Suction samples were collected on a weekly basis for 16 (2013) and 18 (2014) consecutive weeks starting before bloom and until the end of August adding up a total of 4,920 samples. Samples were processed sorting the insects from the vegetal debris and classifying and counting the NEs captured. All NEs were identified to the highest taxonomic level possible, e.i. species or genus, except for spiders and parasitoids that were identified to family level. Difficult specimens were sent to Lund University for identification by specialists. The presence of flowers was established every week using a 2 m^2 quadrat placed in 5 different spots per orchard. Landscape complexity was quantified based on land use data obtained from the Integrated Administrative and Control System database, IACS, and the Swedish Land cover Data, SMD. A landscape complexity index was computed as the proportion of non-crop habitat surrounding the sampling plot. Orchards were divided into complex vs. simple landscapes.

Results: A total of 18,960 predators of aphids and scales (including spiders) and 32,580 parasitoids were collected during 2013 and 2014. Out of the total predators, 7,681 individuals belonged to taxomomic groups that were observed to be predators of RAA and WAA. The use of synthetic pesticides in conventional orchards had a marked effect on most of these groups compared to their populations in organic orchards (Fig. 7). The most affected groups were predaroty heteroptera, Anthocoridae and Miridae. Ladybirds and Cantharidae beetles were also affected. However, pesticide spray did not appear to impact earwig populations (Forficulidae). Syrphid flies and lacewing larvae (Chysopidae) did not vary between management systems either (Fig. 7). The presence of some predators was also enhanced in orchards surrounded by complex landscapes with high percentage of seminatural habitats, i.e.

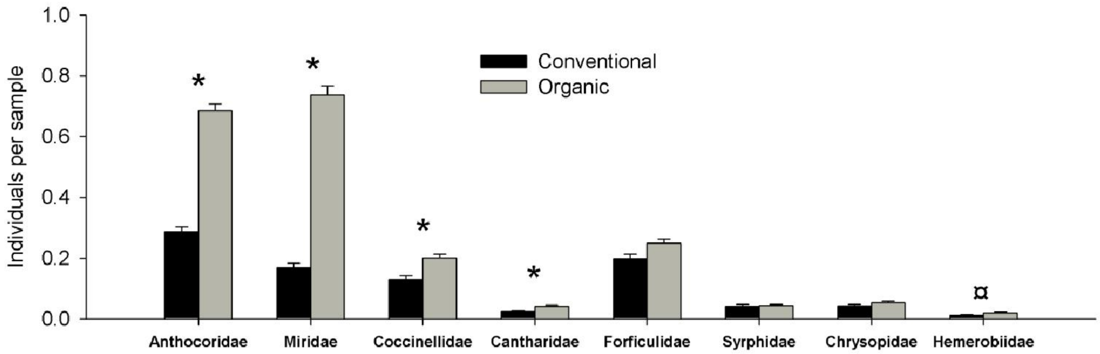

Fig. 7. Mean (± SE) aphid predators per sample in conventional and organic orchards. Symbols indicates statistically significantly different values (GAMM, * $P < 0.05$, ¤ $P < 0.10$).

ladybirds and the species *A. nemorum* (GAMM, $P = 0.006$ and $P = 0.004$ respectively). The total amount of parasitoids collected was not affected by synthetic pesticides spray in conventional orchards (7.1 ± 0.2, mean individuals per sample ±SE) compared to organic (6.3 ± 0.2) (GAMM, $P = 0.552$). Concerning taxonomic families to which WAA and mussel scale parasitoids belong, Encyrtidae presence was not affected by synthetic pesticides (GAMM, $P = 0.432$). In addition, more Aphelinidae were present in conventional management (GAMM, $P = 0.013$) probably due to the presence of WAA's parasitoid, *A. mali*, associated to high WAA populations in some conventional orchards.

