The QB

The North American Lily Society Quarterly Bulletin

Vol. 72, No. 2 | June 2018

NALS 2018 West Des Moines, Iowa

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Controlling Lily Leaf Beetle

A Follow-up – Part 3

By Paul Siskind

This is an update to a pair of articles published in the NALS Quarterly Bulletins *in March 2017 and June 2017. Part I provided an overview of the life-cycle of the beetle as well as a discussion of an Integrated Pest Management approach to controlling it in gardens. Part II discussed the results of an experiment that I ran in the summer of 2016 that compared the effectiveness of three different "safe" insecticidal sprays and compared the beetle's preference for different types of lilies. This article is a follow-up, including new results from my experiment in summer 2017.*

Introduction

The pair of articles published in the *Quarterly Bulletin* last year[1] outlined an environmentally friendly integrated pest management approach to controlling the lily leaf beetle, based on previously available information augmented with observations and results from my own experiment. However, last year's experiments left a number of important questions unanswered:

- Is there a difference in the effectiveness of the two types of neem oil that are found in commonly available in commercial products?
- Is diatomaceous earth actually effective in controlling the beetle? If so, how should it be integrated into the IPM strategy?
- Were the late-season matings that I observed last summer just a rare aberration?
- If late-season matings by the beetles are not uncommon in North America, how might this affect their overall life-cycle (and their potential danger to both native and ornamental lilies in North America)?

COURTESY TIM HAYE, CENTRE FOR AGRICULTURE AND BIOSCIENCE INTERNATIONAL

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 U.S. and eastern Canada, and pockets of infestation have been recorded as far west as Alberta.

In summer 2017, I conducted another round of my experiment, revised in order to try to answer some of these questions.

Revised Experimental Design and Methods

Like the previous year, the experimental plot was 25 feet long by 5 feet wide. It was divided into five 5- by 5-foot plots with 4-foot tall fabric barriers between the sectors, to prevent the insecticide

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sprays from blowing into the neighboring plots. The other edges were left open, so that the beetles could move in, out or among the plots.

As before, I let some "weeds" grow around and within the experimental plots, to simulate a garden with lilies growing among other plants.

I used the same mix of types of lilies that I had used the previous year. However, because many of them had been totally defoliated the previous year, I added a few new bulbs to replenish the plots. I also added LA hybrids to the plots, because LA hybrids have become popular in the commercial market.

Each plot contained three or four of each of these:

- A mix of Asiatic varieties.
- A mix of LA hybrids.
- The trumpet species *Lilium regale.*
- A mix of OT hybrids.
- The Oriental 'Stargazer.'

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 is also a certified 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.

Control Methods and Protocol

Based on my findings from last year, I used a different combination of control methods, in order to clarify and refine their comparisons. For the insecticidal sprays, I

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used commercial products.

Control methods used in the five plots:

■ **Handpicking** – I hand picked and squished all adults, larvae, and eggs that I found on the lilies in this plot.

■ **Diatomaceous Earth** – Applied by aerial dusting. Given the nature of the dusting method in an open-air environment, it was difficult to consistently measure the amount used.

■ **Neem Oil** – approx. 0.003% by volume[2] 100% neem oil (cold-pressed)[3], diluted using a half teaspoon per 28 ounces of water.

■ **Spinosad** (spinosyn A and spinosad D) – approx. 0.0078% by volume. Prepared from concentrate.[4] The concentration listed is of the active ingredient, as prepared.

■ **Rotation Plot** – In this plot, I rotated the treatment methods, starting with handpicking and a dusting of diatomaceous earth (Rotation 1); neem oil (Rotation 2); and spinosad (Rotation 3). I then repeated the sequence.

I applied the treatments about twice per week, thinking that a typical gardener might attend to their lilies once per weekend plus one more time during the week. However, I sometimes shifted treatment by a day or two because of rain.

Because a typical gardener would likely vary the number of squirts (or the amount of dusting) depending on how many beetles and larvae were found on a given plant, I used six squirts per plant as the basic amount; but I added a few more squirts on a lily that had a lot of beetles/larvae on it.

