The QB

The North American Lily Society Quarterly Bulletin

Vol. 71, No. 2 | June 2017

Controlling Lily Leaf Beetle

An Integrated Pest Management Approach — Part 2

By Paul Siskind

This is the second part of a two-part article. Part I appeared in the March 2017 issue of the ***Quarterly Bulletin****.*

Introduction

In Part I of this article, I provided an overview of the natural history of the lily leaf beetle, and discussed how its life cycle makes controlling it challenging. I also introduced the practices of Integrated Pest Management, and suggested a practical IPM strategy that lily gardeners could use in their own gardens.

This part of the article discusses an experiment that I ran last summer (2016), which examined two aspects of IPM that relate to controlling the beetle:

- The effectiveness of three different "safe" insecticidal sprays; and
- The beetle's preference for feeding on different types of lilies.

Genesis of My Experiment

My interest in growing lilies began about seven years ago, when a friend sent me a martagon bulb as a gift. At the time, I didn't know much about lilies, and I had never heard of a martagon. I was intrigued by being able to buy and grow original species lilies. I dove head first into my new obsession, blundering my way through the challenges I didn't know I'd be facing.

The beetles started appearing two years after I started stocking my lily beds. Because I have a rather laissez-faire attitude about gardening, I made the mistake of thinking "I'll start dealing with them next year." Of course, this was a big mistake.

Paul Siskind has worked in a variety of fields. Along with his primary career as a composer and teacher, he has also been active as a consultant and advocate regarding harassment and discrimination in the workplace. He now is also working towards certification as a Master Naturalist. Paul is on the faculty of St. Lawrence University, Canton, N.Y. He lives in northern New York, about 20 miles south of the Ontario border. He grows his lilies in USDA Zone 4b.

After I began reading about the beetle, I realized my new hobby was at risk. I began experimenting with homemade "safe" ways to combat the beetle.

My first idea was to use makeshift traps to lure the beetle away from the beds, similar to those used for Japanese beetles.

Because it's thought that lily beetles find lilies primarily by scent,[1] I used mashed lily bulbs to see if I could lure the beetles away from my garden. That was a total failure.

BEETLE, next page ▶

1. Naomi Cappuccino; personal communication.

BEETLE, from the previous page

The lures didn't attract any beetles at all.

Because I live in a rural area overrun with deer, I generally have to spray my lilies with deer repellant. It's not surprising that being sprayed with deer repellant makes the beetles fall off the lilies. Because I didn't yet know much about the beetles, I assumed the deer repellant had killed them.

Hoping deer repellant might be an easy way to kill two birds with one stone, I began looking at the various types of chemicals found in deer repellants.

Many commercial deer repellants are simply a mixture of rotten eggs with extracts from plants that have a pungent odor and/or taste, such as garlic, cinnamon, cloves, thyme, hot peppers, peppermint, etc. Many of those plant extracts also repel insects and/or have insecticidal properties.

I raided my kitchen and mixed up various concoctions of spices, oils, soaps, etc. I spent the rest of that summer capturing beetles and larvae and torturing them by dropping these noxious homebrews on them. Even though many of them appeared to irritate the beetles and/or larvae, few actually killed them unless they were totally drenched with liquid.

However, some of them caused the larvae to shed their fecal shield, which would make them vulnerable to predation by other insects and birds. That has potential to be part of a strategy to control the beetle. The two spices that seemed to do this best were cloves and cayenne pepper.

Clove oil has been cited as a good natural insect repellant and insecticide because it is also environmentally friendly.[2] The principle active compound of clove oil is eugenol. Eugenol works by interrupting the transmission of nerve impulses, causing the insect's muscles to spasm.[3] It works on contact as well as through ingestion.

Clove oil also acts as a repellant to some types of beetles.[4] However, there's a paradoxical aspect to clove oil. Even though it repels some insects, it attracts others.[5] Thus, it's sometimes used in pest management as a lure away from desired plants, rather than as an insecticide.

In my zeal to test my clove homebrew in situ, I sprayed some on one lily. Not surprisingly, the beetles on the lily immediately dropped off, but because I couldn't find them on the dark soil I didn't know if they had been killed.

When I went out the next day to see if the spray kept beetles away from that particular plant, I saw the spray had already burned some of the leaves. In fact, the homebrew was so potent that the lily quickly browned out and went dormant. I thus learned an important lesson about the risks of experimenting with homebrews, and I decided that I would stick with commercial products in safe concentrations.

Two Effective Commercial Products

There are two commercial "natural" insecticides that are frequently mentioned on the Internet as being effective in controlling the beetles yet are "environmentally friendly." They are neem oil and spinosad. These are different types of chemicals and have different modes of action on the beetles or larvae.

BEETLE, next page ▶

2. https://entomology.ca.uky.edu/ef451
3. http://www.clemson.edu/extension/hgic/pests/pesticide/hgic2770.html
4 https://www.ncbi.nlm.nih.gov/pubmed/11701389
5. http://www.tandfonline.com/doi/abs/10.1080/096708797229040

BEETLE, from the previous page

The differences between neem and spinosad are usually reported in nontechnical ways, such as: "Neem kills larvae and repels adults. It is most effective early in the season and on young larvae. ... Late-season larvae seem to be somewhat resistant to neem."[6]

Another source reports that spinosad is "effective on larvae," but doesn't mention any effect on adults.[7] Because information found on the Internet is sometimes based on anecdotal evidence and/or is outdated, it's worth examining the differences between neem and spinosad in more technical detail.

Neem Oil

Neem is a tree (*Azadirachta indica*) native to India. Oil can be extracted from its seeds. This oil has been used in traditional Indian medical practices for two millennia[8] and is also used extensively in skincare products. Interest in natural healthcare has led to neem oil products becoming available worldwide.