The possible effect on NE populations of sulfur (Kumulus® DF) as a disease control method in organic growing was assessed by comparing sulfur-sprayed organic orchards with unsprayed orchards. The regular spray of this compound did not have an observable impact on predators (Fig. 8). Only ladybirds seemed to be affected negatively while the rest of aphid predator groups had a high variation in both sprayed and unsprayed orchards that resulted in no significant differences (Fig. 8).

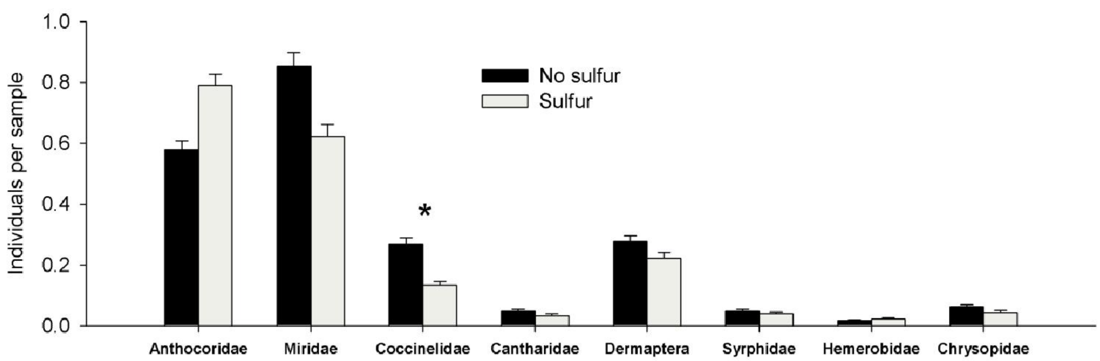

Fig. 8. Mean (± SE) aphid predators per sample in sulfur-sprayed and unsprayed organic orchards. * indicates statistically significantly different values (GAMM, $P < 0.05$).

The mean amount of parasitic wasps per sample was significantly lower in sulfur-sprayed orchards (5.2 ± 0.2) compared to unsprayed orchards (7.3 ± 0.3) (GAMM, $P < 0.001$)

indicating a possible effect of the compound on this group of natural enemies. However, this drop in parasitic wasps could also be related to a decrease in certain host species as observed for the mussel scale under sulfur treatments. There was no effect of sulfur on Encyrtidae (GAMM, P = 0.471) while the Aphelinidae population was higher in unsprayed orchards (GAMM, $P < 0.001$). The impact of natural insecticides approved in organic management, such as Raptol®, could not be evaluated due to the lack of their use during the period of the study.

The effect of tree understorey management was assessed for earwigs, predators that hibernate as adults in underground nests. Earwig populations were compared between orchards using soil tillage and orchards with no soil disturbance. Conventional orchards were included in the analysis as no effect of synthetic pesticide use was observed on earwigs. No evidence was found that the current understorey tillage practices in organic orchards have an effect on earwig populations (GAMM, P = 0.711). Earwig abundances were very similar in orchards with tilled understoreys (0.22 ± 0.02 earwigs per sample ± SE) and orchards with undisturbed soils (0.23 ± 0.01).

The impact of flower presence between apple tree rows on NEs was explored for predator groups that are known to be attracted to pollen and nectar sources, i.e. lacewing adults, Anthocoridae and ladybirds. It was not possible to do it for hoverflies due to the low number of adult individuals collected. Ladybirds and lacewing adults peaked clearly during apple bloom, probably attracted to high quantities of pollen, so the effect of flowers density was assessed from petalfall until the end of RAA and WAA presence in 2014 (weeks 22-29). Ladybird abundance did not correlate with flower density (GLMM, P = 0.068). However, lacewing adults were present in higher numbers in orchards with higher flower densities (GLMM, P = 0.023, Fig. 9). Anthocoridae (*Orius* sp. and *Anthocoris* sp.) responded also positively to the presence of flowers (GLMM, P = 0.022, Fig. 10).

