

# Chapter **NINETEEN**

## **How To Win The War On Bugs**

### **In This Chapter**

- **Learning To Identify Pests**
- **What They Eat**
- **How To Keep Them Off Your Plants**
- **How To Kill Them Safely In Your AquaponiGarden**

### **You Like Eating What You Grow, And Bugs (And Other Critters) Do Too!**

One of the greatest things as well as some of the biggest challenges with any kind of gardening is that you are producing food. As a result, your AquaponiGarden is a sitting duck for all the hungry eaters out there that don't know how to produce their own food, but certainly know a good deal when they see it. These are all the myriad species of insects that think your AquaponiGarden was made just for them.

If your garden is always indoors, you should have minimal problems with pest insects eating your plants; this is because inside your house is not their natural habitat. Some bugs may get brought in with cuttings, or may fly or crawl in if you have your garden near a window with no screen on it, but this will still be minimal, and you may be able to get rid of them simply by picking them off. You will probably never need the other pest control methods in this chapter, unless you run into some really hungry, really committed bugs who follow you inside somehow.

If you're outdoors, in addition to bugs, you may also have birds, mice, rats, squirrels, rabbits, or deer trying to eat your plants. Setting traps or getting a cat are simple ways to control rats and mice. Deer and rabbits require fences. For birds, string up some "orchard netting", available at greenhouse supply houses. Squirrels are a challenge, and you'll probably need a shelter of some kind. You've got to outsmart them, and the pests are not at all lacking in intelligence!

This chapter is for you who have their AquaponiGardens outdoors, or who move them outdoors in the warmer months of the year. However, even indoors you need to keep a sharp eye on your plants, as bugs just might find them anyway!

## The “Golden Period” Before The Bugs Find You

When we first started our aquaponics system, we were utterly amazed by the fact there were simply no bugs! We had always heard how hard it was for organic farmers to fight pests, and were excited to find out that it was easier than we thought. In fact, we went so far as to mention this to a good friend, Donna Mitts, who had been an organic gardener her whole life, and even teaches it at a local school. She threw her head back and laughed out loud, then said, “Your farm is so new that they just haven’t found you yet!” Did she ever turn out to be right!

Here in Hawaii we joke about something called the “coconut wireless”, which refers to how quickly news spreads here in the Islands. Turns out the pests have their own coconut wireless, because first just a few showed up, and they sent out the word to all their friends and family. About a week later, all of a sudden we were absolutely overrun with bugs, thousands and thousands, and we had no clue what to do.

The thousands of aphids we could easily identify, and hundreds of caterpillars, but we had no idea where they had all appeared. And we did not even know what a lot of the bugs were! There were some insects we had never seen before, so we called Donna again, and she came over to check out our new bug zoo.

We remember seeing what we thought were cute little light green butterflies flying happily around our plants, landing gently on the leaves now and again. We learned from Donna that these pretty flying insects were in fact cabbage moths, and every time they landed, they were laying their eggs. Aha! That’s where all the caterpillars had come from!

Donna also identified solanaceous leafhoppers that were rapidly sucking the life out of our tomatoes, coating every stem, that looked just like rose thorns. She showed us leaf miners, which were leaving little trails through the leaf. She pointed out tiny little white flies that were leaving behind a terrible, sticky mess.

She told us about some organic solutions she used, but had no clue whether or not most of those solutions could

be safely used with our fish. So, in early 2008, we began our research, and decided to start by learning to understand insects better.

## What ARE Insects, Exactly?

Insects have lived on the planet Earth for about 350 million years, and have adapted to live just about everywhere, from the very hot to the ultra-cold. Insects have also found ways to turn just about everything into their home, including plants, animals, other insects, soil, water, snow, deserts, buildings, stored products, and people, and they’ve been just as creative in turning almost everything into food. And believe me, if we consider something edible, there are insects who do as well! Most insects are not pests, and are completely harmless, but some are a real problem when trying to grow food, as we were just beginning to find out.

## Characteristics of Insects

Insects are invertebrates, which means they have no backbone or internal skeleton, but they do have an exoskeleton (outer skeleton), in the form of an outer hard shell. Their bodies are segmented with three major body regions: the head, thorax, and abdomen. Adults have two antennae, two compound eyes, six legs, and - if they have wings - they’ll have either two or four wings. They come in a huge variety of shapes, sizes, and functions. Insects are cold-blooded (sort of - in insects, it’s not really blood); unlike mammals, which we are. Their body temperature closely follows the temperature of their environment.

Insects are different from mites, ticks, and spiders, all of which have only two major body sections, and four pairs of legs, and do not have antennae or compound eyes. Centipedes (ouch!) are also different than insects, with one pair of legs on each body segment, and millipedes have two pairs of legs on each body segment. Sow bugs are actually crustaceans, like crabs, shrimp, and lobster (yum!), and usually have seven pairs of legs...perhaps we should try sowbugs cooked with butter and garlic. If we got enough of them, that just might be a tasty dish!