Neem oil is very complex, and it contains a mixture of natural insecticides. The most potent of these is azadirachtin.[9] Azadirachtin disrupts an insect's hormones, and has two effects:

■ It disrupts their feeding behavior, which causes it to eventually die of starvation; and

AHIMSA ALTERNATIVE INC./ TJSHYDROPONICS.COM

Cold-pressed neem oil contains the chemical azadirachtin, which is effective in combatting beetles. However, hydrophobic extract neem oil does not have azadirachtin and is not effective. In Canada, lily growers may have to look among healthcare products because it is not approved as a pesticide.

■ It disrupts the metamorphosis of larvae.[10] Even though azadirachtin is an irritant on contact, its hormonal effect only occurs through ingestion.[11]

Even though various products are labeled as containing "neem oil," there is a difference between types of neem products. There are two ways of getting neem oil from the neem seed: by using alcohol to extract the oil and by a cold-pressing process.[12]

The critical difference is that the alcohol

BEETLE, next page ▶

6. https://www.researchgate.net/publication/280684286_Clove_Oil_as_a_Source_of_Attractant_Pheromones_to_the_fruit_flies_Ceratits_capitata_Wiedmann_and_Bactrocera_zonata_Saunders_Dipetra_Tephritidae
7. https://www.gardeners.com/how-to/lily-beetle/8090.html
8. https://negreenhouseupdate.info/updates/lily-leaf-beetle
9. https://en.wikipedia.org/wiki/Azadirachta_indica
10. https://npic.orst.edu/factsheets/neemgen.html
11. http://extoxnet.orst.edu/pips/azadirac.htm
12. http://www.gpnmag.com/article/explaining-azadirachtin-and-neem/

BEETLE, from the previous page

extraction process removes the azadirachtin from the oil. The remaining oil without the azadirachtin is properly called "clarified hydrophobic extract of neem oil," even though it's often just called "neem oil." The resulting oil mostly works like an insecticidal soap (i.e. suffocating an insect). However, insecticidal soaps are not effective in controlling lily leaf beetles or larvae.

The cold-pressing process doesn't remove the azadirachtin from the neem oil. Thus, if you want to shop for a "neem oil" product that works on lily leaf beetles, make sure that you buy the cold-pressed neem oil.

I've found that many insecticides that are advertised as containing "neem oil" contain the hydrophobic extract, not the cold-pressed oil. This is the case with many "rose sprays," because neem oil kills leaf fungus and mites even though the azadirachtin has been removed. I had to search to find commercial insecticides that contain the cold-pressed neem oil.

The situation in Canada is more confusing.

Neem oil had been available in Canada, as both a skincare product as well as an ingredient in gardening products.[13]

However, "neem oil" as an ingredient had never been approved for use as a pesticide in Canada, because no company had ever applied for approval of such a product.

In 2012, Health Canada began enforcing its regulations against pesticides that contain neem oil more strictly. As of June 2016, there were still no "neem oil" products that had been registered with the Pest Management Regulatory Agency for use as a pesticide.[14]

There is one "neem-based" pesticide product that has been approved by Health Canada's PMRA: TreeAzin. However, TreeAzin's label states that it contains a "5% solution of azadirachtin," and it specifically states that it "is *not* neem oil."[15] TreeAzin has been approved to combat tree-eating insects, primarily the emerald ash borer. It hasn't been approved for use against the lily leaf beetle. Furthermore, TreeAzin is not a spray. It's applied via systemic injection. In order to use TreeAzin, you must be a licensed pesticide applicator.

Even the regulations against neem oil in Canada are specifically against its use as a pesticide. It appears to be readily available as a healthcare product.

Spinosad

Whereas the properties of neem have been known for more than 2,000 years, spinosad wasn't discovered until 1985. Spinosad is a synthetic version of chemicals produced by a bacterium that was first discovered in an unused sugar factory in the Virgin Islands.[17] Unlike neem, spinosad affects insects on contact as well as by ingestion.[18]

Spinosad kills insects by disrupting the chemical that passes a nerve signal

BEETLE, next page ▶

13. http://www.gpnmag.com/article/explaining-azadirachtin-and-neem/
14. http://www.flowerscanadagrowers.com/news/neem-based-leaf-shine-products-no-longer-legal-for-use
15. http://www.cbc.ca/player/play/2690623262
16. http://www.bioforest.ca/index.cfm?MenuID=19&PageID=1049#q04
17. https://en.wikipedia.org/wiki/Spinosad
18. http://www.dowagro.com/turf/products/insecticides/conserve_additional.htm

BEETLE, from the previous page

from one nerve cell to the next. The result is that nervous system becomes overexcited so the insect can't control its muscle movements. However, it can take a day or two for the insect to die.[19] In some species, spinosad is more toxic to larvae, but in others it's more toxic to adults.[20]

Products containing spinosad are available in Canada and the U.S.[21]

Experimental Design, Methods

I live in northern New York, about 20 miles south of the Ontario border. It's on the edge of the St. Lawrence River Valley, near the foothills of the Adirondack Mountains. While we're listed as Zone 4b on the USDA map, we often dip below minus 25 degrees F, and occasionally down to minus 30 degrees F. The back of our property where I put my experimental plot is surrounded by pasture and woods.

The Lily Plots

My experimental plot was 25 feet long by 5 feet wide. It was divided into five 5- by x 5-foot plots. I put 4-foot tall fabric barriers between the sectors to prevent the insecticide sprays from blowing into the neighboring plots. I left the other edges open so the beetles could easily enter or leave the plots, move to a neighboring plot, etc.

The plots were fenced in to protect them from deer. However, I let weeds grow around the perimeter of the experimental plots, to simulate a garden with lilies growing among other plants nearby. Within the plots, I periodically pulled out most of the larger weeds but, because the beetles are so easily disturbed by nearby movements, I weeded the plots less thoroughly than a typical gardener would.

CHUCK ROBINSON

This experiment shows spinosad being effective in combatting lily leaf beetles throughout the season. It is available in Canada and the U.S.

