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Controlling Lily Leaf Beetle

An Integrated Pest Management Approach — Part I

By Paul Siskind

This is the first part of a two-part article. Part I provides an overview of the life cycle of the beetle, as well as an overview of a variety of approaches that can be used to control it in gardens. The concept and practices of integrated pest management will then be introduced as the preferred approach. Part II (which is scheduled to appear in the June issue of the Quarterly Bulletin) will discuss the results of an experiment I ran last summer that compared the effectiveness of three different "safe" insecticidal sprays. It also compared the beetle's preference for different divisions of lilies.

(Editor's note: The author is from Canada, and not all pesticides, etc., are available for purchase in other countries.)

Background

Lily gardeners throughout Canada and the northern United States are likely familiar with the lily leaf beetle (*Lilioceris lilii*), a nonnative invasive pest that can quickly decimate a stand of lilies.

Of obvious concern to ornamental gardeners and the commercial trade, the beetle also has potential to extirpate populations of rare and endangered species of native lilies. While significant research has been conducted on the use of biological controls to counter the general spread of the beetle, most of the information about control methods for home gardeners has been collected through anecdotal observations.

However, controlling the beetle in home gardens is a critical component of protecting our native lilies. In North America, native lilies tend to grow in small, low-density stands.[1] While some species have a fairly wide distribution, others have very limited ranges, and the concentration of lilies within these ranges is often rather sparse. Thus, native lilies offer the invasive beetle a limited supply of feeding and breeding sites, which might otherwise limit the reproduction and spread of the beetle.

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Adult lily leaf beetles.

Conversely, lilies are ubiquitous in gardens throughout North America. This unnatural density of food and breeding sites greatly increases the reproductive and dispersion capacity of the beetle. Thus, controlling the beetle in high-density lily gardens can help prevent the spread of the beetle into the more sparse native populations.

Natural History

An adult lily leaf beetle is about 3/8 inch long. The tops of their head and

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1. http://bonap.net/NAPA/TaxonMaps/Genus/County/Lilium

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wing covers are bright red, and their underside, legs, and antennae are black. There's no obvious sexual dimorphism.

The beetle was originally native to Asia and Europe, although its specific native range is unclear. The Invasive Species Compendium lists it as native throughout Eurasia (and even North Africa), with the exception of the United Kingdom (where it is now considered invasive).[2] This native range matches where most of the world's native lily species were originally found.

The leaf beetle family (*Chrysomelidae*) contains over 37,000 species, many of which feed on just a few types of related plants.[3] This is reflected by their common names, such as the cottonwood leaf beetle, the swamp milkweed beetle, the cereal leaf beetle, the Colorado potato beetle, etc. As these names also imply, many of them are serious pests of food crops.

The lily leaf beetle feeds mostly on species in the Liliaceae family, particularly on the genera *Lilium* and *Fritillaria*. They also will occasionally feed on a few other genera, such as *Polygonatum* (Solomon's seal), *Streptopus* (twisted stalk) and *Solanum* (nightshades), but they can't complete their life cycle on them.[4]

Luckily for gardeners, they don't feed on the *Liliaceae* genus *Tulipa* (tulips).

Life Cycle

Most sources state the beetle lives for only one year, and there is only one generation of beetles per year. However, some sources claim an adult might live for a second year, but only lay eggs in their first summer.[5] Other sources claim that two generations can be produced in a single summer.[6] (I will discuss this more in Part II of this article.)

Adults hibernate during the winter, buried in leaf litter. These adults emerge from hibernation at the same time as most lilies are sprouting, and they immediately begin feeding on the developing stalks. It's not known exactly how the beetles find the lilies amid other plants. It's thought that smell plays a primary role.[7] These adults feed for about five weeks and do only moderate damage to the leaves of their host plants.

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Eggs of lily leaf beetles.

During this time, the beetles also mate. The females then lay their eggs on the underside of lily leaves. A single female can lay more than 400 eggs.[8]

The eggs are about 1/16 inch long, and are often laid in rows. They are bright orange when they're laid, but they darken a little before they hatch. The eggs hatch in about a week.