## Insect Development

All insects develop from eggs. Most hatch after the egg is laid, but some, like the aphids, hatch within the female, and live young are produced. Aphids are almost always female, and are effectively hatched already gravid (pregnant), and each one begins hatching tiny aphids very shortly after her own hatching, which is why they can multiply and take over so quickly in your aquaponics system – their population grows exponentially! There are three basic kinds of insect development from the egg to the mature adult insect:

### Simple, Gradual Metamorphosis

Metamorphosis is the change from the egg to adult stage. Eggs hatch and there is a gradual change as the immature forms, called nymphs, mature to the adult stage. Nymphs have compound eyes and antennae and resemble the adults but are smaller, without fully developed wings, and cannot reproduce. Wings of the adult develop externally, and there is no resting stage, as there is with a pupa. Nymphs usually live in the same habitat as the adults. Grasshoppers, cockroaches, and aphids have a gradual metamorphosis, which is why you see small ones that look just like the larger individuals.

### Incomplete and Complete Metamorphosis

Some insects have a metamorphosis that does not include a resting stage, but is not simple and gradual; it is referred to as “incomplete.” Dragonflies are an example of an incomplete metamorphosis: their nymphs live in water, have gills, and differ dramatically in appearance from the adults; they emerge from the water and molt into the adult form with wings, without a resting stage. Occasionally, you’ll find a dried out, light beige, ghost-like shell of what is about an inch and a half long fierce-looking insect, near the edge of your troughs or on a plant. It’s the left-behind shell of a dragonfly nymph, after it has crawled out of the water to molt into the adult dragonfly that we all easily recognize. The shell left behind looks nothing at all like a dragonfly.

## Pest Insects And Their Relationships To Plants

If you recognize any of these insects on your plants, you have a problem, and you need to read the rest of this chapter to figure out the best way to control them:

- Grasshoppers, beetles, caterpillars, and slugs chew on leaves, stem, and fruit.
- Aphids, leafhoppers, thrips, mites, whiteflies, and scales suck plant sap.
- Caterpillars, rot and twig borers, weevils, and leafminers bore and make tunnels in plant tissue.
- Fruit flies and katydids lay eggs on plant tissue.
- Some wasps and mites create galls on plants.
- Cockroaches, whiteflies, ants, aphids, and caterpillars contaminate crops with their waste.
- Bagworms, leaf-cutter ants, and leaf-cutter bees remove parts of plants for their nests or shelter.
- Ants carry and protect pests (aphids in particular), and eat fruit and vegetable tissue.
- Aphids, leafhoppers, and ants transmit plant disease.

### Good Insects (AKA Beneficials)

If you see any of these insects on your plants, you do **not** want to kill them; they are good for your plants!

- Bees and flower flies pollinate flowers that produce fruits, seeds, nuts, vegetables and flowers.
- Honey bees, silkworms, and mealybugs create useful products such as honey, beeswax, silk, and dye.
- Ladybugs, praying mantises, lacewings, and some flies and wasps provide biological control as predators and parasites that destroy pest insects and weeds.
- Butterflies and beetles are colorful: they give us beauty, and are collected as a hobby.

A common way for gardeners to control pest insects is by introducing beneficial insects (lady bugs, praying mantises, and many more) that eat the pests into their gardens. You can purchase beneficial insects from special supply houses that ship them to you overnight in cardboard containers, if it’s not too hot or too cold. All you have to do is open the container and let them loose onto your garden; they do the rest.

However, these small aquaponic gardens do not provide much area for your beneficial insects to colonize and live in. For instance, if you purchase some ladybugs because you've got an aphid problem, the ladybugs will eat all the aphids in your small garden then fly away in search of more food. Unless your aquaponic garden is near an outdoors area with a fair amount of vegetation that will help "house" and feed the ladybugs, encouraging them to stick around, there's not much point in trying to use beneficial insects.

Smart gardeners who want to encourage their beneficials to stick around will find out what plants their natural habitats are and put a few of these plants in large pots around the periphery of the garden. There are whole books about techniques for using beneficials, and so it's beyond the scope of this book; we just wanted to let you know that beneficials are an option.

## Using Physical Barriers

Keeping the insects off your plants is the most effective way of keeping them from eating your plants. You keep crawling insects off by putting weed mat on the ground around your troughs; and flying insects off by putting floating row cover on over your troughs. Inside your house, a greenhouse, or a screen house will also provide protection.



***Weed mat effectively stops the growth of weeds - at least for a while!***

## Weed Mat

Physical barriers include weed mat to install underneath an aquaponic garden that is situated directly on the ground. Weed mat keeps weeds away from the sides of your troughs, and if you have a three- to four-foot open space around your troughs with no weeds at all, it becomes more difficult for pests to move from the weeds to your plants. You can buy weed mat at your local garden center or construction supply center.

