



Regional Training Workshop on Mass Production of Beneficial Insects and Nematodes

15 – 19 May 2017

Department of Agriculture, Thailand

Plant Protection Research and Development Office

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Goniozus nephantidis for controlling *Opisina arenosella* walker

Opisina arenosella walker (black-headed caterpillar)

Introduction

Black-headed caterpillar or *Opisina arenosella* Walker is an insect pest that can be found in South Asian countries like India and Sri Lanka. The first outbreak in Thailand in July 2007, have affected the yield of coconut, farming land as well as businesses related to it.

The pest control of black-headed caterpillar should be done when first sighted for easier, faster elimination with little cost, and most importantly, it would not affect the produce and the use of chemical pesticides can be avoided. However, if left alone until the coconut leaves become dry, it would be harder to control the black-headed caterpillar and could eventually result to the death of coconut trees.

Finding solution to the outbreak of black-headed caterpillar, it is necessary to have cooperation from all different sectors including the government, business and private sector related to coconut and coconut farmers as well as owner of uncultivated coconut land that needed integration by controlling the black-headed caterpillar once sighted, so as not to let it multiply and spread further.

This document has collected the steps and procedures in controlling black-headed caterpillar starting from cutting and destroying the affected area of coconut leaves, to the use of Bio bacteria (BT) and *Goniozus nephantidis* or Muesebeck as well as the right use of chemicals. Therefore, it is advised to follow the procedures closely for effective and successful control of black-headed caterpillar that would benefit coconut farmers, environment and consumers.



Scientific name: *Opisina arenosella* Walker

Order: Lepidoptera

Class: Oecophoridae

Black-headed caterpillar is native to and can be found widespread in South Asia: India, Sri Lanka and Pakistan. As for Southeast Asia, it is found in Cambodia, Myanmar and Indonesia. The first outbreak of Black-headed caterpillar in Thailand happened in Prachuap Khiri Khan Province in 2007.

Characteristics of Infestation

Black-headed caterpillar destroys coconut leaves by eating its surface at the bottom part. After that, it would create a web from its excrement which used to cover its body along the leaves and would inhabit the area. The lower part of coconut leaves are destroyed first wherein the affected area are dry and brown in color. Each leaflet may have the appearance of being held together like raft. If the infestation is severe, it can cause death to coconut trees.



Affected coconut leaf

Biology of *opisina arenosella walker*



- **Egg** - The eggs are oval and flat in shape. Mature females would lay eggs in small group. Newly laid eggs have light yellow color and would turn red when nearly hatched.
- **Larva** - When hatched, the larvae would stay together in group before slowly moving to eat the coconut leaves. The larvae are light-brown with long brown stripes running along the body.
- **Pupa** - The pupa has light-brown color and would turn dark brown when nearly hatched. Fully matured Black-headed caterpillar would create a web to cover its body and enter the pupa.
- **Adult** - In adult stage, the black-headed caterpillar turn into nocturnal moth that has light brown wings. During day time, it would stay under the coconut leaf. It would lay eggs in group on the silken tunnel or galleries that it constructed or in the remains of leaves destroyed by black-headed caterpillar. One female adult could lay approximately 49 – 490 eggs.

Life cycle

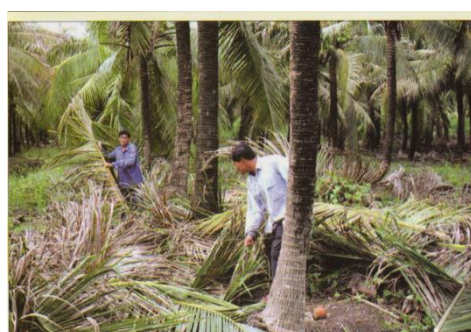


Food

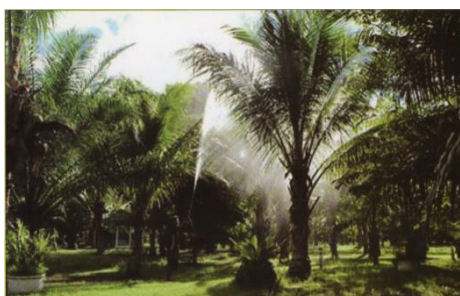
The food source of black-headed caterpillar are coconut tree, Palmyra palm, date palm, Betel nut, Palm oil, and other decorative palm trees such as Bismarck palm, MacArthur palm, Sealing-wax palm, Foxtail palm, and Lady palm. Moreover, it has also been found to destroy banana trees planted under coconut trees.

Controlling *opisina arenosella walker*

1. Cut the affected leaves and submerge it in water or burn it immediately during day time.



2. Spray *Bacillus thuringiensis* with ratio of 80 – 100 milliliters mix with 20 liters of water. Spray 3 – 4 liters per tree covering the entire leaves. This solution should be spray during afternoon with 7 – 10 days interval.



The *Bacillus thuringiensis* can destroy many kinds of larva and it is safe for humans, animals, pests and environment. The chosen solution should be newly produced and is registered under the Department of Agriculture.