The larvae feed much more voraciously than the adults do. In fact, a group of larvae can often totally defoliate a lily stalk within a few days. I've noticed that larvae

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2. http://www.cabi.org/isc/datasheet/30800
3. https://en.wikipedia.org/wiki/Leaf_beetle
4 http://bugguide.net/node/view/2017
5. https://www.rhs.org.uk/science/pdf/plant-health/lily-beetle-litrev-pdf
6. http://web.archive.org/web/20070510143253/http://www.lilies.org/lilybeetle.pdf
7. Naomi Cappuccino; personal communication.
8. https://extension.unh.edu/resources/representation/Resource000480_Rep502.pdf

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tend to move upward along the stalk as they feed, unless the top of the stalk has already been denuded. The larvae go through four stages (instars) as they grow, eventually reaching about 3/8 of an inch long in about two or three weeks. At this point, they climb down the stalk and burrow into the ground to pupate.

The new adults emerge in about two or three weeks. They resume feeding on whatever's left behind from the onslaught of the larvae. Because the numbers of adults in a garden waxes and wanes during the mid- to late summer, it appears at least some of these new adults fly away to new areas, while other new beetles might fly in from other areas.[9]

In my gardens, I usually find very few beetles by September, even if it's still warm and even if there are still intact lilies to feed on. But because it seems unlikely that they would begin hibernating that early (and hibernate in a plot with depleted food sources), my guess is that they have some sort of innate dispersal behavior to move away from a plot of lilies which might be depleted next spring.

In sum: A "season" of the beetle has three overlapping "waves":

- adults that hatched the previous year;
- this year's larvae; and
- this year's new adults.

Predators and Defense Mechanisms

Adult beetles have an effective defense mechanism. When they see movement nearby, they quickly let go of the leaf, and

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Larvae of lily leaf beetles.

slide off it, dropping to the ground. This makes it very hard to pick the beetles off of the plants (unless they fall into the crook between the leaf and the stalk). They usually land on their backs. Because their bellies are black, it's very hard to see them against the soil background. Many sources claim that the beetles also emit a

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9. http://www.lilynook.mb.ca/Lily_Beetle.html 10.
10. http://oregonstate.edu/dept/nurspest/RLLB.pdf

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squeak when they're disturbed,[10] but I have only heard this once.

While the adults' escape and camouflage behavior is an effective protection from predators (including human gardeners), the larvae have a very different defense mechanism. They cover their entire body with a coating of their own excrement. This defense mechanism (called a "fecal shield") is common among many chrysomelid beetles.[11] In the lily leaf beetle, this layer of excrement can be quite thick (about 1/16 inch), and it remains viscous and slimy. They cover their entire back and sides, and often their heads as well.

It is assumed that the fecal shield provides three types of protection:

- physical slipperiness;
- a foul smell and/or taste;
- and it might contain natural chemical insecticides that were ingested from the plants they eat.

The fecal shield is an effective defense mechanism, and the larvae appear to have few predators in the wild. If the larvae shed their shield (e.g. when molting, or to dislodge an irritant), they appear to be easy prey for predator such as spiders and wasps.[12]

The fecal shield makes it hard (and disgusting) for humans to pick off the larvae by hand. They can be "flicked" off of a leaf, but the larvae are resilient, and they can crawl quite a distance on the ground to find another lily.

In their native range, it appears that the beetle's population is kept in check by four species of very small wasps and two species of very small flies.[13] These insert their eggs into the body of the larvae (through the fecal shield); when these eggs hatch, they eat the larvae/pupae from the inside, killing it. This type of parasitism is fairly common among insects.

History of North American Invasion

The beetle was first reported in North America in 1943, in the Montreal area. According to the Invasive Species Compendium, that infestation stayed fairly localized. It wasn't until 1981 that the beetle was reported outside of Quebec province (in Ontario).[14] It is surmised the beetle arrived in an infested importation of bulbs from Holland.

The beetle was first reported in the US in 1992, in the Boston area. Because there had been no reports of the beetles in between Canada and Boston, it's possible that the Boston population arose from a second importation, rather than spreading down from the Canadian population.