Choice of Lilies

Various sources report that some types of lilies appear to be more "resistant" (i.e. less attractive) to the beetles/larvae than others:[22]

- There's general consensus that Asiatics are the most preferred type.
- Some Orientals appear to be less attractive than others (e.g. *Lilium auratum*)

BEETLE, next page ▶

19. https://en.wikipedia.org/wiki/Spinosad
20. http://npic.orst.edu/factsheets/spinosadgen.html
21. https://en.wikipedia.org/wiki/Spinosad
22 See: https://extension.umaine.edu/publications/2450e/
https://www.gardeners.com/how-to/lily-beetle/8090.html
http://lilybeetletracker.weebly.com/lily-beetle-control-share-your-solutions
http://gardening.wsu.edu/new-invasive-lily-leaf-beetle/

BEETLE, from the previous page

Lilium henryi (particularly 'Madame Butterfly'), *Lilium speciosum* and 'Black Beauty' seem less appealing.

■ *Lilium canadense* and other North American natives (e.g. *L. philadelphicum*) appear to be susceptible.

■ It's possible that martagons and trumpets (particularly 'Golden Joy') are less attractive than Asiatics.

Because this information is fragmentary and anecdotal, I decided to plant four types of lilies in each plot, hoping to collect some data about the beetle's preferences. I chose lilies based on my understanding of important genetic lineages, range of blooming times and commercial importance.

I chose these lilies:

■ The Asiatic 'Orange County,' chosen as a "generic" type of Asiatic;

■ The trumpet species *Lilium regale*, which I assume to be in the bloodline of many trumpet varieties and hybrids;

■ An Oriental x trumpet cross ('Conca d'Or'), because of the current popularity and commercial value of OT lilies; and

■ The Oriental 'Stargazer,' because of its historical popularity and commercial importance (and because it might have some *L. speciosum* and/or *L. auratum* in its bloodline).

I planted all of the bulbs in the fall 2015.

Choice of Insecticide Sprays

Having read about the effectiveness of neem oil and spinosad (but also about the possible differences in effectiveness against adults versus larvae), those were the most obvious choices. Because my initial interest was sparked by the seeming effectiveness of deer repellant, that was the third choice. For the deer repellant, I stuck with a type that contained clove oil along with putrescent eggs and cinnamon oil.

For the sprays, I purchased commercial home-use products. The concentrations of the active ingredients were:

■ **Clove oil:** approximately 0.14% by volume. Prepared from concentrated deer repellant.

This is the concentration of clove oil, as prepared. Neither the label nor the Material Safety Data Sheet specified what the concentration of eugenol is in the product.[23]

■ **Neem oil (clarified hydrophobic extract):** approximately 1.1% by volume and prepared from concentrate. Because I used clarified neem oil rather than cold-pressed, this spray had no azadirachtin in it.[24] (I made this mistake because I didn't know the difference between the two types of neem oils.)

■ **Spinosad (spinosyn A and spinosad D):** approximately 0.0078% by volume, and prepared from concentrate.[25] This is the concentration of the active ingredient.

I list the concentrations as approximate, because I prepared them from concentrate. Like a typical gardener, I didn't measure everything as precisely as would a scientist.

BEETLE, next page ▶

23. http://www.ortho.com/smg/goprod/ortho-deer-b-gon-deer-rabbit-repellent-concentrate-animal-repellents/prod10790014?&

24 http://www.bonide.com/assets/Products/Labels/l917.pdf

25. https://www.gardeners.com/how-to/lily-beetle/8090.html

BEETLE, from the previous page

Research Questions, Hypothesis

These are the primary research questions of this experiment:

■ Do any of these three "natural" and "safe" chemical insecticidal sprays show enough control of the lily leaf beetle to be useful for a typical lily gardener?

■ Do any of these sprays show any more effectiveness than the others?

■ Does the effectiveness of these chemicals differ between adult beetles versus larvae?

There also were secondary questions this experiment could address:

■ Were there any differences between a spray's short-term effectiveness versus its effectiveness over the course of a season?

■ Did the beetles prefer any of the types of lilies more than the others?

■ Was the use of a combination of these sprays any more effective than just one spray by itself?

My main hypothesis was that no single spray by itself would be the best approach in controlling the beetle over the course of a season. Rather, using a combination of sprays has potential for being more effective over the course of a season. My rationale for this hypothesis was based on the interactions of the many factors discussed in Part I of this article and above:

■ The complex lifecycle of the beetle.

■ The short but overlapping timespans of the stages of the lifecycle;

■ The defense mechanisms used by the adult and larval beetles;

■ The differences in effectiveness that had been previously reported for the chemicals; and

■ The different modes of actions between the chemicals.

My primary objective was to collect data and make observations that would be useful and practical for home gardeners rather than designing a tightly controlled study as a scientific research lab. This practical objective affected how I set up the plots (e.g. allowing beetles to move from one plot to another), and the way that I allowed other weeds to grow nearby, mimicking garden conditions. This objective also affected the products I chose to use and how I applied them.

Conversely, this experiment was more systematic and controlled than just collecting anecdotal observations in different garden settings. Thus, this could be called a "semicontrolled" experiment, similar to in situ studies that a naturalist might do in the wild instead of a laboratory experiment.

Spraying Protocol

I sprayed the lilies about twice per week. My rationale for this was my assumption that a typical gardener who is somewhat serious about controlling the beetle might spray their lilies once per weekend plus perhaps one more time during the week. This frequency is slightly higher than the typical suggestion of spraying every 5-7 days that is suggested by many sources[26] but is still reasonably practical. However, I sometimes shifted spraying by a day, if it was raining or if rain was predicted. Thus, the length between sprayings ranged from

BEETLE, page 27 ▶

26. https://www.gardeners.com/how-to/lily-beetle/8090.html

BEETLE, from the previous page

three to five days.

For the plot that tested a combination of the chemicals, I set up a consistent rotation of the sprays: The first time I sprayed, I used deer repellant, the next time I used neem oil, the next time I used spinosad and then I repeated the cycle. Thus, the lilies in the rotation plot received the same spray about every 10th or 11th day.