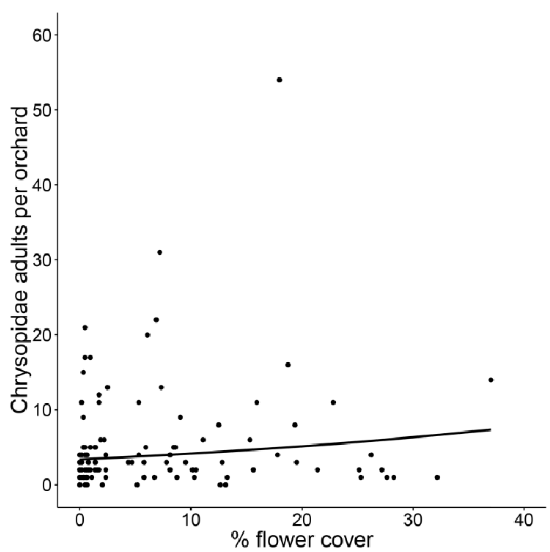

Fig. 9. Relationship between % flower cover between tree lines and Chrysopidae adult abundance in conventional and organic apple orchards in weeks 22-29 (2014).

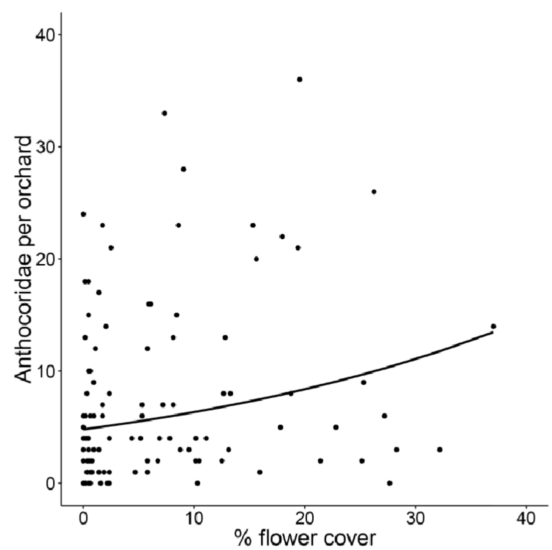

Fig. 10. Relationship between % flower cover between tree lines and Anthocoridae adult and nymph abundance in conventional and organic apple orchards in weeks 22-29 (2014).

Objective status/discussion

1. To establish the role of natural enemies in the suppression of WAA, mussel scale and the RAA in Swedish apple orchards. This objective was fulfilled for the RAA and the mussel scale. According to the results, predators play a very significant role for the suppression of small RAA colonies and therefore prevent the colonies from reaching sizes that cause commercial damage. Predatory bugs, and in particular *Anthocoris nemorum*, were observed to be relevant for early predation in Swedish orchards. However, the role of ant-aphid mutualism on biological control was not taken into account in our 2013 experiment and its importance cannot be discarded. Biocontrol halved mussel scale population development mainly due to predation. Parasitism reduced the population by around 10%.

2. To assess the impact of different orchard management practices on the presence of natural enemies and on their regulatory effect on RAA, WAA and the mussel scale. The impact was assessed for pesticide spray, sulfur spray, understorey tillage, orchard cover management (flower presence) and use of pollinizer trees. Pesticide spray affected important predator groups translating into a drop of RAA biological control. The lack of effect of the current pesticide usage on parasitoids and earwigs (described as relevant mussel scale predators) is probably the reason why no differences in biocontrol were observed between management systems for this pest. Concerning WAA, it was present in significant numbers almost exclusively in conventional orchards supporting strongly that in Swedish conditions it could be an induced pest. The composition of the predators present in small WAA colonies, mainly predatory bugs, suggests that early predation could be hampered in orchards with recurrent pesticide use. In addition, the use of pollenizer trees as management strategy was shown to act as a source of WAA infestation for commercial trees and limit *A. mali* capacity to parasitize the pest. Sulfur spray and understorey soil tillage, practices common in organic orchards that were initially regarded as potentially disturbing of natural enemies, did not have a relevant impact, at least on the potential control of the pests considered. Surrounding seminatural habitats and flower presence within orchards correlated positively with some important predators as Anthocoridae. This indicates that Anthocoridae populations and biological control of the RAA, and probably the WAA, can be increased by reducing or substituting pesticides, using flower strips and having insect reservoir habitats around orchards. Predatory Miridae presence would benefit considerably from reductions in pesticide use. Both groups are quite resident and can be promoted through management options. Our results indicate that very little can be achieved from a management perspective to increase biocontrol of the mussel scale. However, sulfur is extremely efficient at controlling the pest.