In fact, the population in Boston appeared to spread more rapidly than the Canadian population. Beetles had reached New Hampshire by 1997, Vermont by 1998, Maine by 1999, New York by 2000 and Connecticut by 2001.

It hasn't been definitively determined that these new infestations came solely from the Boston population, but a tracking map compiled by Naomi Cappuccino (at Carleton University) seems to indicate two distinct paths of

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11. http://www.lilynook.mb.ca/Lily_Beetle.html
12. Naomi Cappuccino, personal communication.
13. http://www.cabi.org/isc/datasheet/30800
14. http://www.cabi.org/isc/datasheet/30800

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infestations which converge in western New York and southern Ontario.[15] (If you would like to add your garden to the tracking map, use the reporting link on her website.)

Dr. Cappuccino's tracking map shows how the beetle has spread westward across the continent, as well as southward along the Atlantic coast. The beetle arrived on the West Coast (in Washington state) in 2012,[16] and has also been reported in Alberta.

One interesting aspect about the spread of the beetle is that in North America, it (so far) has mostly spread through temperate and cold regions, whereas the Invasive Species Compendium reports that it is native to Algeria and Morocco (as well as "present" in the Canary Islands).[17]

This is puzzling, because lily species appear to not have been native to these countries.[18] It's contradictory that the beetle would have been native in countries that didn't have their principle plant host, but it could well be that lilies were brought there during the Roman Empire (or earlier), thus making the beetle appear to have been native there.

Biological Control Methods

As discussed above, the beetles have few natural predators, even in their native range. Their main predators are the six species of parasitic wasps and flies. None of these wasps or flies are native to North America,[19] and no native wasps or flies appear to target this particular species of beetle.

TIM HAYE, UNIVERSITÄT KIEL/BUGWOOD.ORG

Parasitic wasp, *Tetrastichus setifer.*

Importing some of these wasp/flies into North America has been the principle focus of research and control efforts here. To date, three species of parasitic wasps have been released, and have become established in eastern North America.

As noted in Vol. 69 No. 2 of the NALS *Quarterly Bulletin* (p. 34), Dr. Elizabeth (Lisa) Tewksbury at the University of Rhode Island is conducting this research, and she is collecting samples of larvae to track new populations of the wasps as they become established. Please visit her website if you would like to help her track the spread of the wasps by sending her some larvae from your garden.[20]

Physical Control Methods

Physical control methods include

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15. http://lilybeetletracker.weebly.com/map.html
16. http://oregonstate.edu/dept/nurspest/RLLB.pdf
17. http://www.cabi.org/isc/datasheet/30800
18. https://en.wikipedia.org/wiki/List_of_Lilium_species. Based on: http://apps.kew.org/wcsp/namedetail.do?name_id=280381
19. http://web.uri.edu/biocontrol/sample-page/lily-leaf-beetle-larval-collections-2016/
20. http://web.uri.edu/biocontrol/sample-page/lily-leaf-beetle-larval-collections-2016-mailing-instructions/

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things such as using protective netting, hand-picking, traps, physical irritants, etc. These methods are obviously environmentally friendly, but they are work-intensive and not always practical for many gardeners.

Hand picking can be effective if you have just a small plot of lilies to manage (and lots of free time). In order for it to be effective, it must be done early in the season, thoroughly (i.e. remove all adults, eggs and larvae) and very diligently (i.e. almost daily). However, for most gardeners, this method will probably just lessen an infestation. It likely will not bring it down to truly manageable levels over the course of an entire season.

Because the adults drop off leaves quickly when they see movement, you have to act quickly to catch them before they disappear on the ground. I've found that the beetles are more sensitive to motion above them. Coming in from the sides or below seems to spook them less.

Many gardeners hold a cup of soapy water under the leaf with the beetle, and hope that the beetle falls into the cup, but because lily leaves are often curved it's sometimes hard to predict exactly where the beetle will fall.

My technique is to cup one hand, and move it slowly underneath the beetle so that my middle and ring fingers touch or straddle the stalk. This helps catch any beetles that might slide down the leave into the crook of the stalk before dropping off the leaf. I don't bother with carrying a container of soapy water to kill the beetles. I simply use my thumbnail to break the head off of the beetle's body.

