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Raising Beneficial Insects for the Control of Longtail Mealybug and Brown Soft Scale in the Fernery

Jean Marie Gauthier

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Author: **Jean Marie Gauthier - Plant Protection Intern**

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Abstract:

Longtailed mealybug (*Pseudococcus longispinus* Targion-Tozzetti) and brown soft scale (*Coccus hesperidium* Linnaeus) are two of the most abundant pests in the Morris Arboretum Fernery. Targeting these two pests, I chose to research methods of raising beneficial insects for biocontrol. Culturing beneficials requires the culture and study of the host insects and growing enough plant material for them to thrive in a quarantined environment. Only when a healthy population of hosts has been raised can the culturing of beneficial insects begin. A small population of the beneficial wasp *Metaphycus flavus* Howard was reared from my population of brown soft scale and released into the Fernery. This project will continue after my internship at the Morris is completed; in the fall when I return to my graduate program in Seattle, Washington I plan to complete the culture of plant material, hosts and particularly the culture of an additional encyrtid wasp parasitoid that requires longtailed mealybug to reproduce. With luck I shall be able to send beneficials by mail for release into the Fernery in several months.

TABLE OF CONTENTS

INTRODUCTION

The Morris Arboretum Fernery is a unique environment, showcasing a huge assortment of diverse fern species. It is highly appealing to visitors throughout the year, because it mimics stepping into another world with its primitive and overwhelming greenery. Ferns are known in general as plants with few pests and diseases, though in interiorscapes several pests flourish due to an elimination of predators and the addition of high relative humidity. These conditions extend many pests' natural life cycles so multiple generations occur though they would not normally in their native habitat outdoors. Ferns are often susceptible to phytotoxicity when chemical controls are used. While I have been monitoring the Fernery, the pests of greatest concern are longtailed mealybug (*Pseudococcus longispinus* Targion-Tozzetti) and brown soft scale (*Coccus hesperidium* Linnaeus). Both of these sucking insects are in the superfamily Coccidea, and are known for having physical and biological characteristics that make them difficult to control.

DESCRIPTION OF PEST OBSERVATIONS

Mealybugs have waxy secretions that cover their bodies. This wax serves as protection against chemicals that are sprayed on them. Sexual reproduction rather than parthenogenesis is the normal mode of increasing the population and adult males are small, flying insects that may be mistaken for a small fly or gnat. Some species of mealybugs, such as the common greenhouse pest, citrus mealybug (*Planococcus citri*), lay eggs in a mass of loose cottony wax, protecting them from dehydration, predation and the application of sprays. Longtailed mealybug does not create waxy egg masses but does produce a lot of wax to protect the young crawlers. This mealybug is oviviparious, meaning it lays eggs that immediately hatch, a reproductive strategy similar to giving birth to live young (viviparity). The adult female longtailed mealybugs appear to 'tend' their young by coating an area around a leaf axil or crevice with loose cottony wax, blocking access to the young from the outside with their bodies, and moving minimally to feed. In contrast, the foraging adults observed that are not tending young are mobile and move along stems and onto other plants while feeding (Johnson and Lyon 1991; Cranshaw 2004; Triplehorn and Johnson 2005).

It takes some time for the instars to move away from these protective cottony clumps. For a relatively brief window of time while searching for food, the crawlers are not covered in wax. If contact sprays were applied while either the adults or the hatch location's waxy secretions do not protect the crawlers, control would be relatively successful (Johnson and Lyon 1991). Longtailed mealybugs also prefer to move along the undersides of leaves or on interior stems, making them less obvious and easy to miss if the interior of a plant is not examined thoroughly. Chemical control is difficult unless systemic insecticides are used. In sensitive environments with additional restrictions (i.e. proximity to fish, areas open to visitors and children, plants that react adversely to chemical sprays), cultural and biological controls become the methods of choice.

