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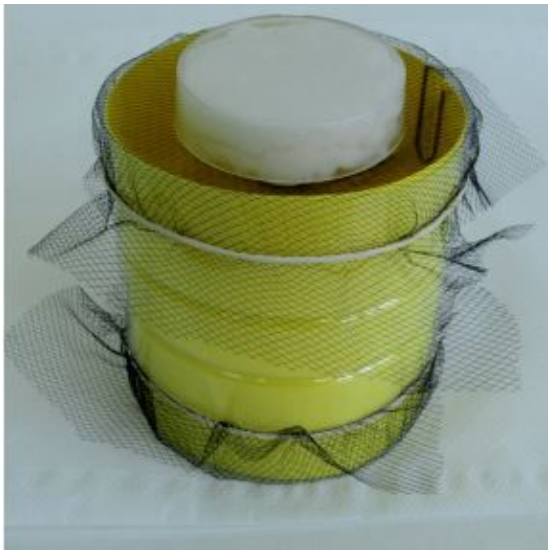
SOS: Food & Ag
Winter 2018

Small Scale Rearing of Lacewings, Predatory Mites, and Entomopathogenic Nematodes

Green Lacewings (*Chrysoperla carnea)*:

This is the most succinct small scale production technique I have found. It uses easily accessible feeding materials, as well as inexpensive materials to create enclosures. It could likely use some adaptation to efficiently store the containers, however for my purpose this method should do well.



Adult Lacewings are held in containers made from plastic bottles, cut to 80mm x 100mm. The inside of the cylinder is lined with yellow cardboard, and then the tops are lined with tulle mesh (1.4mm openings)

A half petri dish filled with cotton wool sits on top of the mesh, and it should be saturated with water however not dripping.

Each one of these containers can hold up to four pairs of lacewings.

Environmental Conditions:

Temperature	**20 ± 2°C**
Humidity	**65 ± 5%**
Photoperiod	**16:8h**

Food: Adult lacewings are fed honeybee pollen loads. About 300mg is place at the bottom of each cage.

Larvae are fed mealworms (*Tenebrio Molitor*). These can be provided already dead to simplify this process. I will either rear these mealworms (which is easy, I have done it on accident before in my terrariums), or buy them. They are widely available as pet food. A drop of sucrose solution should be provided for newly hatched larvae as well.

Each larvae is fed three mealworms per week, or sooner if they manage to eat them quicker. Whenever they eliminate their food they should be given more.

Here is a table to determine what size mealworm to feed each instar. I should be able to do this by sight after some experience.

Instar	Size (mm)	Weight (mg)
1	4-5	.5 -1
2	6-8	2-4
3	9-12	6-12

Storage: Lacewing eggs kept at 8°C are viable for a few weeks, so if I am shipping eggs, it will be important to send them in insulated containers with cold packs. Larvae will need to be somewhat isolated to prevent cannibalism; providing them food within their storage or feeding them before they are shipped can help prevent this to some extent. Overnight shipping with cool packs should be enough to do the job here, and if I am selling them to a distributor or client locally it should be easy enough to store and transport them.

Eggs will be held in a bran medium when they are stored, and they can be distributed this way. I am going to experiment with other application and storage techniques though. Some companies ship them on cards, which you then simply place out.

Conclusion:

This method is simple, but straightforward. Many of the materials required are recycled (water bottles), and the enclosures are entirely inexpensive to create.

There is no listed enclosure developed for larvae, and they must be house separately. This will be something I need to develop on my own, however a plastic box with many cells would likely be a good enough solution.

Also, the individual enclosures will need to be optimized. A larger container that fits many of them may solve this, just so many containers could be moved at once. This should be easy enough to set up.

While it is unlikely that I can use this method to sustain a population of lacewings that is commercially viable, if it is optimized, with larger and more compartmentalized enclosures, it may do the job. Either way, it should be an easy enough way to get my feet in the water.

I'm going to look into gathering materials for this, come up with how much it costs to create them, and make sure I have a few for the beginning of next quarter.

Predatory Mites:

Common Biocontrol Mites:

Amblyseius swirskii- Useful for thrip control in warm, humid climates.

Phytoseiulus persimilis- An obligate spider mite predator (Tetranychus spp.), especially useful against two-spotted spider mites, Tetranychus urticae. This can be disadvantageous, as if prey is unavailable they are unlikely to survive.

Amblyseius californicus- Active mites that feed on Tetranychidae. They are less specialized than *P. pesimilis*, and will feed on other arthropods or pollen, making them more survivable.

Amblyseius degenerans- Aggressive towards thrips, with a tendency to establish on flowers. They will also consume spider mites or pollen.

Amblyseius cucumeris- Most useful in western flower thrip control. They typically consume the first instar larvae. Additionally, they feed on pollen and other mites.