We've found that laying down a layer of 6-mil black construction plastic under the weed mat works best. Here in Hawaii we have a 365-day growing season, and a lot of sunshine and rain, all of which combine to make fighting weeds an almost full-time job. Adding this plastic under the weed mat before you stake it down makes it virtually impossible for weeds to grow through the weed mat, whereas with weed mat alone, it's not hard for weeds to come through.

## Floating Row Cover

Floating row covers prevent pests from landing or crawling onto the leaves of your plants. It's really simple: if an insect pest can't touch the surface of a leaf, it can't eat it or lay eggs on it! Floating row covers are probably the best kept secret in all of organic food production. Row covers are basically just a very flexible woven screen fabric that lets as much light through to your plants as possible, and can be put over your troughs.

Look for a product that meets this description at garden stores and greenhouse supply stores. Because this product is usually sold in rolls of hundreds of yards by wholesale supply houses and manufacturers for heavy commercial use, your local garden store may not have "row cover", but you can sometimes find greenhouse "side screen" that is flexible and transparent enough to function as row cover. Get the screen that looks like it was made from clear fishing monofilament line, and has a screen size about the same as regular window screen, for it needs to let as much light as possible through. This is not window screen; window screen will not work well as row cover, because it is stiff and blocks a lot of light.

Floating row cover comes in different weights, with the heavier weights offering the advantage of creating a micro-climate where both heat and humidity are conserved, which translates to earlier and larger yields in cold weather.



*Floating row cover, available at garden centers. It's breathable, lets the sun through, and stops insects from laying their eggs on your plant's leaves.*

## Prevention

Preventing the problem of pests is always preferable to trying to knock down a large population that is already in place, and eating the food that you should be eating. There are many steps you can take that fall under the category of prevention. Here are some of the methods and controls you can safely use with aquaponics systems:

### **Diatomaceous Earth For The Prevention of Ants, Fleas, And Cockroaches**

Aphids are one of the main pests we combat in our systems. They show up quickly, and because they're almost all female clones, and they're already gravid (pregnant) when they hatch, they multiply VERY quickly. One of the easiest ways to prevent aphids from colonizing the plants in your system is to prevent ants from carrying them up onto your rafts, because aphids are transported and "milked" by ants. If you control

ants in the ground, you prevent aphids from taking hold in your system. You can control ants by spreading diatomaceous earth (DE) in a three to four-inch band just around the outside of your trough area, on top of the weed mat system we just described.

DE is the fossilized remains of diatoms, which were tiny sea creatures that lived millions of years ago. It is almost pure silica, along with some beneficial trace minerals, and enlarged under a microscope, it looks like shards of glass. On any insect that has a hard external shell (carapace), such as ants, the DE works its way in under the hard shell and punctures the insect's body, which then causes death by dehydration. Understand that DE is not an attractant, so you have to take the DE to where the ants live, they won't come to it.

DE is totally non-toxic, with no increased tolerance over time such as insects develop when using poisons, because the method of killing is purely PHYSICAL, rather than chemical. DE is great for use in your house as well, because fleas and cockroaches are affected in the same manner as ants, as they also have a hard carapace. Use a turkey baster to spread it easily along the sides of your troughs on the ground, and buy a lot of it. It keeps well (it's already millions of years old!) and it's not at all expensive. Amazon sells food grade, OMRI-approved DE in different sizes, and Earth Works Health sells a 50-pound bag for \$33, that's guaranteed to be less than 0.5% crystalline silica. Find it here, at their website: <http://www.earthworkshealth.com/>. You can also often find it at garden supply stores and farm and ranch supply stores in 5- and 10-pound bags.

### **Some important things to know about DE:**

- If DE gets wet, you must re-apply. If it gets wet, it loses its effectiveness. Even morning dew can be enough to render the sharp shards ineffective.
- Make sure not to breathe it! It's utterly non-toxic, but the rule remains – as with any substance – wear a dust mask to avoid getting these sharp shards in your lungs.

- Avoid DE that is made for pool filters. The kind formulated for use in pool filters has far more crystalline silica (which **is** toxic) because it has become crystallized by being super-heated. This type of diatomaceous earth is very **poisonous** if inhaled. **Avoid DE made for pool filters!**
- Avoid DE that includes toxic chemicals that causes the insect to become more active. These chemicals will speed up the process of killing the insect because the increased movement of the insect causes it to lose moisture and dehydrate more quickly, but it's toxic to your fish! A dead giveaway is a label that says "97% Diatomaceous Earth", with 3% some other chemical. **You want 100% DE.**
- Food grade DE is completely non-toxic because it is less than half a percent of crystalline silica and was intended to be added to animal feed. This means it is safe enough to eat and not as toxic to your lungs if you happen to breathe some in. In spite of it being completely safe for people and animals, it is very dangerous to insects. The insecticidal DE described below is required for commercial growers but is more costly, so for your aquaponic garden there is no need to purchase high-priced insecticidal DE when food grade is just as effective, and less expensive.
- Insecticidal DE is also food grade, 100% DE that has no added chemicals whatsoever. The crystalline silica content is also very low in this kind of DE, it's absolutely the same as food grade, with the only difference being that it has an EPA label allowing it to be sold as an insecticide. The EPA charges a tremendous amount of money to register a product with them, and hence the resultant products are usually also very expensive. If this is all you can find, it's fine to use, just the most expensive.