Brown soft scale, like longtailed mealybugs, appears to tend their young. Reproduction commonly is parthenogenic and male insects are rarely seen. The female scale changes from a soft, flat and pale insect to a hardened, more convex form with dark brown vein-like markings. Underneath the shell of the hardened females are numerous red crawling young, which mature in a brood chamber. Brown soft scale are also oviviparious, and eggshell remnants are usually visible when female scale are flipped over and the newly hatched young are observed (Stimmel 1987). The crawlers seem to remain underneath the adult for some time, even though they are potentially mobile. I could not find information as to whether they are merely being protected at this state or whether the adult is somehow providing them with food. Eventually they migrate away in search of appropriate plant strata to permanently attach to for feeding. Again, it is at this crawler stage they would appear more vulnerable to contact sprays, not having developed the more protective exterior shell of a settled scale. The literature suggests that brown soft scale can protect themselves against some of their enemies by coating newly laid parasitoid eggs with honeydew (Gauld and Bolton 1988; Schweizer et al. 2002). This is known as encapsulation. Brown soft scale has a much smaller list of natural enemies than longtailed mealybug, and few of these are ever available commercially in the United States.

Both longtailed mealybug and brown soft scale appear to derive survival benefits due to the developmental time they spend protected by the females and the overlapping life cycles that occur in an interiorscape environment. They are two of the most persistant and difficult to control pests in greenhouses.

EVALUATION OF PREDATORS AND PARASITOIDS

A predator with a well-deserved reputation for effectiveness against mealybug outbreaks is the coccinelid beetle, *Cryptolaemas montrouzieri* Mulsant. This coccidophagus species is popularly known as the mealybug destroyer. Its larvae in particular are voracious predators, crawling rapidly around the environment and searching out all instars and adult mealybugs to feed upon. Interestingly, it has been reported that fourth instar larvae (and possibly the previous instars) perceive their prey only by physical contact. Adult 'crypts' also are said to feed on scale, but far less preferentially. They do, however, detect their prey by visual and chemical stimuli. At a distance of 14mm, an adult will stop and 'jump' towards its prey. Since this species is so voracious, it is difficult to keep a large enough population of prey available for rearing purposes. Though available through commercial sources, mealybug destroyer is costly and fluctuating populations often prevent its availability for purchase. Preparing an artificial diet for mealybug destroyer has been attempted and met with little success, implying that mixtures such as meridic or oligidic diets where components may include honey, yeast, royal jelly or liver are missing substances required by this species for proper development, despite containing most of the known necessary nutrients. Meridic diets have only minor amounts of natural substances added while in oligidic diets they supply most of the dietary requirements. Some success has been achieved in rearing mealybug destroyer by using lepidopteran eggs, particularly the species *Sitotroga cerealella* and *Chloropulvinaria psidii*. These lepidopteran eggs are considered "unnatural" essential preys since the mealybug destroyer would not encounter them under natural conditions because of different habitat specificity or lack of seasonal synchronization. They have the advantage of being easy to be cultured in the laboratory in large quantities with minimal investment of space and resources (Hodek and Honek 1996). Another factor in rearing and effective release into an environment is the mealybug destroyer's sensitivity to temperature. It will not control pests effectively in environments below 60 ^{0} F. Optimally, it forages and reproduces best in temperatures of 71-77 ^{0} F (Flint and Dreistadt 1998).

Adult coccinelids are strongly influenced to move upwards in interiorscapes and migrate out of vents. There are now several cases of ladybird beetles that were introduced through biocontrol programs and have become pests for homeowners. Large quantities of some species will seek out attics and other spaces to hibernate, and then as the temperature increases, they come crawling out of every crack in the house. Many species have also displaced native coccinelids, yet non-native beetles continue to be sold as an "ecologically friendly" alternative to chemical control for landscapes. Beetles that are harvested in hibernation at a high elevation usually migrate out of the purchasing homeowner's yard; they instinctually know that when the temperature warms up, they are supposed to fly a certain direction towards a lower elevation. Unfortunately this is often into the ocean if they have been moved from their natural habitat and their sense of direction confused (Flint and Dreistadt 1998). Presently mealybug destroyer has not yet been found as a pest in the environment, however the adults do try to find their way out of interiorscapes and populations often need to be replenished. While it is not inconceivable that it could establish in landscapes in more subtropical regions, it has a reputation of declining and needing supplementation when used for biocontrol programs in citrus orchards (Hodek and Honek 1996; Goolsby personal comm. 2005).