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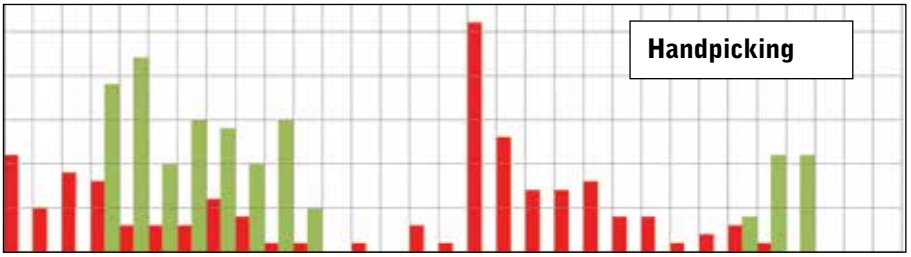
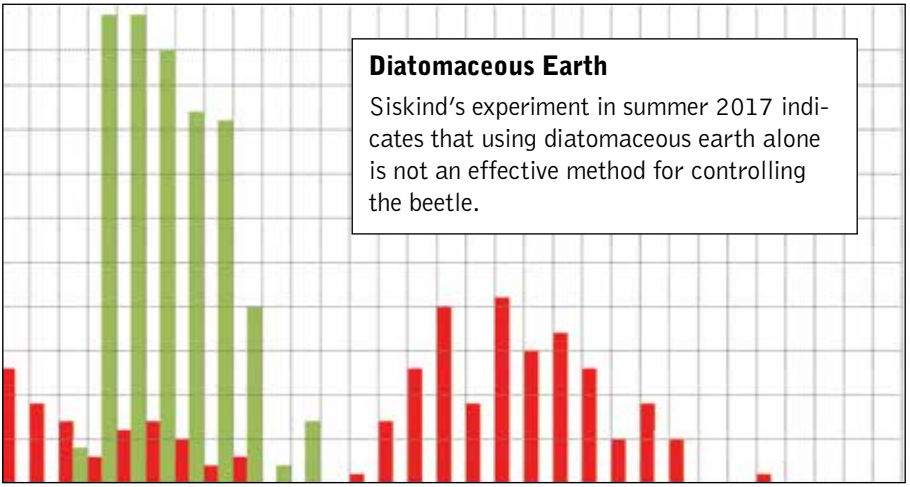
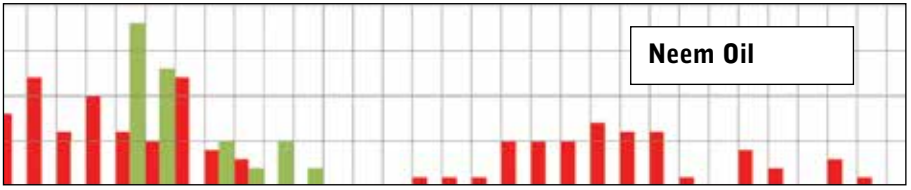
Quantitative Data

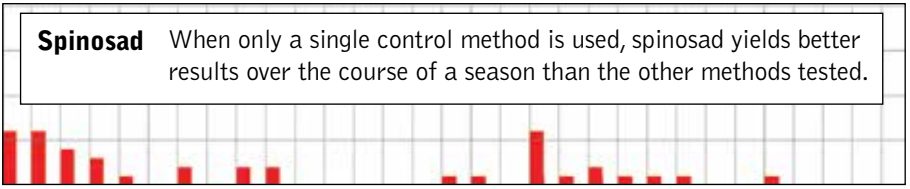
The following graphs on page 21 tally the number of beetles and larvae found in each plot over the course of the season (May 19 to Sept. 15), with sample dates separated by vertical lines. Each horizontal line represents five beetles or larvae.

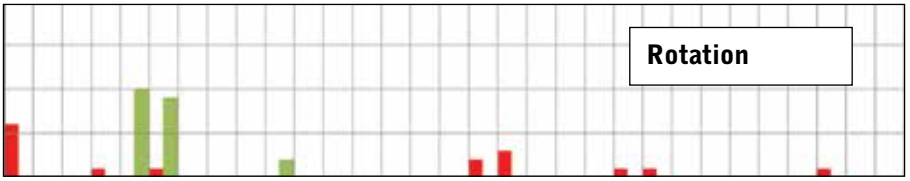
Adult beetles Larvae


Handpicking


Diatomaceous Earth
Siskind's experiment in summer 2017 indicates that using diatomaceous earth alone is not an effective method for controlling the beetle.


Neem Oil


Spinosad
When only a single control method is used, spinosad yields better results over the course of a season than the other methods tested.