*Diatomaceous earth is excellent for use around your house. It is a wonderful, non-toxic organic pest control for everything from ants to cockroaches. Sprinkle it along baseboards and in cupboards, and*

*anywhere else that bugs are a problem. It's a great solution for household bugs as well!*

## **Boric Acid To Prevent Ants And Cockroaches**

Another similar method is to spread boric acid in the same way you'd spread DE. NOTE: "Borax" and "Boric acid" are not the same. Borax is  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ , or hydrated sodium borate, while boric acid is  $\text{B}(\text{OH})_3$ . To kill ants, roaches, or fleas, you need boric acid. But on a cautionary note, boric acid is **toxic** to children and pets if eaten. If you're using it on the ground, you should know that you are adding boron to the soil, and excess boron renders the ground useless for growing anything. It takes only a very small amount to be excessive - boron is actually considered an herbicide. For both these reasons, DE is by far the preferable material to use, and we do not recommend the use of boric acid to kill ants unless you are very careful, and know it will not be eaten by pets or children!

Boric acid is quite expensive from the pharmacy, but you can get far less expensive boric acid that is meant for killing roaches. It is available online if you can't find it in local stores, but Home Depot usually has it. "Victor" is one brand of boric acid that is made to combat roaches, and is commonly available at home and garden centers. Keep in mind this method is not for use on the rafts in your aquaponics system, but rather only on the ground where the ants and cockroaches live; this chemical will build up in your system and kill your fish and plants if you put it on your rafts or vegetables!

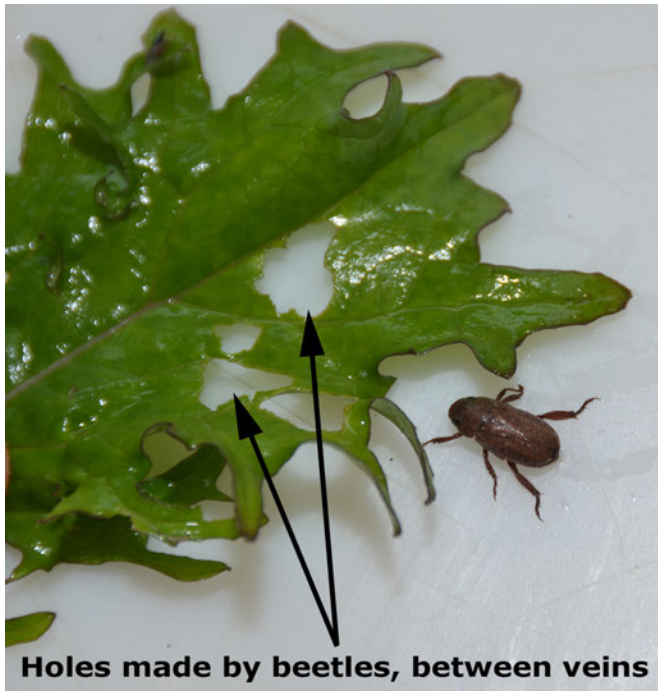
## **Orange Oil (Limonene) To Prevent Ants**

For killing ants outdoors, orange oil (d-limonene) kills on contact, as well as disrupting the chemical trails that ants follow (which is why they're always running along in a line, one after another). Mix 2 to 4 ounces of orange oil and a small squirt of soap in a gallon of water and drench the entire ant mound. You can find orange oil at some feed stores, or order it online (I get all my essential oils at Liberty Natural, <http://www.libertynatural.com>); it's quite inexpensive. Keep in mind this method is **not** for use on the rafts in your aquaponics system, but rather only on the ground where the ant colony lives; this is an oil that will stick to your fish's gills and kill them if it gets in the water.

## Lighting To Prevent Nocturnal Foliar Feeders

There's an elegant solution to keep foliar feeders, such as Chinese rose beetles, away from your aquaponics garden. And this mechanical answer makes your aquaponics system look wonderful at night! Depending on what ethnic group you belong to, we've heard these beetles called "Japanese beetles", "Chinese beetles", "Asian beetles", in Hawaii, as well as "Rose beetles". In the daytime, you will swear there is nothing visible eating your plants; this is because they hide under the ground level during the daytime and come out after dark to feed.

They did a lot of damage in our systems before we learned this simple trick, especially in our sprouting tables, where one or two cruise through and leave a wide swath of destruction, eating the tops off of hundreds of tiny sprouts. Rose beetles leave behind what are called skeletonized leaves – they eat the soft tissue between the veins, and leave the veins behind, leaving the leaf looking like lace. It's a distinctive pattern.