Hand picking eggs is a tedious chore. First of all, the eggs are laid on the underside of the leaves, so one must crawl around and look under every leave to find them. The eggs have a somewhat hard shell, so it takes some pressure with a fingernail or a knife blade to scrape them off. Sometimes, it's just easier to rip off the top half of the leaf and crush it.

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While applying ashes to the leaves of *L. tigrinum* seemed somewhat effective in repelling lily leaf beetles, it is difficult to get ashes to stick to the narrow, curled leaves.

The fecal shield makes hand picking the larvae difficult and disgusting. The excrement is viscous, so it's very difficult to get a grasp on a larva with your fingers. Plus, it does have a little bit of an odor, and it does leave a dark stain on skin and fabrics.

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The cleanest way to hand pick larvae is to use a small knife (or popsicle stick) to push the larvae into a cup of soapy water. As mentioned above, it's easy to flick the larvae off of leaves, but they might survive and crawl to another lily stalk.

If I find a leaf with many larvae on it, sometimes I'll just rip off the entire leaf instead of bothering with removing the larvae one by one.

Some sources have reported that covering newly sprouting lilies with a mound of an abrasive substance can deter (and perhaps even kill) the adult beetles as they emerge, and the growing plants can also be dusted later in the season to kill larvae. The most commonly suggested abrasive is diatomaceous earth (which also is used to control other garden pests).[21] The theory is that the abrasive acts by scratching the beetles' wings so that they can't fly, and/or causing them to dehydrate.[22] Of course, abrasive powders must be reapplied after a rain.

It has also been suggested that wood ashes are similarly effective,[23] so I tried some on *L. tigrinum* that had grown to about 2 inches. The ashes seemed to somewhat effectively repel the beetles and grubs for a few weeks, but getting the ashes to adhere to the thin curved leaves was difficult, and it was rather unsightly.

Chemical Control Methods

Ornamental gardeners have traditionally relied on broad-spectrum insecticidal sprays to get rid of insect pests from their gardens (such as DDT, malathion, dieldrin and, more recently, pyrethrins).

However, with increasing awareness of the important biological roles that many types of insects play in the balance of natural ecosystems as well as in agriculture (e.g. pollination, pest control, etc.), people have become aware of the great harm that indiscriminate use of broad-spectrum insecticides does to the world's environment at large.

Thus, many gardeners (and farmers in general) are turning away from the use of broad-spectrum insecticides. This new sensitivity to environmental impact has led to a vast expansion of research (and a booming commercial industry) centered around "safer" and "eco-friendly" alternatives to the older broad-spectrum insecticides (i.e. less harmful to beneficial insects and the overall ecosystem).

There are a number of different approaches to using chemicals in a "safer" manner to control insect pests. Among them:

- Attractants, which lure pests away from gardens (and often into traps);
- Repellants, which drive pests away from specific ornamental areas;
- Soaps and oil sprays, which coat and suffocate the pests;
- Narrow-spectrum pesticides (i.e. which harm fewer species, and impact fewer beneficial species);
- Limiting the application of pesticides to specific areas (i.e. controlling wind dispersal, using it only in specific seasons, or at specific times of day, etc.);

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21. http://www.bdlilies.com/redlilybeetle.html
22. http://www.calgary.ca/CSPS/Parks/Pages/Planning-and-Operations/Pest-Management/Red-lily-beetle.aspx
23. http://digital.brentandbeckysbulbs.com/i/116108-2013-fall-2014-spring/67

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■ Using pesticides that break down more quickly, leaving less harmful residue; and

■ Using pesticides that interrupt only specific types of behaviors, such as how the insects feed, how they locate food sources, breeding behaviors, etc.

Additional important factors to take into account when determining how effective a given chemical might be on a particular type of insect (in particular situations) include:

■ Whether the chemical is effective on contact, or if it must be absorbed or ingested;

■ Whether the chemical immediately kills the insect, versus taking a while to kill it;

■ Whether the chemical must actually kill the insect, versus interrupting its reproductive processes (e.g. blocking a hormone);

■ Whether the chemical just sits on the surface of the plant's leaves, versus getting absorbed systemically into the plant's vascular system; and

■ How long the chemical remains active after it's exposed to air, sunlight, water, soil microbes, etc. This affects when it might need to be reapplied.