Hypoaspis miles- A soil mite, which feeds on fungus gnat larvae, springtails, and thrips in their pre-pupae and pupae stages.

Rearing Protocol:

In some methods, a host plant is provided with an established pest population.

In this method, a specific prey mite is used, and there is no host plant necessary. The species of mite is *Thyreophagus entomophagus.* It is fed a carbohydrate yeast based diet (>5% sugar), which is then added to bran (20% diet to 80% bran). This can be variable in size, with the patent citing 30mL-10L. These containers should be vented with 60 micron nylon mesh disks. The proper temperature is 15-30°C (28°C is ideal), while the proper humidity is 70%-90%. This is ideal because the predator mites and prey mites can all coexist in the bran, and when the medium is also useful in transporting predator mites on crops (by lightly sprinkling the bran onto them).

Thyreophagus entomophagus is a particularly notable food source, because it doesn't display defense behaviors other prey mites do, such as alarm pheromones. It is also relatively inactive and will not move if it has a food source, making it less stressful for the various life stages of the predatory mites.

Predator:prey ratios are important to think about. Many other prey mites have 1:4 - 1:10 ratios, however *Thyreophagus entomophagus* requires more, ideally 1:30 - 1:70, with at least a 1:50 starting ratio.

Conclusion:

This would be an effective method to attempt, and if I could establish both the pest and prey colonies it could be lucrative, cheap, and done at a small scale. Also, it can be used for many species of mites with different strengths and weaknesses, and doesn't require a host plant, which causes more time and space restraints.

I would need to pick a proper food mixture, and the patent describes some that would be suitable, however this may be worth a try.

Entomopathogenic Nematodes:

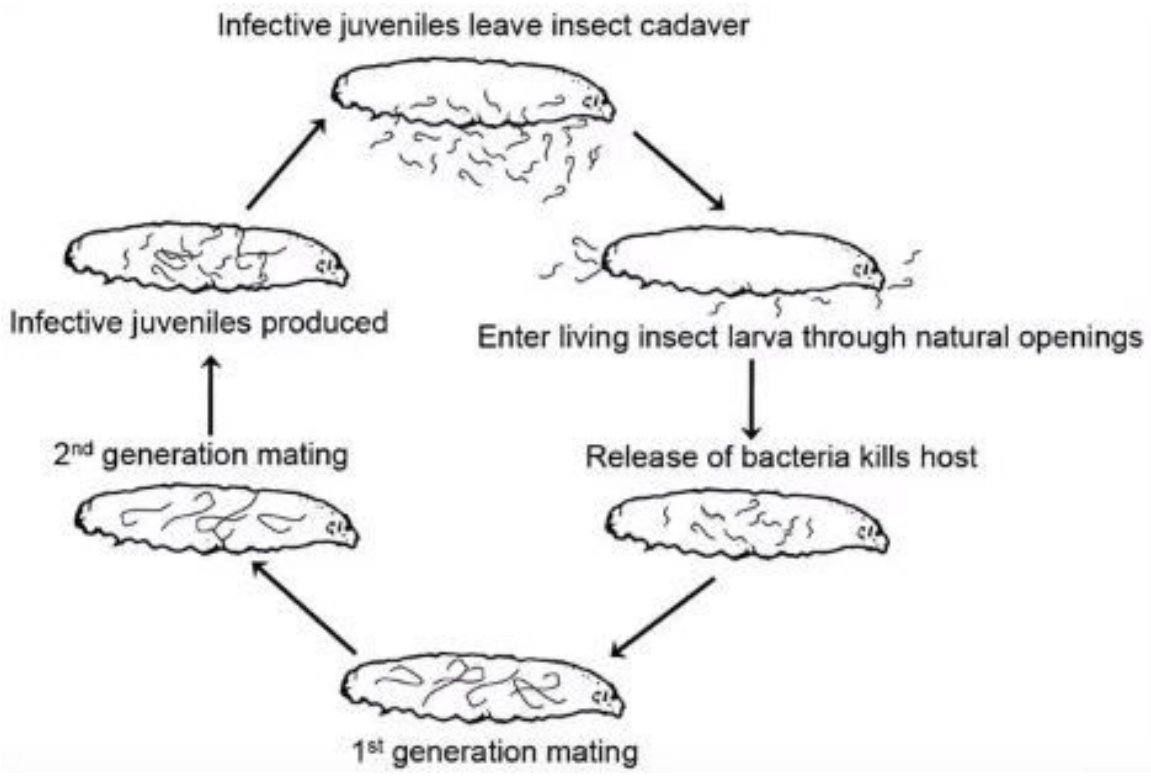
Nematodes can be a very useful tool for controlling soil pests. They are semi-microscopic unsegmented roundworms, and entomopathogenic species attack insects.

This method is based on this video from MSU, and the photos of the method are taken from said video.

