## Pest Discussion: Aphids 2013

Aphids are a fascinating insect. Many, including our well known Green Peach Aphid, have two, three, or more, completely unique life cycles. The black flying aphids that move into your greenhouse may be the same ones that are all green, without wings, surrounded by 10 "babies" a month later. The phylloxera-like insect eating your plant roots may also be the same aphid. The more I get to know about aphids, the more I am amazed. Managing aphids will always be a challenge. Don't even think about eliminating aphids. They are so diverse and adaptable that even if you did eliminate them, it would probably lead to the end of life on this planet.

Fortunately for us, everything that eats insects loves aphids. They are sweet. They are dense. They seldom defend themselves. They are the living example of "the best defense is a good offense". Their strategy is simple; just reproduce as fast as you can and you will hopefully survive.

This pre-amble explains to some extent what you see in your crops. When a Green Peach Aphid flies into your crop, it lays its eggs in its favourite plant. The flying stage is "diploid", like humans, some are male and some are female. This allows for sexual reproduction which is the fastest way to select for the appropriate characteristics, such as temperature range, host suitability, and chemical resistance. Once they have mated and reproduced, they shift to "haploid" stage which is asexual. At this stage, they are all female and the ten little babies surrounding this wingless adult are actually clones, all perfectly adapted to your crop and chemicals. In the haploid stage, the Green Peach Aphid can complete its lifecycle in about a day. If you had a good scalpel and a steady hand, you could dissect one of those "little babies" and find another 10 of them in their abdomen. This explains why you suddenly discover a plague. Over one weekend, in ideal circumstances (your protected greenhouse is ideal), 1 aphid can become 10,000 or even 100,000 by the time you take a walk on Monday morning.

Before we go any further, I mentioned that they seldom defend themselves. Instead, they produce honeydew; such a delicious, sweet excrement other insects, namely ants, make caring, nurturing and defending aphids their lifes' work. Ants "farm" aphids. While man was struggling to get out of his hunting and gathering rut, ants had already figured out agriculture. Ants guard their flock. Ants remove predators and parasitoids. When predators or parasites become overwhelming, they pick up the prettiest aphids and move them to a safe place. If you are going to make a dent on the aphids, you are going to have to get through the ants first. You are going to have to kill the ants. Most of the species of ants that we work against have a "hive" system of governance. If you can kill the Queen, the hive disperses. Most of the ant strategies involve tricking the worker ants into taking a toxic snack back to the Queen and hopefully killing her. I will let you figure out how you can get rid of the ants. Maybe in the future, we may be able to rear and sell Ant-eaters but, it is a bit of a stretch for an insectary.

Our aphid strategy, you will see, is completely different from our competitors'. In some cases it is almost exactly the opposite. The difference is that we do not refrigerate any of our products. About 18

years ago while we were trying to figure out why our *Aphidoletes* were working exceptionally well at a greenhouse in the Westland of Holland, and a competitor's was not, researchers such as Guy Boivin in Quebec were studying the effects of cold storage on the searching abilities of parasitoids. Cold storage, specifically temperatures below 8 C, even just for a few hours, completely eliminate a wasp's ability to search. *Aphidoletes* was first commercialized by Applied Bio-Nomics Ltd. with the help of Linda Gilkeson, a post doctorate. Linda published a few papers and the industry decided to start producing *Aphidoletes* (Aa) based on the fact that it eats virtually all known aphids and it can easily be stored for extended periods without affecting emergence. Storage does affect egg laying, showing a linear decline in eggs laid vs. storage time and, unknown at that time, cold storage affected searching abilities as well.

The performance of "fresh" Aa was astounding. Our distributor in Holland was very careful to monitor the searching radius of the "fresh" Aa and we all were surprised when it became obvious that Aa had a much larger effective searching radius than any of the parasitoids. This research suggested that Aa was capable of "prevention" as long as surplus Aa were being released on a regular basis. In BC, later the same year, we approached a small pepper grower and asked if we could try out this "prevention" idea. The trial was a complete success. Of special interest in our searches was the search for solitary aphids on a leaf. In every case, we found an Aa egg associated with these single aphids. This showed us that Aa was capable of finding single aphids, a critical ability for true prevention. In the following year, we went down to Oregon and did some trials in propagation areas where aphids, because of their virus vector capabilities, were a significant threat, causing crop losses. The trials worked so well that at the end of the trial, more than one customer said, "I can't tell you how well they worked, because we don't have any aphids anymore".