I initially planned to spray each lily the same number of squirts each time. However, I realized a typical gardener would likely vary the number of squirts depending on how many beetles and larvae were found on a given plant. Thus, I decided to use six squirts as the basic amount, but I added a few more squirts on a lily that had a lot of beetles/larvae on it.

I sprayed each plot from both directions (from the sides without the barriers). When I sprayed, I sprayed mostly horizontally in order to hit the undersides of the leaves, but I wasn't obsessive about that. I didn't give extra attention to finding and spraying egg clusters beyond what a casual gardener might do.

Record keeping

Because it took more than a week for all of the lilies to sprout, I didn't begin counting the beetles until most of them had sprouted in each plot. At first I was concerned that this would cause a problem with the beetle counts, given the fact that the beetles start feeding as soon as the lilies start emerging. However, even after a week, I didn't find a single beetle in the plots.

I realized this was because these were new plots, and they were far from any other infested garden beds. Thus, I realized that I needed to "seed" the experimental plots with adult beetles from my other beds in order to get critical early season data. Over the next three days, I captured about 60 beetles, and released about a dozen of them into each plot. (I say "about" because some of the beetles immediately flew out of the plots or into a neighboring plot, etc.)

On each spraying day, I counted the number of adults and larvae I found on each individual plant. I tried to be fairly thorough but not obsessively precise. The beetles would sometimes fly to different plants while I was counting so it wasn't always possible to be exact. If a beetle was on the ground or on a barrier and was obviously close to a particular lily, I would count it as being "on" that lily, but if it wasn't in an obvious spot I would omit it from the count.

After doing the counting, I jotted down qualitative observations that I thought might be significant. These observations generally focused on how much leaf damage each plant sustained, and when a stalk had been totally defoliated (thus no longer providing any food), etc. Later in the season, I focused on how many buds and flowers each plant put out. I also took pictures at points throughout the season to augment the qualitative data.

Ending the Experiment

By the beginning of August, the number of adults and larvae in each plot settled into a consistent and predictable pattern; so I expected the experiment would probably just slowly wind down over the next few weeks. However, on Aug. 3, I noticed something very unexpected. In the control plot, a pair of adults was mating!

As discussed in Part I, most sources report that the new generation of adults doesn't mate or lay eggs during their first summer. They wait until the next spring,

PAUL SISKIND

Adult lily beetles mating in August, though most sources say the beetles wait until spring, after hibernation. This documentation of first-summer mating potentially gives credence to the assertions that the beetles can produce a second generation within the same year.

BEETLE, from the previous page

after hibernation. In fact, according to Naomi Cappuccino, an associate biology professor at Carleton University, Ottawa, Ontario, there haven't been any confirmed reports of first-summer adults mating in their native Europe[27] Thus, this documentation of first-summer mating potentially gives credence to the assertions that the beetles can produce a second generation within the same year. Or, perhaps a new behavior has begun to evolve in the North American transplants, which could potentially have devastating environmental consequences.

On Aug. 15, I again saw a pair mating. I had no way of knowing if this was the same pair that I had seen the week before.

After consulting with Dr. Cappuccino, I decided to end my experiment, and collect all of the remaining adults from the plots to keep them in captivity. I did this for two reasons:

- It would be easier to determine if the mating beetles would lay eggs before hibernating if I kept them in captivity, rather than risking having them fly away from my experiment plot and lay their eggs elsewhere.

- If they did lay eggs, it might be possible to develop a breeding strain of the beetles that has two generations per season. Having such a strain would enable scientists who are working with the beetles in their labs to get twice the amount of research done each season.

I collected 12 beetles, and kept them in a fish tank. Even though they continued to mate, they didn't lay any eggs. Unfortunately, none of them survived through hibernation.

Results

Quantitative Data

A general summary of the data is presented in Figures 1a-e (pages 30-31). There is a separate graph for each plot labeled with the type of spray.

Qualitative Results

Given the fact that some of the chemicals affect the beetles and larvae differently, the best measure of the comparative effectiveness of the chemicals is by the qualitative differences in the health of the foliage and the plants' floriferousness over the course of the season rather than just tallying the beetles. Put simply: Who cares if there's a red bug on the plant if it's not

BEETLE, next page ▶

27. Personal communication.

PAUL SISKIND

Clove Plot

All three of the Asian stalks (foreground, left) have been completely defoliated. One of the trumpets (foreground, right) has been completely defoliated, and another is half-defoliated. The OTs and Orientals (rear) are still in good shape.

PAUL SISKIND

Spinosad Plot

The Asiatics (foreground, left) and the trumpets (foreground, right) show little damage to the leaves, and they all have healthy flower buds developing.

BEETLE, from the previous page

actually eating the plant or laying eggs?

On June 27, all three of the Asian stalks were completely defoliated. One of the trumpets was completely defoliated, and another was half-defoliated. The OTs and Orientals were still in good shape.

For comparison, in the spinosad plot on the same day, the Asiatics and the trumpets showed little damage to the leaves, and they all had healthy flower buds developing.

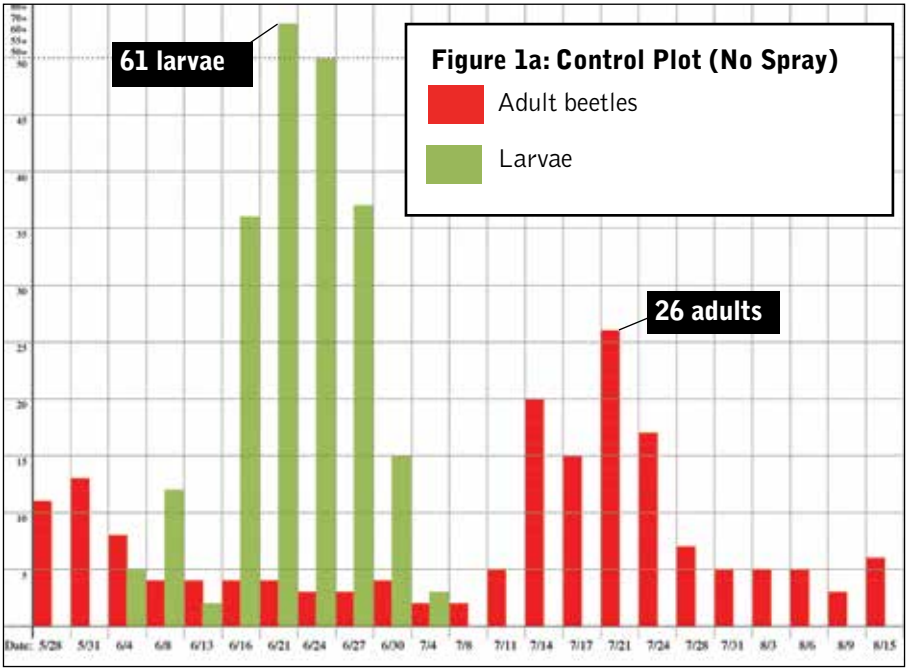
The qualitative comparison was even more stark at the end of the flowering season.