Due to this temperature requirement and the tendency for adults to escape, I felt mealybug destroyer, though an effective longtailed mealybug predator, should be supplemented with a hardier natural mealybug enemy. In my personal communications with John Goolsby, who extensively researched beneficial control of longtailed mealybug for his doctorate degree (1994), he emphasized that an interiorscape program focusing on using *Cryptolaemas montrouzieri* alone would suffer from their propensity to fly upwards towards light in search of higher density mealybug populations. He felt that citrus mealybug is more effectively controlled by mealybug destroyer, perhaps because mealybug destroyer also eat the egg sacs of this species, whereas with longtailed mealybug the eggs hatch immediately and for the crypts pursuing multiple crawlers is less effective (Goolsby personal comm. 2005).

There are numerous sources suggesting the ideal interiorscape mealybug and scale controls are tiny parasitic wasps of the family Encyrtidae (Gauld and Bolton 1988; Goolsby 1994; Flint and Dreistadt 1998; Triplehorn and Johnson 2005). Goolsby's work (1994) focused on three encyrtid species known to control populations of longtailed mealybug. He stated that encyrtids tend to stay in interiorscapes and establish long term populations that do not require supplemental releases. He feels that though encyrtid wasps also have a reputation for being difficult to rear, they actually require fewer mealybugs to produce large populations of beneficials in cultures. Beneficial wasps are more difficult to find grown by beneficial insect companies, yet they have a reputation for being highly effective. I felt learning to culture these wasps could provide the Morris Fernery with a solution to long-term and more self-sufficient pest management.

METHODS AND MATERIALS: LONGTAILED MEALYBUG

The first step in culturing parasitoid wasps was to establish thriving host populations of both mealybug and scale. These pests had to be cultured in an environment where they would not become a danger to valuable plants being grown for the living collection. Interestingly, though these are very common pests, there is relatively little literature available on how to culture them. Every source I found recommended different methods. Raising insects appears to be individually tailored to each species and situation. Trial and error as well as creative tinkering play major roles. Longtailed mealybug has a reputation of being harder to culture. However, I was successful in growing a thriving population of longtailed mealybug in a growth chamber on organic sprouted potatoes. The parasitic wasps I plan to culture are highly specialized and may only be able to reproduce when provided with the required host species. I felt it was worth the effort to focus on growing both longtailed mealybug and brown soft scale rather than 'easier' possible hosts.

My first mealybug set up, started in mid-October, imitated Douglas Walker's methods (Walker 1999) where sprouted potatoes were placed on top of canning jars in a moat of saturated potassium nitrate. Several plastic tubs with canning jars were placed inside a Percival I-35LL growth chamber set to 24 ^{0} C and 18 hours of light per day. After recovering living mealybugs from the moat and having fungal hyphae appear several times in the potassium solution, I abandoned this method in late November. I began removing sprouts from the potatoes and tried culturing mealybugs on the sprouts in petri dishes housed in opaque ventilated Rubbermaid storage boxes. Soon afterwards I was able to find less opaque storage boxes to increase the level of light for the insects. I piled up sprouted potatoes in a mound inside a 9.5" x 15" x 6" clear acrylic shoe box with 2" screened holes drilled in the lid. A sponge soaked in water was placed on a petri dish inside the box to provide additional humidity and rewetted on average every three days. I kept a small humidity reader inside the boxes to check the overall humidity. As the potatoes rotted or became covered in insect honeydew, I would transfer mealybugs to fresh potatoes.