Rotation

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Qualitative Results

Given the fact that different treatment methods affect the beetles and larvae in different ways and at different times in their life cycle, the best measure of the comparative effectiveness of the chemicals is the qualitative differences in the health of the foliage and the plants' floriferousness over the course of the season.

Put simply: Who cares if there's a red bug on the plant if it's not actually eating the plant or laying eggs?

One factor in this year's experiment that makes qualitative comparison of the plants difficult is the fact that the plots contained a mix of bulbs from the previous year augmented with a few new, fresh bulbs.

Because some of last year's plants had been completely defoliated, those bulbs were somewhat depleted, resulting in stunted plants that didn't produce flowers.

Specifically, none of the Orientals in the spinosad plot produced any flowers. In addition, we had an unusually cold and wet summer, which also seemed to cause less-than-optimal growth.

However, even with these factors, there are some inferences that can be made from observations about the general health of the leaves at the end of the season.

Discussion

This year's data corroborate many of the observations and inferences gleaned from last year's experiment.

There are three "waves" of infestation over the course of a season.

The first wave is composed of adults that hibernate over the winter. They begin laying eggs very soon after emerging. Their infestation quickly peaks, usually within a week. After this peak, these adults appear to die off slowly (or they fly away to new areas), and they are gone by the fourth, fifth or sixth weeks.

The second wave occurs when the new larvae hatch and develop. This begins about two or three weeks after the adults emerged. The wave of larvae lasts for about a month. The wave of larvae ends at around the same time as the first wave of adults ends. There's now a short lull (around the fifth or sixth week of the season) when there are relatively few adults and larvae present.

The third wave is mostly comprised of the new generation of adults that has just pupated. However, new observations and discussions with other researchers indicate it's possible that a few lingering old-generation adults are still present. This will be discussed below.

The beetles show a strong preference for Asiatic lilies over other types, for both feeding and as sites for laying eggs. They also appear to prefer trumpets and LAs over Orientals, with OTs being their least-preferred type (possibly because of the thickness of their leaves).[5]

Because the larvae do the most damage, Asiatics are more vulnerable to early and complete defoliation than other types. However, even modest damage to leaves done early in the season to all types causes significant leaf death later in the season because of desiccation.

The revisions that I made in this year's experiment also yielded some new observations and inferences.

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It is difficult to apply powder onto eggs and larvae on the underside of leaves, where they tend to congregate.

Even dousing adult beetles with diatomaceous earth seemed to have little effect.

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Ineffectiveness of Diatomaceous Earth

In last year's articles, I cited sources which reported that diatomaceous earth can be used to control lily leaf beetles.[6] The abrasive powder is purported to scratch the beetles' wings so that they can't fly, and/or causes them to dehydrate.[7]

However, my experiment this summer indicates that using just diatomaceous earth alone is not an effective method for controlling the beetle.

The diatomaceous earth plot had many more adults and larvae across the season than the other plots. Even just handpicking is more effective than diatomaceous earth.

The ineffectiveness of diatomaceous

PHOTOS BY PAUL SISKIND UNLESS OTHERWISE NOTED

The ineffectiveness of diatomaceous earth is visually apparent in these two photos taken Aug. 2. The photo above shows Oriental 'Stargazer' plants in the handpicked plot compared to 'Stargazer' plants in the diatomaceous earth plot.

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earth was also visually apparent.

However, by the end of the season, the ineffectiveness of diatomaceous earth became less apparent, because the early season leaf damage done in the hand-picked plot "caught up" due to late-season desiccation.

In fact, I found little evidence that even a significant dousing with diatomaceous earth directly onto adult beetles had much of an effect, even after multiple dousings over a week.

Another factor that makes diatomaceous earth ineffective as a control method is that it's hard to dust the powder onto eggs and larvae on the underside of leaves, where they tend to congregate.

While these observations don't necessarily indicate that diatomaceous earth doesn't offer any beneficial control of the beetles, they indicate that diatomaceous earth by itself isn't an effective control method. It is also unsightly.

Comparison of the Two Types of Neem Oil

As discussed in last year's articles, there are two methods of extracting neem oil from neem seeds:

1) by using alcohol to extract the oil; and

2) by a cold-pressing process.[8]

The critical difference is that the alcohol extraction process removes azadirachtin from the oil. Even though neem oil contains a mixture of different natural insecticides, the most potent of these is azadirachtin.[9] Conversely, the cold-pressing process doesn't remove the azadirachtin from the neem oil.