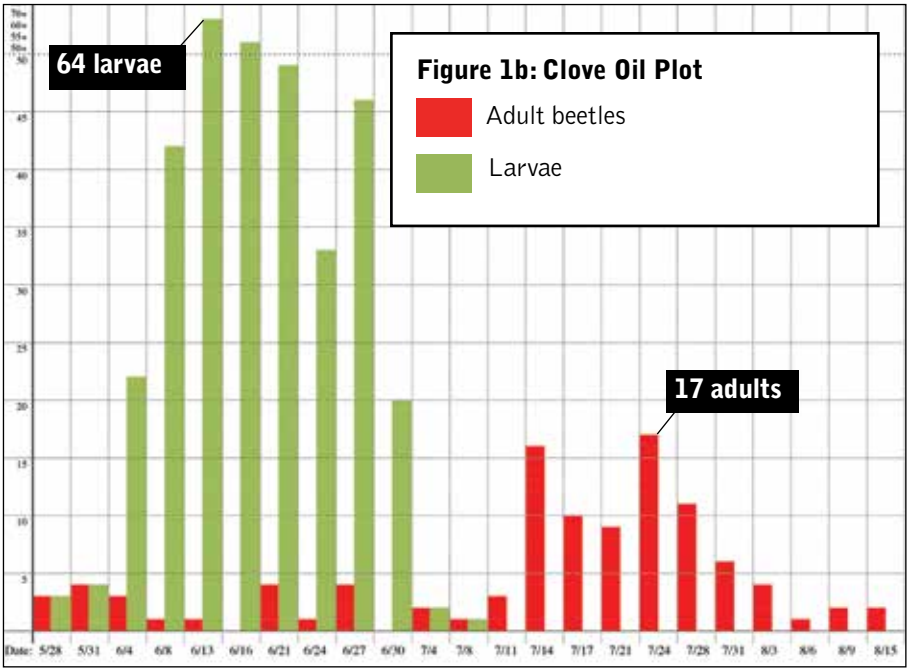
All three plots had adults in them over the previous weeks. There were at least 26 in the control plot, 17 in the clove oil plot and 10 in the spinosad plot. However, accompanying photographs show the quantitative tallies don't fully convey the effectiveness of the sprays over the season.

I noticed even if the adults and larvae didn't totally defoliate a lily early in the season, lilies that sustained only moderate early damage still lost most of their leaves later in the season. I suspect even if the leaves "just" had holes chewed into them without being totally eaten, those holes cut off the flow of water and nutrients to the leaves as the summer progressed, so they eventually died anyway.