*Kale leaf skeletonized by Asian Rose Beetles, with the beetle on the right. Arrows point to the characteristic damage they cause.*

Below left is a photo of a kale leaf that's been attacked by Chinese rose beetles. They eat the leaves of a lot of different plants, including rose, grapes, beans, egg plant, corn, cucumber, ginger, and ornamentals. They have a life cycle that includes hatching out of eggs laid in the ground; swarming around the plants above where they emerged, eating everything in sight, mating, and then dropping back to the ground to lay eggs.

Because they swarm, feed, and breed most actively in the two hours after dusk, and hate light, the answer is to keep things lit up, at least for a couple of hours after the sun goes down. We strung a few strings of cheap white LED Christmas lights around the perimeter of our aquaponics systems, and over our sprouting tables, then hooked them up to a timer so they were on during the first two to three hours of darkness, and have never since had this problem. And it looks wonderful at night.

## Using Resistant Plant Cultivars

One main way of maintaining a healthy and vibrant aquaponics system is to use plant species and cultivars (varieties) that are well adapted to your local conditions and which show resistance to your local pests. To find out which cultivars to plant, talk to gardeners and farmers in your area. They'll tell you which varieties are best, as well as a wealth of other valuable information; they're almost always willing to "talk story" about their passion.

The technical term of these well-adapted plants is "host plant resistance," which means plant cultivars that exhibit less insect damage when compared to other cultivars under similar growing and pest population conditions. Host plant resistance is often taken to mean immunity to pest damage, but there's really no such thing as immunity. There are three main kinds of host plant resistance: **tolerance**, **non-preference**, and **anti-biosis**.

- **Tolerance** is when a plant survives or produces better than a standard variety with the same number of pests, or when insects can attack a plant without it suffering a lot of damage.

- **Non-preference** occurs when a cultivar is attacked less frequently than other cultivars, even though pests could choose to eat either variety. For whatever reason, some cultivars seem to be less “tasty” to insect pests, or may possess certain physical or chemical properties that discourage insect feeding or egg-laying.
- **Anti-biosis** is when a plant has physical or chemical characteristics that protect the plant from pests. For example, plants with tough stems or chemicals such as aromatic essential oils that repel insects are examples of anti-biosis in plants.

These factors may be outside your conscious awareness, but at some point you might have an insight or an “Aha!” moment, when you notice that a plant just generally grows or produces better than another cultivar. We’ve planted dozens of different kinds of tomatoes, for example, and two of them showed dramatically fewer pests than all the others. Those two have shown up all over our property as “volunteers”, growing here and there, doing very well on their own.

When selecting seeds, read the description in the catalogs for information on resistant cultivars that will grow well in your area. Check with your county extension agent, local nurseries, and other gardeners and farmers for best cultivars to grow. Over time, your experience with different cultivars will show you very clearly which ones are best suited for your aquaponics system. If you’re growing heirloom varieties, which we strongly recommend, you can save the seeds from the cultivars that do best in your system and won’t need to purchase seeds (this is why we have tomato “volunteers” on our property!).

## Control

When you notice that the preventive measures and physical barriers you’ve put in place are not working to keep the bugs away, pest control is required. The next step is what to do next to both effectively and safely get rid of the bugs.

Mechanical controls, like trapping or weeding, are always the very first action step to take. If the insect population continues to grow, then additional pest control methods will be needed, such as targeted spraying of biopesticides.

**WARNING: NEVER USE organophosphate or other conventional pesticides in or anywhere NEAR an aquaponics system; they will kill your fish. Period.**

**DO NOT USE even “approved” organic pesticides such as oil, soap, pepper, or wax sprays! They will build up in your system, and eventually kill all your fish! It just takes longer to get to the “Period”!**

## Mechanical Controls

Mechanical control includes the use of physical methods like picking off insects by hand. Handpicking of insects and insect eggs provides fast and effective control, and works particularly well with larger foliage-feeding insects such as tomato hornworms, potato beetles, and squash bugs. Mechanical control methods are pretty easy for a small aquaponics system, if you stay on top of bug populations! Preventive devices and barriers are often easy to use, but their effectiveness varies.

Mechanical controls include using a stream of high-pressure water to knock insects off plant stems and leaves. Make sure to use this tactic only on sturdy plants to avoid damage to the plant. You can also physically remove the individual leaves that are harboring the pest, if there are not too many of them, or remove an entire plant from the garden if necessary, as a last resort.

It works very well to use mechanical traps called colored sticky traps, which are used to control or monitor insects. Insects are attracted to yellow, blue, red, and white. The glue does not dry out and the traps will last until the surface area is completely covered with insects, even when rained upon. Some sticky traps have a grid pattern on them to help you count the stuck insects to better understand what bugs you have, and how many.

Additional mechanical controls are pheromone-baited traps that attract a certain sex, usually males, of an insect species, which helps reduce the mating population in the area. Food baits are also used in traps and usually attract both sexes.