## Indoor-protected crop

With this knowledge we fully developed our Aphid Prevention System, which was basically releasing Aa weekly, or even bi-weekly, using a "surplus strategy". The surplus idea is that you have to release more Aa than the number of aphids present will be able to support. Assuming that each Aa can kill 100 aphids, this would mean that if you had a million aphids in a protected location, you would have to apply 10,000 Aa to kill them all in one sitting. So, you can see how important it is to start clean. We have started 1 hectare Pepper houses with 1 release point of 1,000 Aa weekly and have demonstrated that, provided they don't find what they are looking for in the near vicinity, they will find aphids at the far corners of the house. The real challenge with this system is staying ahead of the aphids. That same 1 hectare pepper house would increase the number of release points to 3 (3 X 1,000) when any aphid is seen, to a 3 X 3,000 release when any colony is seen, to 3 X 5,000 release when full venting and the normal aphid season is on, all the way up to 3 X 10,000 if it is a particularly bad year for aphids.

It is always better to release too many than too few. First, it increases our sales, and second, if an Aa can't find a logical place to lay its eggs because there are already Aa eggs or larvae present, they will just keep expanding their search, even going outdoors into your surrounding environment. When they do this, they will find enough aphid density to be able to feed into a successful diapause, successfully over-winter, and re-emerge in the spring when they can continue to expand into your defensive circumference or even move back into your protected environments. We have seen this work amazingly well at Butchart Gardens, just down the road from us. They started with our Aa about the first day that

we were producing it, but only in their propagation areas. Over the years, they found that the entire garden was being populated by the "extra" Aa that were leaving the glass houses and moving into the entire garden. Now, when aphids erupt in the garden, Aa is quick to follow, cleaning up before additional efforts need to be made.

This is another reason why we use Aa as our main control. *Aphidius* species**,** like all parasitoid wasps, always prefer their native host or, in the case of mass rearing, their adapted host. We rear our *Aphidius matricariae* on the Green Peach Aphid. We use the Green Peach Aphid because that is the most common pest throughout our customer base and because it is a relatively large aphid. Researchers are now fairly well agreed that size does count. In numerous genera of wasps they are finding that the bigger the wasp, the more eggs and therefore greater efficacy. We prefer *A. matricariae* because it has the lowest effective temperature range of the current selection of mass produced aphid parasitoids. Customers in the ornamental industry need the "prevention" our fresh products can give, but also require performance at a lower temperature range.

In many cases, we don't just rely on Aa for our aphid strategy. In the pepper house example, when dealing with the Green Peach Aphid, instead of going beyond a 3 X 3,000 release, we would also release *Aphidius matricariae* into the hot spots, to create a "banking" system.

The rule with Green Peach Aphid management is that it is easy as long as you overreact at the beginning. Starting a "prevention" program will work perfectly as long as you stay preventative and you haven't applied a chemical that will affect the Aa. The bad news is that Aa is our most sensitive biological control to chemical residues. You will notice in all of my recommendations and discussions that I do not talk much about IPM. This is because I know it doesn't work, at least in the way it is currently being employed. Our approach is that with these fresh products, you will not have to resort to a chemical intervention. But even if you do decide on a later chemical intervention, the prolonged absence of the chemical challenge will only benefit its effectiveness.

In 2012 Don Elliott developed a prototype for a flying aphid trap. We have been experimenting with it for the past 9 months and are convinced that it has the ability to significantly reduce the aphid pressure dynamics in any crop. In our situation, we are only dealing with the Green Peach Aphid, but there is no reason to not believe that this trap, shown below, will not attract the winged version of most aphid species.

The trap is simply a modified “bug zapper”. We remove the bottom plate and duct tape a “duct booster fan”, blowing down, to the bottom of it. The wiring in the bottom of the “zapper” is tapped into for the “duct fan”. We then use an elastic band to hold a “paint straining bag” onto the discharge end.