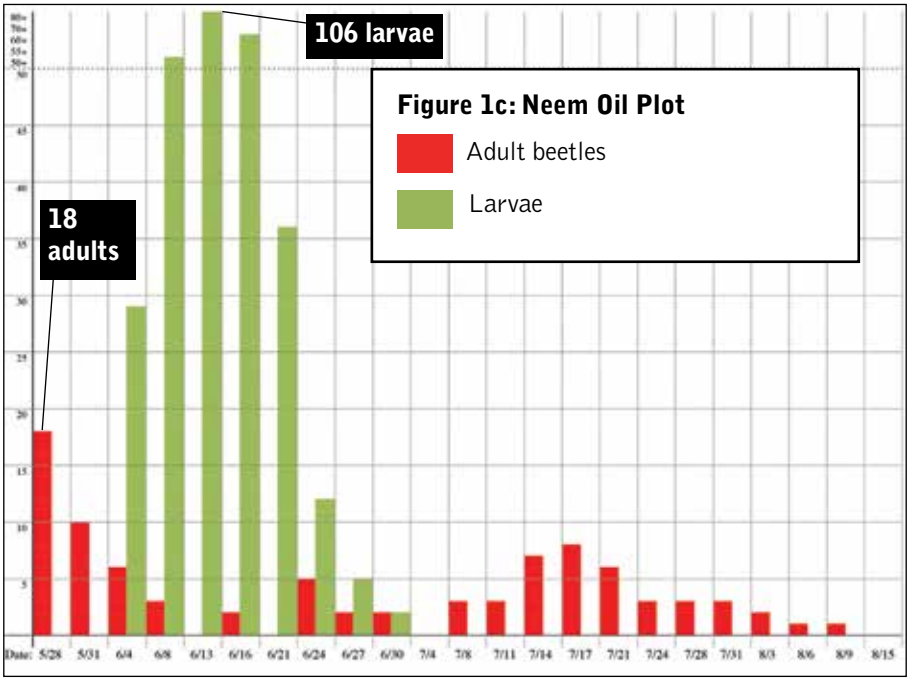
BEETLE, page 32 ▶

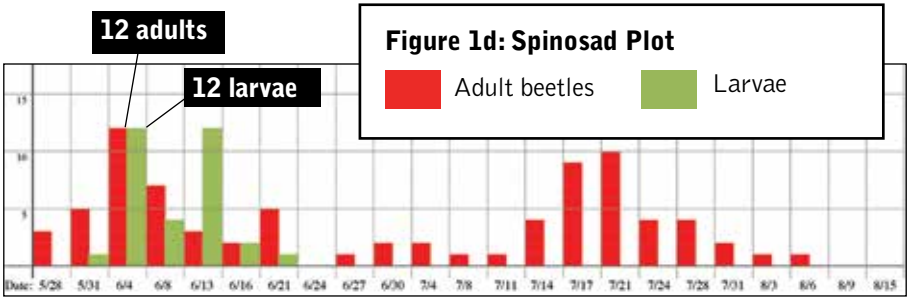
Lily Leaf Beetle Incidence

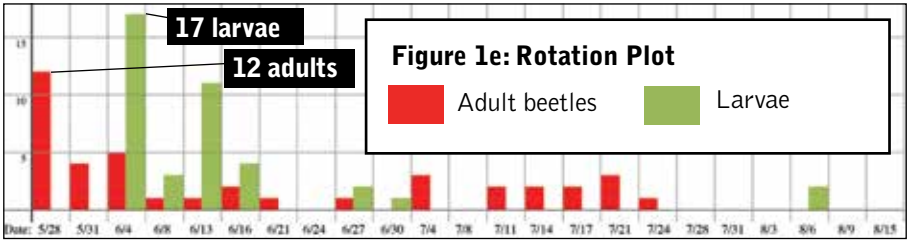




Each graph chronologically tracks the total number of adult beetles (red bars) and larvae (green bars) found on all of the lilies in each plot. Toward the top of the graphs, the vertical space of the very high numbers are "scrunched" for typographical layout reasons (i.e. the tallest bars should actually be taller). The data was recorded from May 28, 2016, through Aug. 15, 2016.







BEETLE, from page 29

Discussion

Because my experiment was only semicontrolled, and because it was conducted in situ, it's hard to make definite conclusions from the quantitative data. Furthermore, the small sample sizes lower the statistical reliability of the data. However, because some trends were fairly clear among the plots and the data reflect previously reported information, I believe some fairly strong inferences can be made from the data.

Three Waves of Infestation

The data corroborate that the known lifecycle of the beetle creates three waves of infestation during the course of the season.

The first wave is composed of adults that had hatched the previous summer. Their population quickly peaks within a week, as they emerge from hibernation. After this peak, these adults appear to die off slowly, and they are gone by 4-6 weeks.

It is possible that these adults don't die but rather fly away. However, my data indicate the number of adults found in the plots later in the season were proportional to the number of local larvae and weren't augmented much by adults that had flown in from other areas. This appears to indicate that the beetle completes its life cycle within a single year, and that only one generation is produced in a year.[28]

The second wave occurs when the new larvae hatch and develop. This appears to begin quickly after the adults had emerged, within two weeks. The wave of larvae lasts for about a month, and the population density roughly follows a bell curve. The

BEETLE, next page ▶

Comparing Oriental lilies in the control, clove oil and spinosad plots offers a stark contrast at the end on the flowering season, on Aug. 9, 2016. The Oriental lilies in the spinosad plot, shown in the picture on the right, were in much better shape.

PAUL SISKIND

Oriental lily in the Control Plot

PAUL SISKIND

Oriental lily in the Clove Oil Plot

PAUL SISKIND

Oriental lily in the Spinosad Plot

28. In a personal communication, Naomi Cappucino told me that there have been no confirmed reports of a second generation in the beetle's native Europe.

BEETLE, from the previous page

wave of larvae appears to end at around the same time as the first wave of adults. This was observed in my control plot as well as in the sprayed plots.

The third wave is probably comprised of the new generation of adults that has just pupated, although it's possible that a few lingering old-generation adults are present.

The shape and timing of these three distinct waves creates a lull around the fifth week of the season, when relatively few adults and larvae are present. This occurs when the first two waves are winding down, but the third wave of new hatchlings is pupating and hasn't yet peaked.

This lull might explain why some people believe a second batch or even a second generation is produced during a summer. I believe my data undercuts the probability of this happening in general although it could possibly happen with a few individuals. Rather, the lull before the third wave creates an illusion that a new batch or generation has been produced.

In my plots, the shape of the curve of the third wave in each plot roughly followed the shape of the curve for the larvae in the same plot. This suggests newly hatched adults tend to begin feeding on nearby lilies rather than immediately fly away in search of a new food source. However, the peaks of the third-wave curves never came close to the peak numbers of the larvae. This suggests either:

■ there is some degree of mortality and/or predation of the pupae; and/or

■ a fair number of the newly emerged adults disperse from their birth-plot (presumably in search of a less-depleted food source).

However, according to Elizabeth Tewkesbury, a researcher at the University of Rhode Island, it's unlikely that the predatory parasitoid wasps that she has released have arrived in my area yet.[29] She also noted that in some species of beetles some pupae take two years to metamorphose into adults. Thus, the lower number of adults could have been due to either dispersion or delayed metamorphosis.

Comparison of Sprays

■ The clove oil plot had fewer adults in its tally than the control plot did, fairly consistently throughout the study. Conversely, the clove plot had at least as many larvae as the control plot, and they were present over a longer period. But in the third wave of new adults, the number in the clove plot was again less than in the control plot. This suggests that the eugenol in clove oil has an insecticidal effect against adults but not against larvae.

This appears to be corroborated by comparing the clove oil plot versus the spinosad and rotation plots. The clove oil plot had modestly more adults than the plots treated with spinosad, but it had a lot more larvae. By the end of the season, the lilies in the clove plot looked just as bad as the ones in the control and the neem plots because the larvae do more damage to the leaves than the adults do. This suggests using clove oil appears to be more effective against adults than nothing but using spinosad is more effective than clove oil against the adults and in the overall quality of the lilies over the course of a season.

BEETLE, next page ▶

29. Personal communication

PAUL SISKIND

Early use of spinosad appears to have a positive effect on protecting earlier blooming Asiatic and trumpet lilies even though they are preferred early season foods, which can be seen here in a photo taken July 18, 2016, of the spinosad plot.