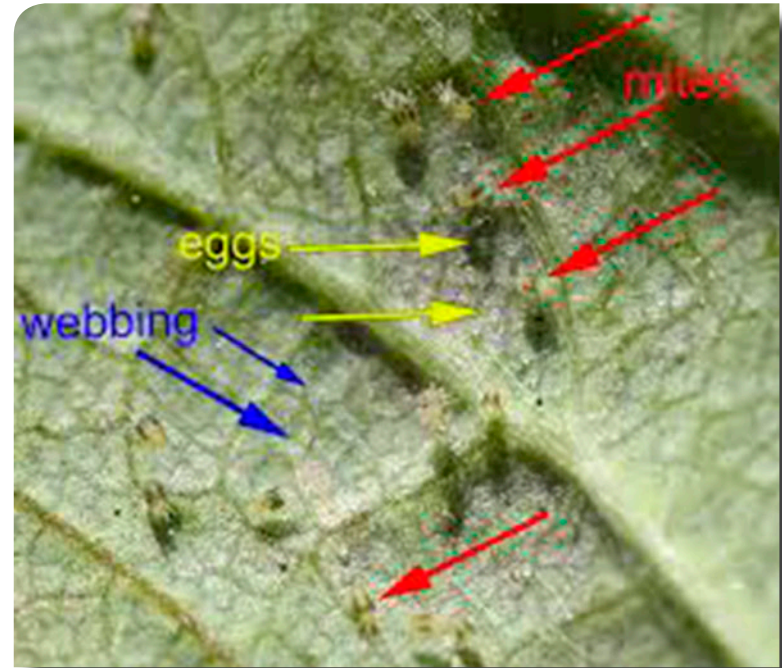
There are other physical traps that are effective at mechanically containing certain pests, which you can place strategically around your aquaponics system:

- A small pan placed flush with the soil and filled with beer will attract and drown slugs and snails.
- A thin copper tape (1-mil to 4-mil), and a half inch wide, applied to the perimeter of your trough's rim, will keep slugs and snails from crossing over into your rafts. Slugs and snails cannot stand to travel across copper. This tape is sometimes available with a sticky back from electronics industry sources, and can be stuck directly onto plastic surfaces with good results. It's expensive, but certain.
- A container, half-filled with a 10% solution of molasses in 90% water will attract and drown grasshoppers and some beetles. Adding a smashed banana or other fruit will improve the attraction properties.
- Many people recommend blacklight traps, which are broad-spectrum insect attracting devices, but studies have shown that the electrocution devices kill **more** beneficial insects than pests, so these are **not** a good solution.

### Temperature and Humidity Control For Spider Mites

Spider mites in particular prefer hot, dry conditions. Over 85°F/29.4°C will cause explosive growth in spider mite populations. Using a stream of water as mentioned previously will knock spider mites off, as well as increasing the humidity around the leaves, which also helps to bring spider mite infestations under control.

However, spider mites merely knocked off can survive and colonize nearby plants, so you'll want to take more aggressive steps unless the initial population is very small. You can also mist your plants daily to increase humidity. If you see evidence of spider mites at all, take immediate action. I cannot stress enough how difficult they are to suppress once they've taken hold in your plants! Spider mite damage shows up as unhealthy-looking, yellowish leaves, with tiny spots on the undersides. These tiny spots are the spider mites.



*Here's what spider mites look like, on the underside of a leaf.*

### Spraying Basics

- It is best to use any type of spray in the early morning or the cool of evening. Do not spray when temperatures are above 80°F/27°C! Your plants may "burn" or have a reaction to what you are spraying in hot temperatures known as "phototoxicity."
- Always perform a test on a small portion of your plants. Wait 24 hours and look carefully for any reaction to the spray. Proceed only if there is no damage.
- Really, truly...**more is not better**. If you are not getting good results don't increase the strength of these remedies without testing first!
- Target just the area you need to treat. Be careful and try not to harm the good guys! You don't want to run off your friends.
- When working with sprays or dusts always protect your exposed skin and face. Use a dust mask, and wear goggles. Some of these ingredients can be irritating to your skin, eyes, and nose, and mouth.

## DIY Bug Spray Made With Nightshade Leaves

To repel aphids and some beetles, as well as to attract some beneficial insects who will eat the pests, you can make a natural “nightshade” spray. Plants belonging to the nightshade family (tomatoes and potatoes) have compounds called “alkaloids” in their leaves. These compounds dissolve easily in water and can be extracted by soaking chopped leaves then using as a spray. The toxicity of the alkaloids are only part of their effectiveness. Scientific studies have shown that this spray also attracts beneficial insects that follow the chemicals in these plants as a cue in searching for their prey.

To make this simple spray, chop some tomato or potato leaves, add water until just covered, and soak overnight. Strain this mixture then add another an equal amount of water to dilute. Take out net pot or entire raft **out** of your AquaponiGarden and **spray infested leaves only**, paying special attention to their undersides. Spray only to the point of dampness, and do not let any of the spray get in your AquaponiGarden’s water.