Initially I had a lot of trouble getting collected mealybugs to feed on potatoes, but they became established around late January. I also grew out a box of citrus mealybug as a back up, which became established in less than two weeks. Due to sharing "cleaned" potatoes between the two cultures, I accidentally introduced longtailed mealybug into the citrus mealybug culture. These were potatoes that were used in one culture but became covered in honeydew. I harvested the insects off the potato sprouts, soaked them in a bleach solution for 30 minutes then allowed them to air dry and regrow sprouts. Apparently this was insufficent to kill residual longtailed mealybug crawlers. By mid-March, the citrus mealybug was no longer evident and longtailed mealybug was thriving in all three of my cultures. In recent weeks, mold has been appearing in my mealybug cultures. This can wipe out insect populations, so I have been working to bring in fresh potatoes to reduce the number of the older, honeydew drenched potatoes and spores present. I also had a sample of each culture examined by Jim Stimmel recently in case other insects were present in my mealybug cultures. They appear to be "clean" at the present time. I have been having problems recently with mold formation in my mealybug cultures and am working on bringing the insect population up again after throwing out several batches of moldy potatoes.

METHODS AND MATERIALS: BROWN SOFT SCALE

My attempts to raise brown soft scale initially were disappointing. Though it has a number of plant hosts, I wanted to grow these hosts in the growth chambers rather than in the greenhouse to prevent scale from getting established on plants meant for the living collection. Out of my trials with ivy (*Hedera helix*), *Aloe vera* and two species of yucca *Yucca filamentosa* and *Yucca* 'Color

Guard', the scale preferred the large yucca leaves of *Yucca filamentosa*. These plants were too large to keep in the incubator, and the detached leaves dry up or rot eventually. Unlike mealybugs, once the scale attached to a leaf, removing them resulted in mortality. After trying to introduce them to aloe and ivy plants, smaller yuccas were finally located and inoculated with scale.

It seemed that biologicial control of brown soft scale is far more successful in the landscape rather than in greenhouse situations. Brown soft scale was a major pest of southern California citrus growers, before effective beneficial programs reduced its populations in orchards. However, relatively little literature exists on how to culture brown soft scale to raise beneficials.

DISCUSSION OF BENEFICIAL INSECT REARING PROCEDURES

I have been corresponding with Dan Palmer (Palmer personal comm. 2004) from the Phillip Alampi Beneficial Insects Research Lab in Trenton, NJ to prepare a set-up to raise parasitic wasps and have been getting supplies from him. For the species raised at the Phillip Alampi, a series of 1-gallon glass pickle jars are used to house the maturing wasps. The center of the metal lids are removed and replaced with fine metal screening, and a piece of filter paper is inserted under the lid to facilitate airflow yet prevent escape of the minute wasps. Plant materials containing the hosts are inserted along with the wasps; the wasps then oviposit eggs in the hosts (synonymously known as 'stinging' the hosts) and the 'stung' hosts are moved out to another jar so the wasps can develop and eventually pupate. This process involves much more observation than the time I have put into raising host insects. The wasps need to be checked daily and many jars are dated and observed through the stages of insect development. A honey solution is provided as an additional food source for the wasps along the side of the jar on a piece of paper towel, and like the host cultures, issues of humidity, fungal growth and insect invasions need to be monitored. A frequent problem is that a 'hyperparasite' will invade parasitoid cultures. These insects are usually other species of parasitic wasps that oviposit through the host and into the developing parasitoids inside. When the parasitoids hatch out, they become weak and the additional species hatches out from them. This species does not provide true biocontrol of the pest, just the destruction of the population of the preferred beneficial. Since both are tiny wasps it would be difficult to discern taxonomic differences during casual observation. Populations may crash before the researcher is even aware of a problem.