BEETLE, from the previous page

However, if you need to use a deer repellant in your garden, you might as well choose one that contains clove oil, which can have a small additional benefit of killing a few beetles along the way.

■ The neem oil plot had a fairly similar tally profile as the control plot throughout the season. This surprised me, because I had read so many reports that neem is very effective at killing larvae and it at least "repels" adults. But as I mentioned above, I had chosen my neem product before I understood the difference between cold-pressed neem oil versus hydrophobic neem extract. Thus, my results indicate that a neem oil product is only effective if it contains azadirachtin, i.e. cold-pressed neem oil. The clarified neem oil appears to have very little effect against either adults or larvae.

■ The quantitative tallies and qualitative observations both indicate spinosad was significantly more effective than either the clarified neem oil or the clove oil. Even when used by itself, it provided good protection throughout the season, so that even the late-season Orientals had healthy foliage and flowers.

The graphs show that the wave of larvae in the spinosad and rotation plots were smaller and shorter than in the control and neem plots, and that the "lull" before the new-generation of adults came a week earlier. This suggests spinosad did indeed cut down on the size of the first-wave adult population, which in turn affected the size and timing of the subsequent wave of lar-

BEETLE, next page ▶

BEETLE, from the previous page

vae. This indicates spinosad kills adults and using it as soon as the beetles emerge from hibernation is an effective strategy.

In fact, early use of spinosad appears to have had a very positive effect on protecting earlier-blooming Asiatics and trumpets even though they are preferred early season foods.

In comparison, the Asiatics and trumpets in the control and clove oil plots had been mostly denuded already by that time.

■ However, I also found evidence that spinosad kills larvae. On Aug. 6, I found two medium-sized larvae on an Asian lily in the rotation plot. I don't know where they had come from because no larvae had been seen in any of the plots for at least a month. One guess is that they had fallen off a lily a few weeks before and had managed to survive and crawl to a new lily, but it took some time to do so. Regardless of why they suddenly appeared, that particular day was a spinosad spray in the rotation.They were gone by the next tally day. This is evidence that spinosad is indeed effective against even medium-sized larvae.

■ Even though my tallies found a good number of adults and larvae on the plants in both the spinosad and the rotation plots throughout the season (especially in the third wave), the actual extent of the damage done to the leaves and flowers/buds was much less than I would have expected with that number of beetles and grubs. This could indicate that spinosad is so highly effective that simple contact (even with residue) and/or minimal ingestion debilitates them quickly. Even if they don't die right away, it inhibits them from eating.

While feeding inhibition has been reported for azadirachtin, I haven't seen it specifically reported for spinosad. However, given the reports that spinosad interferes with control of muscle movements, this effect could readily prevent both adults and larvae from being able to chew on leaves.

Regardless, it appears that spinosad is effective against adults (which hasn't yet been specifically reported), because the lilies in the spinosad plots didn't sustain much damage even when there were significant numbers of adults around.

Spinosad vs. Rotation

The overall quantitative and qualitative results were generally similar between the spinosad-only plot versus the rotation plot. In particular, the profiles of the first wave (previous year's adults) and second wave (larvae) were very similar. However, the third wave (new adults) was smaller in the rotation plot than in the spinosad-only plot.

Given that the clarified neem oil (without azadirachtin) seemed to have very little effect, the rotation plot went through stretches of about a week without receiving either spinosad or clove oil (both of which appear to affect adults). Furthermore, the intervals between spraying spinosad (which is more effective than clove oil) in the rotation plot were usually about 10-11 days. This seems to indicate that in order to control the beetles, a regimen of spraying spinosad at least once a week has a noticeably better effect than spraying it only once every 10-11 days.

Lily Preference

Even though my primary research question was to compare the effectiveness of the chemical sprays, I also designed the

BEETLE, next page ▶

BEETLE, from the previous page

experiment to try to give some information about whether the beetle shows a preference for some types of lilies over others. As mentioned above, there appears to be some anecdotal evidence about this, but the question hasn't been examined in detail.

The beetles showed an immediate preference for the Asiatic lilies. Within the first week, the number of adults and/or larvae on the Asiatics was much higher than on all the other types of lilies. This was seen in all of the plots. (Figure 2)

These data corroborate many previous reports that beetles strongly prefer Asiatic lilies over other types.

However, by June 21, the Asiatics in the control, clove oil, and neem oil plots had been almost completely defoliated. By then, the beetles' preference moved on to the trumpets and the trumpets were still preferred over the OTs and the Orientals. (Figure 3)

By June 27, Asiatics had been completely defoliated and the trumpets highly damaged, whereas the OTs and the Orientals had been hardly damaged.

After the "lull" between the second and third waves, which occurred around the first week of July, the beetles continued to eat what was left of the Asiatics and the trumpets but they also began to show more interest in the OTs and the Orientals. (Figure 4)

Thus, the beetles' preference for type of lily followed the progression of flowering times over the course of the season: Asiatics first, followed by the trumpets, with the OTs and Orientals coming latest in the season. However, it is entirely possible if given no choice of Asiatics or trumpets to

BEETLE, next page ▶

Figure 2: Early Lily Preference

	June 4	June 8	Totals
Asiatics	6 adults + 65 larvae	5 adults + 91 larvae	167
Trumpets	13 adults + 7 larvae	8 adult + 3 larvae	31
OTs	6 adults + 7 larvae	2 adults + 0 larvae	15
Orientals	9 adults + 6 larvae	1 adult + 14 larvae	30

Figure 3: Midseason Lily Preference

	June 21	Totals
Asiatics	3 adults + 27 larvae	30
Trumpets	1 adult + 81 larvae	82
OTs	3 adults + 7 larvae	10
Orientals	7 adults + 32 larvae	39

Figure 4: End of Experiment Lily Preference

	July 11-Aug 15	Totals
Asiatics	59 adults + 2 larvae	61
Trumpets	88 adults + 0 larvae	88
OTs	58 adults + 0 larvae	58
Orientals	56 adults + 0 larvae	56

BEETLE, from the previous page

feed on they will attack Orientals even early in the season.