The Green Peach Aphid is not the only aphid that we have to deal with in a protected crop, however. There are many other aphids associated with specific crops which I discuss in the “Crop Recommendations”.

There are a few types of aphids that are rapidly expanding their host range and can cause significant economic damage.

## Foxglove

I first saw the Foxglove Aphid in the Netherlands, almost 20 years ago. It was devastating an Anthurium crop. The customer was one of ours, but at that time, they used biological control only in their propagation area. Once the plants went into pots and onto the floor, they used the old chemical prevention method of sending a boom across every Friday afternoon. When they noticed the aphid, and the damage, they increased the chemicals, but it got to a point where the chemicals were causing similar damage and, the aphids weren’t being killed.

Our response was to throw everything that we could find at it. Aa, every commercial species of *Aphidius*, Green Lacewings, *Aphytis,* and Ladybugs. Nothing worked at first, but then, as the chemical residues faded, Aa showed up as the only effective control. This was because the Foxglove Aphid had evolved a "defensive" technique that foiled the slow and clumsy predators like the Lacewing and the beetle, as well as the *Aphidius* species. It could scoot out of the way or just fall right off the leaf to avoid interaction. Only the stealth-like Aa larvae could subtly sneak up without triggering the defensive reaction.

The following year I was visiting a nursery in Alberta and on their "Coral Bells" calibrachoa we found the mangled foliage characteristic of the Foxglove Aphid. The aphids on the calibrachoa had the same reaction to what became known as the "finger test". Because the Foxglove Aphid can look quite similar to the Green Peach Aphid, they can be quite difficult to identify if the foliage hasn't had time to show you what aphid you had. The "finger test" came from our experiences in Holland. If you slowly move a pointed finger towards a Green Peach Aphid, you will end up slowly squishing it. With the Foxglove Aphid, your finger will get about 3 inches away and then the aphid will scurry away from your finger.

When I got back to my office, Carol from IPM Labs had called and left a message about a new damaging aphid that she just saw at a nursery on "Coral Bells". North America had discovered the Foxglove Aphid.

In the next year we found it in a commercial Pepper house in BC. An acre was infested and the damage was about to become significant. We inundated the acre with 10,000 Aa and within 3 weeks the entire invasion was quelled. The cost of the 10,000 Aa was significantly lower than the cost of the lost production which results in leaders being split.

Since then, the Foxglove Aphid has been moving into new crops and, even more importantly, into new seasons and temperature ranges. Over the years, the Foxglove Aphid has shifted from a late spring pest to an early spring pest and, in some crops and situations, even a late winter pest. This is a significant change, as Aa, our main Foxglove Aphid control, is very temperature sensitive and only really works fast in late Spring conditions. The good news was that we knew that the trigger for over-wintering diapause in Aa is during the predatory maggot stage, so our original strategy was to just keep putting Aa in the house and the Foxglove Aphid will be consumed. In a cage this strategy works well but, in a real nursery, we have found that Aa prefer the Green Peach Aphid, probably because it produces more honeydew than the Foxglove Aphid and also because the Green Peach Aphid is so easy to catch. But in the cool nurseries, the Aa was having a hard time keeping up with both the Green Peach Aphid and the Foxglove Aphid, so damage from the Foxglove Aphid continued to be a serious problem.

A few years ago we got aggressive with Aa, knowing that we had to improve cool season performance. We started adding LED Christmas lights (the white ones) into cool nurseries and the performance of the Aa increased significantly to a point where we were able to eliminate the Green Peach Aphid during the Winter and force the Aa onto the Foxglove Aphid colonies. Albert Grimm, in Ontario, went one step further and invested in a few expensive high intensity LED lamps in the green colour range so as not to have a dormancy effect on his plants. His results were successful and he improved Foxglove Aphid control.

In Canada, in 2007, Dave Gillespie found a Brown Lacewing in Pepper crops associated with Foxglove Aphid presence. We started to produce Brown Lacewing the following year and found that it had a wide host range with an even larger temperature range. The Brown Lacewing species we have is *Micromus variegatus*. In literature, it is said to complete its' lifecycle in temperatures as low as 4 C. For the last few years we have been releasing them during the winter for Foxglove Aphid control.