Metaphycus alberti is the wasp species considered the preferred natural enemy for control of brown soft scale. Mike Rose, a well-known entomologist who specialized in biological control research, kept this insect in culture for many years (Sclar personal comm. 2004). It had been collected in the Australia region in 1898 originally and was brought to the U.S. in limited numbers to combat brown soft scale in Californian citrus orchards. After his research partner Steve Stauffer died, Rose released cultures of *M. alberti* in selected public garden greenhouses across the U.S. Mike Rose passed away in the fall of 2004. *M. alberti* is not available commercially and it appears no one has continued to raise it. Other species of *Metaphycus* have been used in the biocontrol of scale insects, but the one available commercially, *M. helvolus*, targets hemispherical scale (*Saissetia coffea*) preferentially and is much less effective on *C. hesperidum.* The species *Metaphycus flavus* Howard also has a reputation for brown soft scale control. Though it has been unavailable for sale in the past, in early April 2005 I was notified by

Carol Glenister of the beneficial insect company IPM Labs, Inc. that they had *M. flavus* available for purchase. At the present time I have set up a pickle jar with approximately 30 individuals of this species and detached scale-covered *Yucca* leaves. I have also just released the remainder of the shipment of this species (approximately 170 wasps) into the Fernery. I hope to culture out this wasp and release additional numbers into the Fernery during the remainder of my internship. I am monitoring the scale population in the Fernery in hopes of finding evidence of parasitism. I have vouchered some of the *M. flavus* and continue to release them into the Fernery as they reproduce. They are shifted into other jars with freshly detatched scale-infested yucca leaves every two weeks. The dried leaves with potentially parasitized scale have been left in the Fernery in case additional wasps emerge from their hosts.

In his Ph. D. dissertation on the control of longtailed mealybug, Goolsby (1994) recommended the use of two beneficial encyrtid parasites, *Anagyrus fusciventris* and *Pseudaphycus angelicus*. Australasia is believed to be the native home of longtailed mealybug. I contacted John Goolsby and he recommended *P. angelicus* as the species most likely to provide mealybug control at a lower temperature, though it may take a longer period of time for control to be effective than published in his studies (Goolsby personal comm. 2005). *A. fusciventris* has been raised commercially in the past, it appears not to be available in the U.S. commercially at this time. Goolsby, located in Texas, collected the beneficials in the early 1990's by leaving mealybug-infected butternut squash out to be parasitized in avocado orchards in Southern California and collected from ornamental ivy plantings in several conservatories that had used biocontrol in the past. Many beneficial insects have been released in Southern California to combat citrus and other agricultural crop pests starting in the late 1800's, and significant control of both longtailed mealybug and brown soft scale has been achieved in these orchards where outbreaks once severely damaged crops. The biocontrol program centered in Riverside, California has been responsible for most of these successful introductions, but the established beneficial wasps appear to have become more or less ubiquitous in the orchards and Riverside has moved on to focus on projects involving other pests (Flint and Dreistadt 1998). I am working to find another commercial source or private contact to acquire and culture one of the encyrtid mealybug parasitoids. This portion of my project may be completed in Seattle, particularly if I can keep a population of longtailed mealybug in culture and move it with me back to Washington State.

CONTINUING PROJECTS

An additional feature of my project has been creating a resource binder of information on beneficials for Arboretum Plant Propagator Shelley Dillard. Mark Nelson, last year's Plant Protection Intern, started this project and had completed a well-indexed compilation of MSDS sheets for the chemical control she uses. I am fleshing out the biological control binder with information on beneficial species available to use on thrips, whitefly, mealybug, fungal gnats, shore flies, spider mites, and scale.

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INTERNET RESOURCES

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http://www.associatesinsectary.com/biological-beneficials-main.htm

http://www.ces.ncsu.edu/depts/ent/notes/O&T/flowers/note32/note32.html

http://www.ipm.uiuc.edu/greenhouse/insects/soft_scales/

http://www.rinconvitova.com/history%20BC.htm

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