It's interesting to note that even though by then the Asiatics and the trumpets had been mostly defoliated (in the nonspinosad plots), more than half of the beetles (56.6%) still landed on them and ate whatever they could find left. However, 43.3% of them had moved to the OTs and Orientals, (compared to only 30.4% that were on the OTs and Orientals on June 21), presumably because they were a more intact food source. This suggests the newly hatched adults have a strong preference for Asiatics and trumpets but there is also competition for food, which drives them to the less-preferred OTs and Orientals.

It's also interesting to note that even though the OTs have some of their lineage from the trumpets, the OTs were no more attractive to the beetles than the Orientals. This seems to indicate that there is something in the Oriental lineage that makes them less attractive than pure Trumpets.

As mentioned earlier, there have been reports that some of the Orientals seem less attractive than others, particularly *L. auratum* and *L. speciosum*.[30] This appears to be corroborated by my data.

Conversely, one source lists *L. regale* among those that "appear to be most resistant."[31] However, the data from my experiment appear to contradict that assertion.

It's often reported that Leslie Woodriff didn't keep good records about the parentage of his hybrid 'Stargazer.' Many sources suggest that *L. speciosum* and/or *L. auratum* are in its lineage,[32] although one source posits that *L. nobilissimum* might be in its lineage.[33] Given that *L. auratum* and *L. speciosum* have been mentioned as being less attractive to the beetle, that might explain why the Oriental 'Stargazer' (which was what I used for my typical Oriental) seemed less preferred than the Asiatics and the trumpets.

Another possible (and simpler) explanation for why the OTs were less attractive to the beetles than the trumpets could be something as simple as the fact that OTs tend to have thicker leaves than other type of lilies,[34] making them harder to chew.

Summary, Recommendations

■ The single most important strategy for controlling the beetle is to start as early in the season as possible. Obviously, fewer early adults means fewer larvae, which do the most damage. Also, preventing early leaf damage prevents leaf death by desiccation later in the season.

■ Controlling the beetles throughout the season (even if the lilies seem to look OK) is critical for lessening adults that will make it through the season and re-infest your lilies next spring.

■ Spinosad by itself appears to be effective in controlling the beetles over the course of the season.

■ Clarified hydrophobic neem oil (which has no azadirachtin in it) is not effective

BEETLE, next page ▶

30. https://extension.umaine.edu/publications/24
http://lilybeetletracker.weebly.com/lily-beetle-control-share-your-solutions
31. http://gardening.wsu.edu/new-invasive-lily-leaf-beetle/
32. http://wimastergardener.org/files/2015/12/Stargazer.pdf
33. http://www.flowershopnetwork.com/blog/newsletter-june-2008/
34. http://bdlilies.blogspot.com/2012/09/differences-between-oriental-and.html

BEETLE, from the previous page

against either adults or larvae.

■ Because I used the wrong type of neem oil, my experiment didn't discern whether alternating spinosad with neem would be any more effective than just using spinosad or neem alone.

■ Clove oil (in deer repellant) appears to have a modest effect on controlling adults. However, clove oil alone isn't as effective as spinosad.

■ Using spinosad and clove oil in rotation yielded noticeably fewer adults throughout the season than just spinosad alone, especially in the late third wave. However, the combination of them didn't yield significantly better qualitative results (e.g. health of plants and number of flowers) than spinosad alone. Thus, it's not necessary to use clove oil, but if you're going to use deer repellant, you could choose one that includes clove oil.

■ Using spinosad once a week is more effective than less frequent use. This summer, I'll test to see if using spinosad twice a week is more effective, versus whether it's not worth the extra effort and cost.

■ As discussed in Part I of this article, even if you use a "safe" insecticide like spinosad or neem oil, you lessen their harmful environmental effects by following the strategies of integrated pest management. For controlling lily leaf beetles, this includes diligent hand-picking and the use of diatomaceous earth as soon as the lilies sprout and the beetles appear. For a discussion of a suggested IPM protocol, please refer to Part I in the March 2017 issue of the *Quarterly Bulletin*.

Acknowledgements

The author would like to thank the following people for their help with this project:

■ Dr. Naomi Cappuccino (Carleton University) and Dr. Elizabeth "Lisa" Tewksbury (University of Rhode Island) for information about the beetle.

■ Peter McCoy for his help with monitoring the plots.

■ Dr. Babasola Fateye (St. Lawrence University), Dr. Cathy Shrady (St. Lawrence University), and Dr. Nina Pierpont for their suggestions and encouragement.

http://lilybeetletracker.weebly.com/report-an-infestation.html /Google Maps

Report Lily Leaf Beetle Sightings

As you can tell from this map, the lily leaf beetle (*Lilioceris lilii*) is a serious pest of cultivated lilies in gardens and an emerging pest of native lilies in the wild.

The beetle was introduced from Europe and was first noticed in Montreal in the 1940s. Since then, it has been spreading throughout the northeastern US and eastern Canada, and pockets of infestation have been recorded as far west as Alberta.

The website **http://lilybeetletracker.weebly.com** has been developed to gather information on the beetle's distribution as it spreads throughout North America.

If you have lily beetles in your garden, or if you have seen them on native lilies or even on other plants, please let them know by using the simple form on the "Report an Infestation" page at the website. This will allow them to create an updated distribution map for the beetle.

The site offers basic information about the lily leaf beetle, such as the life cycle of the beetle. There also is information about biological control using parasitic wasps.

Part of the website is devoted to letting gardeners share their solutions.

The website is authored by Naomi Cappuccino, a member of the Department of Biology at Carleton University in Ottawa, Ontario.

You can enter either the latitude and longitude for a site or a street address (or even just the name of your town). Latitude and longitude can be obtained from a number of sites with clickable maps.

Please upload photos as well, as this will help them confirm the distribution.

If you share your information, the website promises that your e-mail address will not be shared. No personal information will be linked to the map.

http://lilybeetletracker.weebly.com