For example, if a chemical takes a while to kill the insect, it might not immediately appear to be effective, but if it kills them before they breed, it might be effective in the long term.

Similarly, a chemical that doesn't kill the adults at all but prevents them from breeding might appear ineffective. Its effectiveness isn't seen until later in the season or the following year.

Another example: A chemical which sits on the leaf surface but isn't absorbed into the plant systemically might kill leaf-eating insects but not affect insects that feed by sucking the juices out of the plant leaf.

One of the most popular types of eco-friendly insecticides are the insecticidal soaps, which kill insects mostly by suffocating them and/or breaking down the coating on their skin, causing them to dehydrate. Unfortunately, these soaps are mostly effective on soft-bodied insects.[24]

While many gardeners report soap sprays are effective against the lily leaf beetle, these reports are anecdotal, and I haven't seen any conclusive report that the soaps alone are actually effective over the long term.

As amateur gardeners have become interested in finding alternative "natural" insecticides, many have experimented with creating their own home-brews to try to combat various pests. This has also been the case with lily leaf beetles (possibly because most of the professional research has focused on controlling the beetle by importing parasitic wasps rather than with insecticides).

A wide variety of home-brews have been suggested by various sources,[25] including rhubarb extract, coffee (liquid and grinds), nicotine, peppermint, cloves, garlic and hot peppers.

In fact, many of these ingredients do have natural insecticidal properties, and many commercial synthetic insecticides

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24. http://www.cabi.org/isc/datasheet/30800

25. http://lilybeetletracker.weebly.com/map.html.

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are derived from chemicals naturally found in plants (e.g. pyrethrins).

However, there are important drawbacks (and even dangers) to experimenting with home-brewed insecticides. First of all, it's hard to know and control the concentrations of the insecticidal ingredients in home-brews, and it's easy to make a spray that will accidentally burn the leaves of the plants. In some cases, a spice that is harmless to humans when ingested can be toxic if inhaled in high concentrations (e.g. cinnamon).[26]

Some home-brews might appear to work in the short term but not actually be effective in the long term (as discussed above).

However, the opposite problem is even more problematic. Some of these chemicals (e.g. nicotine and rhubarb) are actually highly potent broad-spectrum insecticides, which are just as harmful to beneficial insects as synthetic chemicals like malathion.[27]

Using home-brews indiscriminately, without controlling the concentration and method of application, can actually be more harmful to the environment than using a synthetic chemical following the recommended (and tested) procedures.

On top of all of these factors, controlling lily leaf beetles by safe chemicals is made more difficult because of particular aspects of its life cycle:

■ Its quick drop-off behavior protects it (somewhat) if it senses nearby spraying motions;

■ The fecal shield protects the larvae from some insecticides that work on contact;

■ The beetle is very prolific (i.e. a single female can lay more than 400 eggs);

■ Its quick succession through different stages (i.e. from spring emergence of feeding adults, to mating and egg-laying, through four larval stages, pupation, and reemergence of a new generation) gives only narrow windows of time for any one type of chemical to be effective; and

■ The fact that the new generation of adults appear to disperse away from their birth site by mid- to late summer, thus escaping from the insecticides.

The combination of all of these factors together makes it unlikely that any single method (or pesticide) will completely eradicate the beetle in both garden and wild/native situations. Rather, complex pest situations like these are often best controlled by using a multifaceted approach.

Integrated Pest Management

Integrated Pest Management takes a holistic, environmentally friendly approach to controlling pests.

The University of California Division of Agriculture and Natural Resources defines it as "an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest

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26. http://oregonstate.edu/dept/nurspest/RLLB.pdf 27. http://www.cabi.org/isc/datasheet/30800

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control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment." [28]

IPM doesn't preclude the use of chemical pesticides; however, they should be used as a "last resort," starting with the least harmful pesticides first.

The concepts of IPM arose in the 1960s, largely in response to Rachel Carson's seminal book "Silent Spring." Interest in IPM has grown in recent years, as interest in organic and non-GMO foods has increased.