Products that contain "neem oil" obtained by alcohol extraction should properly list it on their label as "clarified hydrophobic extract of neem oil." However, that's not always done, and they sometimes just list "neem oil." Conversely, products containing "cold-pressed neem oil" often state that on their label. Sometimes they just list "neem oil."

While cold-pressed neem oil has been shown to be effective against lily leaf beetles, products labeled "neem oil" processed by alcohol extraction, or "clarified hydrophobic extract of neem oil," is less effective. The problem is that labels often do not correctly tell you which is being presented to you. You must research on the manufacturer's website.

For example, the label on the product pictured above doesn't indicate whether the neem oil is cold-pressed versus clarified hydrophobic extract. The only way to find out is to look on the manufacturer's website. I researched this particular product,

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and it does in fact contain pure cold-pressed neem oil. However, I've found that many products which don't explicitly state "cold-pressed" often contain the clarified hydrophobic extract (especially products marketed as leaf polishes and fungicides for roses).

The presence of azadirachtin makes a critical difference in the effectiveness of the two types of neem oil against the lily leaf beetle. There were many fewer larvae in this summer's experiment, in which I used cold-pressed neem oil, versus the results from last summer, when I mistakenly used clarified hydrophobic extract."

The cold-pressed neem oil is clearly more effective in controlling the beetle over the course of a season. Furthermore, the data corroborate general reports that "Neem kills larvae and repels adults."[10]

Even cold-pressed neem oil doesn't seem to kill eggs; this can be inferred from the data which indicate a sudden appearance of significant numbers of larvae, even though the plants (and presumably any eggs) had been sprayed three times within the previous 11 days. This is because even though azadirachtin is an irritant on contact, it's hormonal effect only occurs through ingestion.[11] The initial spike of larvae quickly declines after the larvae begin feeding, having ingested the azadirachtin.

Comparison of Single Control Methods

The data in in the graphs on page 21 indicate that when only a single control method is used, spinosad yields better quantitative results over the course of a season than either handpicking, diatomaceous earth, or neem oil. The effectiveness of spinosad over handpicking and neem

These photos (taken on July 23) show that the plants in the handpicked plot (above) appear almost as healthy as the plants in the spinosad plot.

oil isn't visually obvious early in the season (e.g. when the Asians, LAs, and trumpets are flowering).

However, by the end of the season, the

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By the end of the season, leaf damage in the handpicked plot (above left) and the neem oil plot (above right) become more apparent than in the spinosad plot (below). These photos were taken Sept. 10.

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leaf damage in the hand-pick and neem plots becomes more visually apparent when compared to the spinosad plot.

Comparison with Rotation of Control Methods

One of the goals of integrated pest management is to try to avoid having the pests develop an inheritable resistance to the chemical pesticide(s) being used. If resistance does develop, that pesticide loses its effectiveness in controlling the pest over time.

One way to prevent resistance from developing is to use a combination of control methods rather than just a single chemical pesticide. This way, if some of the pests do develop resistance to one of the pesticides, they will be killed by other methods before they've had a chance to reproduce and pass the resistance on to future generations.[12]

Besides wanting to combat resistance, one of the main questions underlying

my experiments has been: Is the use of a combination of control methods any more effective than using just one method by itself? My hypothesis was that no spray by itself would be "the best approach" in controlling the beetle over the course of a sea-

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son; rather, using a combination of sprays would be more effective. My rationale for this hypothesis is based on the interactions of variety of factors discussed in Part II (NALS *Quarterly Bulletin*, June 2017), such as the compressed lifecycle of the beetle, the different modes of action of different insecticides, and other reasons.

The results from the summer 2016 experiment didn't successfully answer this question, because of the mistake I had made in using the wrong type of neem oil. This results of summer 2017 give a somewhat clearer answer.

Comparing the quantitative data in the graph for the spinosad-only plot versus the rotation plot, the general profiles of infestation by adult beetles (red bars) throughout the season are quite similar.

It's interesting to note that in the rotation plot, I did a thorough handpicking of the beetles on May 19 (after I had counted them), which seemed to be effective in squelching the initial infestation of adults.