Life Cycle:

Entomopathogenic nematodes leave their cadaver host as infective juveniles. This is the only stage in their life when they are active and mobile. They enter through natural holes inside insects, such as tracheae or the mouth, and then enters the hemocoel. They then release a

symbiotic bacteria that kills the insect host in 24-48 hours, and the nematodes continue to eat, mature, and mate for some time. Infective juveniles are produced and the cycle repeats.



Required Materials for Rearing:

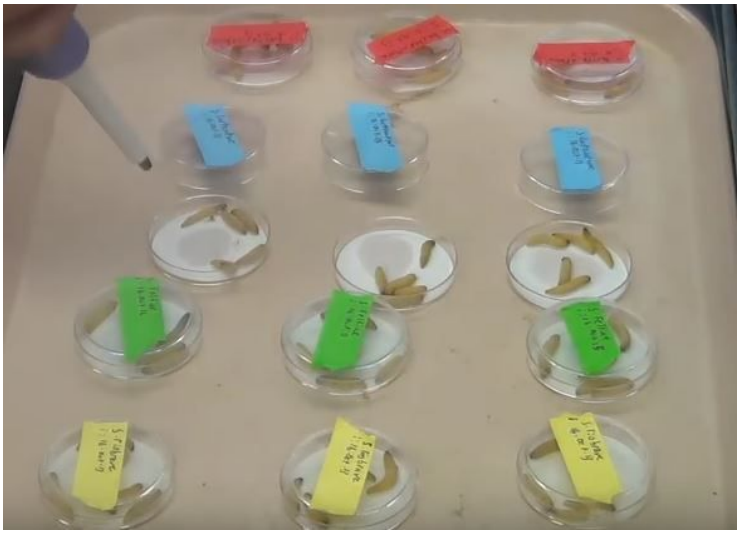
- 10x magnifying microscope or hand lens
- 0-200µL micropipette or syringe
- 100mm & 60mm petri dishes
- 60mm filter papers or paper towels
- 500mL Erlenmeyer flask or mason jar
- 1L tissue flask
- Wax moth larvae

Rearing Process:

1. Colony Assessment and Population Density Count: In this step, you want to find out how many nematodes there are per µL of solution. Place a volume (e.g. 50µL) of the

nematode-water mixture into a 60mm petri dish with a grid pattern, then fill it with deionized water until the bottom is covered. Use a microscope or hand lens to count the number of living, moving nematodes, and repeat this at least 3 times, with the same volume of solution. After doing that, take the average number of nematodes per µL by dividing your average count by the volume you use (50 µL in the example).

2. Host Infection:



A 60mm petri dish with a paper filter at the bottom holds the hosts and nematodes. Each dish fits 5 wax moth larvae (*Galleria mellonella).* The ideal number of nematodes per host is 20, so you should use your calculation from earlier to make sure you know the correct volume to add. Use your micropipette to put the nematodes into the center of the dish, then add ~1/2 ml of deionized water so that the nematodes have solution to move around in. Next, cover the petri dish, and label the nematode species and infection date. These should then be stored in a dark location at room temperature for a week. Each host should provide 25,000 - 100,000 infective juveniles.

3. White trap: The 60mm petri dish described above should be placed into a 100mm petri dish, which should be slightly filled with deionized water. Any alive or diseased larvae should be removed. The color also should be correct; depending on the species of nematode, this may be beige or red. This can then be covered and placed in the same place as the infection period for about 3-4 weeks.

4. Harvesting Reared Nematodes: After waiting 3-4 weeks, you can discard the infected hosts from the 60mm dish. The larger dish will be filled with nematodes, giving it a white slurry appearance. This solution can be poured into the tissue flask. Depending on how successful the rearing was (a hand lens can be used to see how many nematodes are present), you may want to continue to add nematode cultures to this flask, or split them into another. After the satisfactory amount of nematodes is added, add deionized water until the flask is at its max fill line. At this point, the nematodes should be clearly visible inside the solution.

Storage: Short term storage can take place in a dark room. They must remain here for at least 3 weeks before they will be ready to infect new hosts, and can remain this way for up to 2 months. Long term storage can happen in a refrigerator, or by using an airstone and an aquarium pump to aerate the nematodes. Steinernema spp usually can live 6-12 months, while Heterorhabditis spp can live 3-6 months.

Application: They should be applied directly to moist soil. A backpack or airblast sprayer can be used, as long as all filters are removed. Juvenile nematodes will clog them otherwise. Apply in the morning and evening, while maintaining soil moisture. It should be 68-86 degrees F, with soil pH between 4 and 8.

Conclusion: While this method is not ideal for large scale rearing, it is very useful at a small scale. It only uses a few tools and can be done without significant labor, is easily stored, and can be applied quickly enough. Connor has expressed interest in these and I plan on attempting it next quarter. I will need to make sure everything is done organically so they can be used on the farm, and I may need to produce them there so they are certified.