Our competitors are still recommending expensive *Aphidius* species based on trials that were conducted in cages. In a cage, where the *Aphidius* are forced to remain, they will have to make do with the Foxglove Aphid, attempting to parasitize them. What we have seen in the cages is actually harassment. If the Foxglove Aphids are bothered enough, and forced to continually make defensive maneuvers, they will eventually give up and collapse from exhaustion. We see a similar situation in our rearing system for *Aphidius.* If we put too many wasps in, they disturb the aphids to a point where the aphids just give up. Unfortunately, this strategy is far too expensive to employ in a real situation. Even if there were *Aphidius* species that worked (Dave Gillespie found 3 parasites), the fact that damage occurs as soon as they arrive removes the option of using *Aphidius*. *Aphidius* relies on parasitism, delaying its effectiveness to a point where economic damage has already occurred.

The harassment issue however is quite interesting. We have been experimenting with gentle ribbons or strings hanging down from the spray booms. We have sometimes seen significant reductions in Foxglove Aphid damage by passing the boom over the crop, just barely touching the crop, once per hour. I think there is some great potential with this physical method for Foxglove Aphid control.

Our strategy for the Foxglove Aphid is:

- Make sure the Green Peach Aphid is controlled.
- Use the "flying aphid trap" or something similar.
- Introduce Aa weekly using the preventative method.
- Add some supplemental lighting, especially in the "dusk" period. The light level does not need to be very high. Walkway lights will work. LED Christmas "strings" at 1 string per bay will work. Even adjacent street lights have been good enough. You want 16 hours of light.
- If you are in Canada or Europe, release 0.1 *Micromus variegatus* bi-weekly or monthly.
- If you have a boom system, try the "ribbon" harassment strategy. You can start with the ribbons not even touching the crop.

## Melon Aphid

The Melon Aphid can be a very serious pest. Luckily, its host range is quite limited, and cucumbers are the most common susceptible host.

This aphid is dangerous because of its extremely rapid growth rate. It is so fast that commercially acceptable control is usually just chemical.

But this aphid can easily be controlled using biological controls. Although the density of aphids increasing rapidly, Melon Aphid is not a significant virus vector and does not tend to affect the structural integrity of the plants that it targets.

Our approach with this aphid is to just roll it into our "prevention" system. If Melon Aphid does get started before Beneficials are used, you will basically have to double the rates that we recommend for Green Peach Aphids. It should be noted, because we are mostly talking about cucumbers, that if the predatory mite *swirskii* is being used in the crop, we do not recommend the use of Aa, and that means that we don't want to be involved in aphid control in any crop if *swirskii* is present. In a paper by Gerben Messelink, from Bleiswijk, Gerben showed that *swirskii* had a significant interference effect on Aa, preferring to eat the Aa eggs. So, cucumber growers will have to choose between *swirskii* for thrips and imidicloprid for aphids, or *cucumeris* for thrips and Aa for aphids.

### Potato Aphid

This aphid used to be the most damaging aphid, until the Foxglove Aphid arrived. It is a large, aggressive aphid but has a slower lifecycle than the Melon Aphid, so it can be easily controlled and managed by using Aa. Our normal "Green Peach" prevention system will work equally well against the Potato Aphid.

Parasitoids can also work well but nobody in the industry currently rears *Aphidius ervi* on Potato Aphid although it is the natural parasitoid of the Potato Aphid. This is problematic for two reasons. First, parasitoids always work best against their natural or adapted host. By utilizing the smaller "Wheat" aphid, the producers of *ervi* have "tied one of its hands behind its back". Smaller parasitoids mean fewer eggs, not to mention that these parasitoids are refrigerated and therefore unable to conduct effective searches. They are best used in a "Wheat" banking system, where the offspring are at least fresh.