However, there was a short infestation of larvae in the rotation plot about two weeks later. This seems to indicate that even though I squished as many eggs that I could find in the previous weeks, I must have missed a clutch. In fact, all 10 of the larvae that I found on June 3 were all on the same leaf. Even though I sprayed them with neem oil that day, four of them were still alive (on the same plant) on June 7 (and the others were on a nearby plant).

However, this doesn't necessarily indicate that neem oil doesn't kill larvae. Rather, because azadirachtin disrupts an insect's hormones, it has two effects:

1) it disrupts their feeding behavior; and

2) it disrupts the metamorphosis of larvae.[13]

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As can be seen in these photos taken on Sept. 10, lilies in both the spinosad-only (left) and the rotation plots maintained fairly healthy-looking foliage throughout the season. Even by the end of the season, the overall health of the plants in the two plots appear similarly healthy.

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Thus, neem oil doesn't kill the larvae right away. This could explain why it didn't appear to be effective.

On June 7, I sprayed the rotation plot with spinosad. By June 11, there were no more larvae in the rotation plot. Spinosad kills insects by disrupting the chemical that passes a nerve signal from one nerve cell to the next.[14] The result is that the insect can't control its muscle movements, and dies from muscle spasms. However, it can take a day or two for the insect to die.[15] Thus, it's difficult to discern whether it was the neem or the spinosad that had stanched the short infestation of larvae.

Regardless, the lilies in both the spinosad-only and the rotation plots maintained fairly healthy-looking foliage throughout the season. Even by the end of the season, the overall health of the plants in the two plots appear similarly healthy.

Thus, while spinosad might seem a little more effective than neem oil because it kills both adults and larvae (and kills them more quickly), that benefit must be balanced against the risk of creating a resistance to spinosad. Because IPM balances the short-term effectiveness with a perspective of long-term management, in my opinion it's better to alternate the use of spinosad and neem to lessen the risk of developing resistance, even if spinosad alone is slightly more effective from a short-term perspective. However, once the larvae are gone for the season, there's no need to continue using neem oil, because it's not effective against adult beetles.

Late-Season Mating and Late-Season Larvae

In last year's article (Part II, June 2017), I reported that I had found adult beetles mating in August. This was unexpected, because until then there had been only anecdotal reports of a late-season mating in North America, but no documented evidence. Surprisingly, I found a fair number beetles mating in August.

This summer, I again found numerous beetles mating in August. Thus, late-season mating doesn't appear to be just a rare, aberrant occurrence. However, most of the information that I've read about the beetles says that the beetles that hatched earlier in the summer don't mate until the following spring, i.e., after they've hibernated. In fact, two of the principal scientists doing research on the beetle (Naomi Cappuccino, associate professor in the Department of Biology at Carleton University, Ottawa, Canada, and Tim Haye, research scientist at the Centre for Agricultural Bioscience International, Wallingford, England) confirmed to me that late-season matings in Europe (the original home of the beetle) are very rarely observed.[16]

Like I had done last summer, I captured some of these late-season pairs, and kept them alive in a fish tank for a number of weeks into the fall. Even though they mated frequently, they never laid any eggs. This seems to indicate that the beetles don't produce a second generation within the same summer, even though some sources (particularly older sources) report that this does occasionally occur.[17]

Even though late-season mating has rarely been observed, there have also been reports of larvae being found late in the season. Last summer, I found two larvae in August, five weeks after all the previous larvae had disappeared. This summer, I found as many as 11 late-season larvae in

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the handpicked plot. Tim Haye reports that he "regularly" sees larvae in August in Europe, but much less frequently than in the early summer.[18]

The occurrence of late-season larvae could well be the basis for the reports of a "second generation" produced in a single summer. However, both Tim Haye and Naomi Cappuccino believe that these late-season larvae are simply the tailend of the regular breeding season, with two possible explanations: some females live long enough to lay eggs in August; and/or for some reason, these straggler larvae might have hatched and/or matured much later than the rest of their generation.[19]

While those explanations are plausible, they don't explain why there would be no larvae present for five or six weeks before a reappearance of larvae. If they were merely "late developers," one might expect a continual but dwindling stream of larvae, rather than a complete lull followed by a sudden reappearance.

Lisa Tewksbury suggests a very different potential explanation. In the Chrysomelid family of leaf beetles, there are reports that a small percentage of pupae that don't immediately metamorphose into adults. Rather, they remain underground as pupae over winter, and metamorphose into adults an entire year later than the rest of their cohort.[20] Even though this hasn't been confirmed to occur in the lily leaf beetle species, it offers a plausible explanation for the sudden appearance of a small batch of late-season larvae.