While IPM has been mainly targeted to commercial agriculture, many gardeners have adopted it out of general concern for protecting the environment.

As this article has indicated, the IPM approach applies to the lily leaf beetle in a number of ways:

■ IPM recognizes that total eradication of a pest is an unrealistic goal. Rather, the goal is to "manage" the pest, i.e. to keep it at "acceptable" levels that balance both economic and environmental factors.

■ In order to control the beetle, gardeners must understand its life cycle, and use a combination of control strategies at different times throughout the season.

■ Choose chemicals judiciously, and learn how to use them judiciously.

■ Learn more about which types of lilies are less attractive to the beetles so that breeders can develop new strains that will help control the beetles' reproductive potential.

The information discussed in this article, as well as the observations that I've made from my own research (which will be described in the next *Quarterly Bulletin*), lead me to the following suggestions about controlling the beetle using IPM practices:

■ It is very important that control methods be started right at the beginning of the season, to interrupt the reproduction phase of the life cycle. Once an infestation of larvae becomes established in a plot and does its damage, it becomes much harder to control the population.

■ Because the beetle reproduces so prolifically, control efforts must be thorough and diligent. This is especially true early in the season. If early season management is done effectively, you'll have much less work to do on it midseason and beyond.

■ Importing parasitic wasps is an important component in the overall control of the beetle. However, that alone will likely not be enough to control the beetle in garden situations, because the unnaturally high density of food resources in gardens allows a population of the beetles to produce many more offspring than they could in the wild. It's unlikely that the wasps will keep in check fecund beetles in gardens (especially if they have other beetle species that they can parasitize). However, we won't really know this for sure until the beetle becomes more established across North America and more data is collected.

■ However, the wasps will play an important role in protecting wild populations of

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28. https://en.wikipedia.org/wiki/List_of_Lilium_species.
Based on: http://apps.kew.org/wcsp/namedetail.do?name_id=280381

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our native lilies. Controlling the beetles on wild lilies is impractical for humans because of the sparse distribution of wild populations. Conversely, the wasps evolved (in Eurasia) to find the beetles' hosts in spite of their sparse distribution.

■ Even though we will rely on the wasps to protect our native lilies, controlling the beetle in our gardens will play an important role in protecting wild lilies as well. Because gardens allow the beetles to be unnaturally prolific, leaving them uncontrolled in gardens increases the likelihood that beetles will be able to find wild lilies. Even just a few beetles/larvae can decimate a stand of lilies within a season or two. Given the fragility of the populations of our wild lilies, gardeners must help keep the overall population of beetles as low as possible, so that the population of beetles doesn't exceed the capacity for the wasps to keep them under control in the wild.

Recommendations

While I didn't get fully conclusive results from all aspects of my experiment (and there are more aspects that I need to look at in future years), at this point I can offer the following recommendations as a protocol that gardeners can follow which might prove effective in controlling the beetle throughout the season (and reduce future generations):

■ As soon as your lilies begin to sprout, use diatomaceous earth to stanch the beetles as soon as they're emerging from hibernation. It can be applied in two ways: spreading it on the ground around the base of the lily (to scratch the beetles as they emerge from hibernation); or covering the short sprouts under a pile of the diatomaceous earth. Be careful to not inhale dust from the diatomaceous earth, because it will irritate your lungs.[29]

■ Diatomaceous earth should be used throughout the season, especially whenever larvae are found. It can be sprinkled or misted onto the plants (specifically targeting all larvae that are seen). It will need to be reapplied after each rainfall.

■ If you usually use a deer-repellant on your emerging lilies (and when the flower buds start forming), choose one with clove oil as an ingredient. As I will discuss in Part II of this article, clove oil seems to have some effectiveness at killing (or at least repelling) adult beetles. It's not as effective as other insecticides, but it does seem to be more effective at killing the beetle than other ingredients commonly found in deer repellants. If you're going to use a deer repellant, you might as well use one that also kills some beetles as well.