### A Note on "Banker" Systems

Although the aphid "Banker" system, first demonstrated by Pierre Ramakers in the Westland, has been very popular and quite effective in some applications, we do not recommend them. This is because they are effectively false targets for our "prevention" system (attracting our Aa to them, rather than forcing the Aa to find every last aphid in the house). We have seen this interference affect our ability to prevent damage by the Foxglove Aphid in a few Pepper houses. The other problem with the aphid "banker" system is the inevitable breakdown and even negative results when hyper-parasites show up. If the grower is not actively inspecting these "banker" plants, hyper-parasites will take over and ultimately move out into the crop and "unzip" the *Aphidius* control that is established.

10 years ago, hyper-parasites were usually only a couple of species showing up in the summer. We now have at least 5 species of hyper-parasites around, at least in BC, and their presence can be detected as early as March, so now the "banker" system needs to be seriously considered before all of the expense of time and money is committed.

## Outdoor Aphids

When we leave the protected environments, things change considerably. Aphids outdoors have a completely different dynamic. For one reason; they are no longer protected. All of the native predators and parasites are now available and looking for soft, sweet, and dense aphid colonies. Another reason; the outdoor climate is usually much more variable and inconsistent, which delays the aphids from moving into the "haploid" stage, where their growth rate becomes exponential.

Outdoors, we are focussed on inoculation rather than "prevention". Our strategy, which usually works out to about 10,000 Aa per acre every 5 years, involves either inoculating known hot spots, creating a "banking" site or, in areas of prevailing dusk winds, releasing them on the windward side and letting the wind disperse the adults through the crop.

We have found that this technique works extremely well for an amazingly wide range of plants, including pecan orchards, hazelnut groves, cane berries, Christmas trees, bamboo, potatoes, field tomatoes and peppers, and even low growing crops such as strawberries.

Because the Aa can easily over-winter, the application usually lasts about 5 years before a supplemental application is needed again. As mentioned above, large nurseries that use Aa preventatively in their propagation frequently find that the surplus Aa leaving the protected crops are enough to manage the outdoor fields without having to resort to any outdoor applications.

While *Aphidius* species can work well outdoors, we seldom recommend using them for the following reasons:

- They are too expensive.
- Native ones show up anyway, once the sprays stop. This helps us determine when the chemical residues have cleared up to a point when effective Biological control can begin.
- They tend to be species specific.
- If they do establish at a high level in the outdoor crop, they can become a significant source of hyper-parasites in late spring, affecting your protected system.
- In ornamentals, they leave behind mummies which can affect the sales of the plant.

Once the chemical residues dissipate, the entire range of native aphid killers show up, attracted to the honey dew (ladybugs, lacewings, native *Aphidius* and other parasitoids, and even native Aa). One of my favourite "party tricks" is to take a bad plant, or plants, with aphids from a protected glasshouse and just put them outside for a week. When I call the grower a week later, the aphids are gone. Alas, my experience with "protected" crops is that, with arthropods, the protection is more for the pest than the beneficials.

So, the big thing for outdoor aphid management is: don't panic. Even if you are concerned about virus transmission, biological controls will give you better, and cheaper, aphid control than any chemical has done in the past 5 years.

## Our Aphid Biological Controls

Over the years, Applied has experimented with many aphid biological controls. Based on our experience we have selected the follwing products for effective and cost-effective control:

### *Aphidoletes Aphidimyza*

This midge was first characterized in Germany, where a researcher who was conducting experiments with *Aphidius* species found that his aphid culture was completely crashing. He saw a few of the

characteristic maggots of Aa, but he couldn't believe that so few could eliminate so many aphids, until he followed up with more experiments. Aa was as good as he thought. The rest is history.

Applied started rearing Aa about 27 years ago. Because we never could keep up with demand, and we weren't interested in global sales, we never did store our Aa using refrigeration, so we never accidently eliminated our Aa's searching ability or negatively affected their egg laying potential.