However, I found evidence that late-season larvae do indeed come from new eggs laid in late July, rather than any of the other scenarios.

This summer, in my regular garden beds (not the experimental plots), I found a few small larvae on both *L. leichtlinii* and *L. martagon* on August. This surprised me, because I diligently inspect, handpick, and spray my ornamental lily beds throughout the summer. I hadn't seen any larvae for weeks, and any adults were quickly killed. These new larvae were so small that they must have recently hatched from eggs; indeed, I soon found empty egg-cases on the *L. leichtlinii*, on a leaf just under the leaf where I found the larvae. But I'm certain that there were no eggs there a week or two before then.

Even though this is just a single anecdotal observation, it does contravene the "late developer" explanation. It's likely that the questions about late-season mating and late-season larvae can only be fully answered with more research and carefully designed experiments.

Revised IPM Recommendations

■ The most important strategy for controlling the beetle is to start as early in the season as possible. Minimizing early leaf damage prevents desiccation later in the season.

■ Controlling the beetles throughout the season (even if the lilies look OK) will cut down on adults that will reinfest your lilies next year.

■ Even though diatomaceous earth isn't effective as a control over the season, there's no harm in sprinkling it on the ground around the lilies as they're emerging and even covering the shoots with a small pile of it. Even if it kills just a few beetles as they emerge, it's worth it. However, it's not worth the effort to continue dusting the plants throughout the season.

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■ Handpicking should begin immediately as the lilies emerge. Diligence is especially critical early in the season; try to handpick at least once a day. Look for eggs and small larvae on the underside of leaves. Continue handpicking throughout the season. This chore will lessen considerably if you've been diligent early in the season.

■ If you use a deer-repellent on your lilies, choose one with clove oil as an ingredient. Clove oil seems to have some effectiveness at killing (or at least repelling) adult beetles.

■ Spinosad by itself appears to be very effective in controlling the beetles over the course of the season. However, relying on spinosad alone risks the development of beetles that are resistant to the insecticide, which would be a very serious problem.

■ At the beginning of the season, alternate between spraying spinosad with neem oil (which must be the cold-pressed type). Try to spray twice a week, so that each insecticide is used once a week. If you keep up with handpicking, there's no need to spray more often than this.

■ Once the wave of larvae has passed, discontinue using neem oil (unless you start finding new larvae again). If you continue handpicking diligently, you can cut back on the spraying of spinosad. Once per week should be sufficient.

■ As with any insecticide, use as little as necessary. Aim it directly at the lily plants, rather than indiscriminately dousing. Avoid spraying when it's windy, and avoid spraying in strong midday sun (to avoid burning the leaves). Avoid spraying if there are beneficial pollinators nearby.

After you get a bad infestation under control, it's not difficult to incorporate this protocol into your gardening routine. If we're all conscientious in our efforts to control the beetle safely, we'll likely be able to manage it in our gardens and protect our native lilies sufficiently until the imported parasitoid wasps become established across North America. They will then naturally control the beetle for us.

Works Cited

1 North American Lily Society Quarterly Bulletin, Vol. 71, No. 1 (March 2017) and No. 2 (June 2017)

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

3 http://dyna-gro.com/product/neem-oil-v/

4 http://www.bonide.com/assets/Products/Labels/l252.pdf

5 http://bdlilies.blogspot.com/2012/09/differences-between-oriental-and.html

6 http://www.bdlilies.com/redlilybeetle.html

7 http://www.calgary.ca/CSPS/Parks/Pages/Planning-and-Operations/Pest-Management/Red-lily-beetle.aspx

8 http://www.gpnmag.com/article/explaining-azadirachtin-and-neem/

9 https://npic.orst.edu/factsheets/neemgen.html

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

11 http://www.gpnmag.com/article/explaining-azadirachtin-and-neem/

12 http://ipm.ucanr.edu/PMG/r280390311.html

13 http://extoxnet.orst.edu/pips/azadirac.htm

14 https://en.wikipedia.org/wiki/Spinosad

15 http://npic.orst.edu/factsheets/spinosadgen.html

16 Personal communications.

17 http://www.lilies.org/wp-content/uploads/2013/09/lilybeetle.pdf

18 Personal communication.

19 Personal communications.

20 Personal communication.