Don’t let this spray get on your skin; some people are sensitive to the alkaloids. Wash it off immediately with soap and water if it gets on your skin, and **don’t get it in your mouth or eyes!** If you make more than you need, you can seal it in a zip lock freezer baggy, **label it clearly to make sure no one ever mistakes it for food**, and freeze it to use later. Wash your vegetables thoroughly before you eat them.

## BioPesticide Treatments

The following are treatments used on our commercial-scale aquaponics farm, and are mostly beyond what you’ll need. However, to inform you as much as we can about aquaponic gardening technology, we include information on the biopesticide treatments we use on our farm’s aquaponic systems.

If you elect to use any of these treatments, we can tell you that they work very well, but the packages are quite expensive, and far larger than you need for a small AquaponiGarden. However, the good news is, they will last a long time, as long as you keep the package tightly closed between uses!



## Definition

A **Biopesticide** is “a form of pesticide based on micro-organisms or natural products”. The US EPA states that they “include naturally occurring substances that control pests (biochemical pesticides), and microorganisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants)”. They are very safe, and “species specific”, which means that they provide extremely targeted pest control, and do not harm or even affect other organisms other than the ones for which they are designed.

### ***Beauveria bassiana*, strain GHA**

BotaniGard® 22WP is the brand name of a biological mycoinsecticide (beneficial fungus) that controls the juvenile (young) stages of whitefly, aphids, thrips, mealybugs, some beetles, and many other insects. It’s composed of a beneficial fungus called *Beauveria bassiana*, strain GHA, that controls even the most resistant strains of these garden pests. It’s **species specific**, only affecting soft-bodied pests, while leaving hard-shelled beneficials like ladybugs and preying mantises completely unharmed. BotaniGard is sold in one-pound containers, for about \$80.

Mycotrol®O is a biological insecticide that functions identically to Botanigard, except it’s organically-approved, and sold in liquid form. It comes in bottles as small as one pint for around \$65.

Both these products work very well on the soft-bodied insects they are designed to control, and don’t harm your fish at all. As with any spray that you purchase for use on your plants, follow label directions carefully, and remember to wash your vegetables thoroughly before you eat them.

**The following products are available in garden stores, and online. Talk to others in your area, to find out if any of the below plant diseases might be a problem for you:**

### **ActinovateSP®**

ActinovateSP® is the brand name of a water-soluble powder that contains a patented beneficial microorganism called *Streptomyces lydicus* WYEC 108. It's a natural product that effectively controls a wide range of both foliar (leaf) and root diseases. It's sold in 20-gram, 2-ounce, and 18-ounce sizes. This product is relatively new, and somewhat expensive (~\$100 per pound, or \$20 for two ounces).

ActinovateSP® controls many soil borne diseases including Pythium, Phytophthora, Fusarium, Rhizoctonia, Verticillium, late blight, and other root decay fungi, which can cause problems in aquaponics systems, even though there's no soil, because they can be transferred into the water or growing media. We plant seedlings and spray ActinovateSP® before the seedlings are transferred into the main system, onto the top of the coir/vermiculite mix. We also spray it to prevent the foliar diseases of powdery mildew, downy mildew, grey mold (Botrytis), Alternaria, fire blight (Erwinia), leaf spots and rusts, and black spot.

### **SERENADE Garden®**

SERENADE Garden® is the brand name of a broad-spectrum product made by AgraQuest, made from a "friendly bacteria" called *Bacillus subtilis* QST713. It provides protection against a wide variety of the most common fungal and bacterial garden diseases. It's completely non-toxic to bees and beneficial insects. It is very safe for your fish. One of the things SERENADE Garden® does is to cause plant responses that trigger the plant's ability to fight against diseases, like triggering its immune system. It's sold in liquid form, and is about \$20 for one quart.

SERENADE Garden® treats the diseases of Botrytis (grey mold), sour rot, downy mildew, powdery mildew, leaf drop, anthracnose, early blight, fire blight, bacterial leaf spot, bacterial speck, bacterial blight, black spot, leaf spots, canker, rust, scab, septoria, rhizoctonia, pythium, fusarium, and phytophthoras.

### ***Bacillus thuringiensis*, subspecies Kurstaki**

Biological insecticides, or biolarvicides, are based on another "friendly bacteria" called *Bacillus thuringiensis* (*Bt*) are the most proven, most widely used and most successful of the known biological pesticides against caterpillar pests (butterflies and moths). *BtK* kills dozens of caterpillar-type insects, with each *Bt* cell producing a unique crystalline protein which must be eaten by the larval stage (caterpillar) of the pest insect to be effective. Once eaten, very specific gut enzymes which only function in the high pH conditions in the gut of soft-bodied insects and caterpillars dissolve the crystals to form the active ingredient that disrupts the pest's digestive tract and kills them.

After consuming a dose of *Bt*, larvae stop eating within an hour, but usually remain on the foliage until they die, which can be two to three days. Affected larvae move more slowly and shrivel up and become discolored before dying, so it's easy to see how effective *Bt* is, even within the first 24 hours. *Bt* works very well against all crop-damaging lepidoptera (the scientific name for the family of moths and butterflies) pests.