The benefits of Aa are;

- They work against almost every known aphid, including related genera such as the *Adelgids,* Whiteflies, leafhoppers (protected only), and *psyllids* (protected only). They appear to be attracted to any pest that produces honeydew, but will aggressively feed on nymphal and larval stages if contained or inundated (psyillids and Leafhoppers).
- The adults are excellent searchers (fresh only). We can easily use 1 release point per hectare to get complete coverage.
- They are amazing "killing machines". The larvae can kill up to 200 aphids per day, killing every aphid they find and feeding on the aphids when they are hungry.
- Their release strategy (fresh only) requires virtually no labor. We ask you to hold them in your office until they are fully emerged, which also gives you an easy quality test, then go to the same spot in the greenhouse, ideally a north facing panel, open the lid and walk away.
- They can be purchased in 250, 1000, 3000, 5000 and 10,000 sizes to maintain ease of application and build in volume pricing discounts.
- They completely clean the plant of any evidence of the aphids. The honey dew is cleaned up, so even the white exoskeletons of the aphids fall off.

The disadvantages of Aa are:

- They are extremely sensitive to chemical residue.
- They need 16 hours of light to prevent them from going into diapause.
- They prefer warmer temperatures (greater than 15 C).

### *Aphidius matricariae*

*Aphidius matricariae* was the first *Aphidius* species commercialized. It is primarily a Green Peach Aphid parasite and, because of that, has the lowest effective temperature range of any *Aphidius* commercially available. Our *A. matricariae* is reared on the main target species (Green Peach Aphid) and sold as adults. We do not refrigerate any products, which preserves their ability to effectively search. By harvesting the adults, our product is unique, allowing for the newly emerged adults to immediately feed, which is critical in allowing them to mate in a concentrated environment, improving mating efficiency, and allowing us to avoid hyper-parasite inclusion, another critical point.

Because of this special harvesting technique, this product is considerably more expensive, per wasp, than any of our competitors. But, just like in our other "fresh" parasitoids, our release rates and performance easily surpasses everyone else's cost per square meter, which is the bottom line.

When you switch to our product, you must order about 20% of what you would normally order elsewhere. If too many effective *Aphidius* are applied at an aphid site, harassment becomes an issue and cycling and the "banking" effect are disrupted. Parasitoids always work best when they can cycle and reduce, but not completely eliminate the pest.

The benefits of our *matricariae* are:

- Excellent low temperature performance (10 to 15 C).
- Hyper-parasite free.
- Pre-fed and mated.
- Reared on and conditioned to the Green Peach Aphid.
- They are never refrigerated, so full searching ability is preserved.


The negatives of all *Aphidius* species are;

- They tend to be species specific.
- Small wasps lay fewer eggs.
- They are not as good a searcher as “fresh” Aa.
- They are targets for hyper-parasites and are severely affected by them.
- They tend to be considerably more expensive than Aa for the same level of performance.
- They are not capable, under normal situations, of effective prevention.
- They do not clean up after themselves, leaving behind the empty, and quite obvious, mummies

### *Micromus variegatus*

This cosmopolitan Brown Lacewing was first collected and developed by Dave Gillespie, of Ag Canada. It was frequently found by Dave when he was conducting a survey for suitable Foxglove Aphid parasites in Fraser Valley Pepper houses.

In literature, this species is considered a European species, although specimens have been collected in North America in BC (2 separate locations and decades) and in Quebec.

It is a voracious predator. Unlike most Green Lacewings, the adult stage is also a predator. This not only improves predation rates, but also means that the adults can target aphid and other soft bodied insects directly, ensuring that the eggs they lay are situated near the targeted pest sites.

We rear *Micromus* primarily on aphids and whitefly, but we can feed them almost anything that moves. Their aggressive feeding quickly reduces the prey density, but their sense of preservation forces them to continually move throughout the site, looking for denser hot spots where their eggs will fare better.

That being said, their most important trait is their cold temperature performance. Literature shows that this lacewing can complete its lifecycle at 4 C. This temperature allows us to use *Micromus* during the winter in cold ornamental operations, supplementing our other products at that time. Trials in BC and Ontario are continuing, where our main concern is managing the Foxglove Aphid. So far, the results are encouraging. In greenhouses we have observed *Micromus* feeding on Citrus Mealybug in addition to all species of aphids and their relatives.

Robert McGregor of Douglas College has published a few papers on *Micromus variegatus* in Peppers. This year he is doing a research paper using them with Aa outdoors to control the Blueberry Aphid.

Scouting *Micromus* can be difficult because their main predators are birds and therefore they react to coarse movement and hide by playing dead and falling into the litter.