■ Hand picking should begin immediately as the lilies emerge. Again, it's critical to kill as many adults as possible before they lay eggs. Thoroughness and diligence are especially critical early in the season, and again at the start of the "second wave" (i.e. when the next generation of adults is emerging from pupation). This will cut down on next year's population, and also cut down on dispersion to wild lilies and other people's gardens. Continue hand picking throughout the season (but this will lessen considerably if you've been diligent early in the season). Yes, hand picking is tedious and unpleasant, but you can turn that around into something

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positive. Each time you go out and hand pick, you're giving yourself more time to enjoy your lilies.

■ Hand pick eggs as best you can. Sometimes it's easier to simply sacrifice a leaf (by tearing it off) rather than squash all the eggs.

■ Hand pick the larvae as best you can. Even if you can't bring yourself to catch them and squish them, "flicking" them off (and away from other lilies) might prevent some of them from successfully finding a new stalk to climb.

■ If you still find too many adults and/or larvae on you lilies that you can't control by hand picking and diatomaceous earth, you can (should?) resort to using a chemical insecticide. In line with IPM practices, the goal is to choose one which controls the beetles but impacts as few other beneficial insects as possible.

■ The preliminary results of my experiment suggest that an insecticide that contains spinosad might be the best option. Spinosad is a relatively new insecticide, and at this point there are only a few commercial products based on it; so you might have to shop around (perhaps online) to find one. You should use spray with spinosad at least once a week; the preliminary results of my experiment indicate that that might be sufficient, but I can't state that conclusively. In line with IPM practices, use as little of the spray as possible. Aim at any beetles/larvae you see.

■ Numerous sources also recommend neem oil as being effective against the beetle, and also a rather safe insecticide. However, there are different types of neem oil in different commercial products. If you decide to go with neem instead of spinosad, you need to choose a product that contains "cold-pressed neem oil" rather than "clarified hydrophobic extract of neem oil." (Note: If the product just says "neem oil," you can't be sure which one it actually uses!)

■ Furthermore, governmental regulations about the sale of neem oil "as an insecticide" in Canada are confusing, and it's likely that it will become harder to find insecticides with it for sale in Canada. (I will discuss this more in Part II of this article.) Given these factors, and given the preliminary results of my experiment, at this point I would recommend using spinosad rather than neem oil.

■ If you use a chemical insecticide, avoid using any of the broad-spectrum insecticides that are found in many of the common commercial products. These include imidacloprid, malathion, any of the pyrethroids (including pyrethrum and the "methrins," such as deltamethrin, cypermethrin, permethrin) and carbaryl. (There are many variants of these basic classes of chemicals, so also avoid similar-looking names!) Important note: I have listed the scientific name of the active chemicals. Some of them are known by different-looking brand names. You will need to read the details on the label to find the actual ingredients.

■ If you decide to experiment with making your own home-brew out of "natural chemicals," make sure that you do thorough research into the active compounds and their potential hazards (to both humans and beneficial insects). Nicotine, rhubarb extracts and many others can be just as harmful as synthetic

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broad-spectrum insecticides.

Summary

Integrated pest management is accepted as the preferred strategy to control insect pests. This is especially true for invasive species that can never be fully exterminated, such as the lily leaf beetle. IPM practices not only provide the most effective method of control, but they also are the safest to the environment.

It's important to remember that the goal of IPM is to keep the population of the pest down to acceptable/manageable levels over the long term.

The effectiveness of IPM might not be immediately apparent. In other words, don't expect the beetle to immediately (and totally) disappear from your garden.

Also, if a chemical insecticide doesn't appear to kill the adult/larvae immediately, that doesn't mean that it's ineffective. It might take a few days to take effect or it is effective because it prevents the insect from breeding.

Conversely, just because a spray appears to immediately kill an adult beetle on contact (because it falls off the plant), it might have only stunned the beetle temporarily, and the chemical might not actually be effective in the long run.

I plan to discuss the results of my experiment in more detail in the next issue of the *Quarterly Bulletin* as well as discuss other aspects of the beetle and its lily host that still need to be examined in more detail.

However, with the combined efforts gardeners (i.e. "citizen scientists") and the work of professional researchers, it's likely that we will be able to hone our approaches, thus protecting our native wild lilies as well as the lilies in our gardens.