3. To carry out an inventory of natural enemies, generalist predators and parasitoid complexes, present in Swedish apple orchards with the potential to impact populations of aphids and scales. This objective was carried out through observation in RAA and WAA colonies and collection of parasitoids (for all pests) and completed for predators with insects collected in Experiment 2 that included rarer species. Insect collection and identification allowed establishing the cycle of most predators in apple orchards (information not presented). Direct observation of mussel scale predators could not be carried out.

4. To elaborate a dossier aiming at identifying compounds compatible with the key natural enemies established by the study for legal registration in Sweden. The dossier is currently under preparation focusing on predatory bugs (Anthocoridae and Miridae) and ladybirds.

Publications

Porcel, M., Gkounti, V., Tasin, M., Susceptible pollenizer trees increase the establishment and determine the spatial distribution of the woolly apple aphid, *Erosima lanigerum* (Hausmann), in apple orchards. (In preparation).

Porcel, M., Andersson, G., E. Mühlhäuser, Tasin, M., The effect of management on biological control of the mussel scale (*Lepidosaphes ulmi* L.) in apple orchards. (Manuscript).

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Pålsson, J., Tasin,M., Rämert, B., Porcel, M., 2016. Effect of agricultural management on rosy apple aphid biocontrol in Swedish apple orchards. **IOBC wprs Bulletin** 112**,** 49-51.

Porcel, M., Pålsson, J., Andersson, G., Tasin,M., Rämert, B., 2016. Influence of agricultural management on canopy-dwelling predatory and herbivorous arthropod communities in Swedish apple orchards. **IOBC wprs Bulletin** 112**,** 79-82.

Communication with the sector

Results from the project were presented and discussed at the following meetings:

- Ekofruktodling: Studiebesök från Danmark (2013.08.09, Alnarp, organized by the Swedish Board of Agriculture)
- Inbjudan till vandring i äppelodlingarna (2013.09.22, Mandelmanns Trädgårdar, Rörum, organized by Lund U, Georg Andersson)
- Temadag om biologisk bekämpning (2013.11.04, Alnarp, organized by SLU and the Swedish Board of Agriculture)
- Pest management course (2013.12.18, Höör, organized by the Swedish Board of Agriculture)
- Participatory research group meeting (2014.01.31, Kivik, organized by SLU, Weronika Swiergiel)
- Annual Meeting of LRF Trädgård (2014.04.04, Åkarp)
- IOBC (International organization for biological control) meeting: "Integrated Protection of Fruit Crops", Vienna (Turkey) (2014.10.6-9).
- IPM days (2014.11.4-5, Örebro, organized by the Swedish Board of Agriculture)
- IPM days (2014.12.18, Kristianstad, organized by the Swedish Board of Agriculture)
- IPM days (2015.03.19, Hallsberg, organized by the Swedish Board of Agriculture)
- Framtidens ekologiska produktion av äpple i Norden (2015.04.21, Alnarp, organized by EPOK-SLU)
- Att gynna och följa upp naturliga fiender i äppelodling. Workshop part of Ecoorchard CORE organic plus project (2016.02.25, Alnarp, organized by SLU).

Literature cited

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