It's very important that it's environmentally friendly, not harmful to bees, birds, fish, other wildlife, or beneficial insects. And, it's completely safe for our fish. In addition, *Bt* can be handled without the use of expensive protective gear you'd have to use with other pesticides.

Achieving good coverage during application is extremely important. Foliar (leaf) application of *Bt* provides excellent caterpillar control as long as you take care to cover the all the parts of the plant the pests will eat. Use a well-labeled spray bottle, and spray all leaf surfaces, even the undersides of leaves as much as possible, positioning the nozzle at different angles and using enough pressure to penetrate the foliage thoroughly. To maximize coverage, we spray when the wind speeds are 10 mph or less. The brand of *Bt* we recommend is called DiPel®, which is made by Valent Biosciences, and costs between \$12 and \$24 per pound online (check several sources, as prices vary widely).

## Other Aquaponic System Pests: Aquatic Snails

Although they are not strictly a vegetable pest, we have seen aquatic snails show up time and again in our fellow student's as well as our own systems. These snails live underwater and do not survive above water for any length of time. Fortunately, we haven't seen a variety yet that eats plant roots; the ones we've been infested with graze the algae off the sides of the troughs where the sun shines in at the edges of the rafts.

In early 2011, we discovered that Chinese catfish eat aquatic snails. Our systems had become infested with these snails because a farm intern had ignored biosecurity policies on the farm by bringing some aquatic plants in to our systems from PetCo. The snails came in with these plants, as eggs. Chinese catfish apparently do not bother the roots of the plants in the rafts. Here's how we determined this: we ran two tests: we put four 5-inch long catfish into a small tank with 200 snails, and four more into a second small tank with a small raft with plants in it; we didn't feed the fish in either of these two tanks anything during the duration of the test.

After ten days, there were only a few snails left in the "snail tank" that originally contained exactly 200 (we counted, to know where we were starting with), and the catfish in this tank had all grown noticeably fat and larger. In the "raft tank", the plant roots were untouched, and (of course), the catfish were all the same size they had been when they went in. We are now testing this on a larger scale with 100 catfish in one of our systems to make sure there are no other problems, but the catfish appear to be a natural biological control for the snail problem, and function to keep the snail population in check.

A further benefit here is that the catfish will be an additional edible product of the system, not requiring to be fed by us. We probably need to match the amount of catfish to the size of the troughs they go into so that the catfish's need for food is balanced by that trough's ability to supply food (snails). In other words, if we put the right amount of catfish into a trough, they will control the snail population and we will not be required to feed them commercial fish food that we have to pay for. They will not breed in the troughs, unfortunately, but we can still work that out as time passes, like we did with tilapia breeding.

## Plant Pest Identification Aid Resources

[http://www.ipm.ucdavis.edu/IPMPROJECT/about\\_urban.html](http://www.ipm.ucdavis.edu/IPMPROJECT/about_urban.html) - The University of California Statewide IPM Program provides practical information on pest management techniques and identification for a broad range of California pests. Pest control suggestions apply to California, are useful in other areas also - these bugs don't recognize state borders!

<http://vegipm.tamu.edu/imageindex.html> - this site has color photographs of insects common to the vegetable garden, grouped into groups to aid in identification. Detailed information describing the insect and how it damages plants. You can search the vegIPM database for cultural, biological and chemical controls for the pest.

**Remember that both these websites - and others - will offer solutions for dirt gardens, and you have to remember everything you've learned in this chapter and ask "how will this affect my fish?"**



**A yellow sticky trap. Hang these above your AquaponiGarden, to get an early warning when bugs show up to eat your food!**

## Good Bugs

The main friends that we've seen show up to help us combat the bugs that want to eat our food have been lady bugs and praying mantises. Don't accidentally think they're pest species. They're the good guys!



*Above: Baby praying mantis, The Garden Assassin! To the right, the egg casing that the female leaves behind, usually glued to a plant stalk. It contains 100-200 mantis eggs, which all hatch at the same time.*



*Clockwise, from top, left column: Red ladybug adult; Yellow ladybug, eating an aphid; right, a larvae, recently hatched from egg; above, orange, cylindrical eggs, under a tomato leaf.*

### Aquaponics Is EASY When You Remember:

- That there are insects who will eat your food just as eagerly as you will.
- The difference between the methods of physical barriers, prevention, control, and biopesticide treatment, and when to use each one.
- That to control pests, you must **never** use any conventional pesticides; and not even organically-approved pesticides that contain oils, soaps, wax, or hot pepper; because they will kill your fish.
- The acceptable pesticides that **can** safely be used on top of your vegetable troughs. They won't hurt the fish or plants in your system.
- Which acceptable pesticides can safely be used outside your vegetable troughs, on the ground below them, and surrounding them, as long as you make certain none gets into your AquaponGarden's water.