3. Biological Control of *opisina arenosella walker*

Goniozus nephantidis or Muesebeck should be released during dusk when used to control *opisinal arenosella walker*.

4. Use of chemical *emamectin benzoate* 1.92% EC by injecting it in the trunk

In the case of severe outbreak, it is recommended to use *emamectin benzoate* 1.92% EC solution, 30 milliliters per tree. Since the Department of Agriculture has already tested this solution, it is advised that it should not be used on coconut trees with height below 12 meters since chemical residue were found in coconut. The use of this solution is strictly prohibited on green coconuts and brown coconuts.



Goniozus nephantidis (Muesebeck)

Scientific name: *Goniozus nephantidis* (Muesebeck)

Class: Bethylidae

Order: Hymenoptera



Goniozus nephantidis or *G.nephantidis* is a natural enemy that has been used to effectively control *opisina arenosella* walker in India and Sri Lanka. On 28 April 2012, the Department of Agriculture, Thailand imported *Goniozus nephantidis* from Sri Lanka. When tested for its safety and effectiveness in controlling *opisina arenosella* walker, it is found that they are safe to use in Thailand.

Biology of *Goniozus nephantidis*



- **Egg** - Female *Goniozus nephantidis* lay eggs on the body of black-headed caterpillar. The eggs are long, elongated and clear white.



- **Larva** - It has white clear color. When hatched, the larvae would stick to the host's body to get its nutrients.



- **Pupa** - When fully grown, the larvae weave a web to cover itself and enter the pupa stage.



- **Adult** - They become larger and have black color. Their body could run between 1.1 – 1.3 millimeters in length. Male are smaller than female. The end of female abdomen is long and pointed with a stinger at the end which is used to sting black-headed caterpillar to stop its movement. Then, it would proceed to lay its egg one at a time. One female could lay eggs up to 4 – 18 eggs per day. It takes around 15 – 19 days to grow from egg to adult.

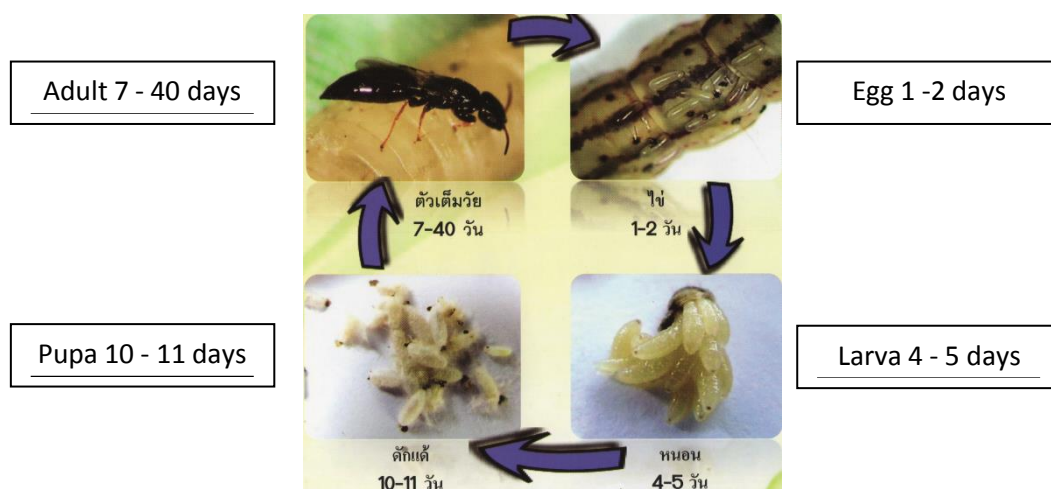


Female



Male

Life Cycle



Rearing of *goniozus nephantidis*

The process is divided into two steps.

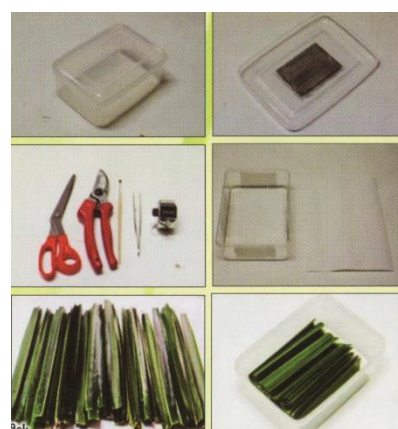
Step 1. Host Rearing for *Goniozus nephantidis*

Black-headed caterpillar (*Opisina arenosella* Walker) and rice moth (*Corcyra cephalonica* Stainton) could be used as hosts for *Goniozus nephantidis*.

1.1 Rearing black-headed caterpillar (*Opisina arenosella* Walker)

Materials and Equipment:

1. Plastic container with drilled cover covered with screen for air ventilation
2. Small brush
3. Honey - 10% concentration
4. Clean water
5. Tissue
6. Fresh coconut leaves
7. Scissor for cutting plant stem and normal scissor for paper

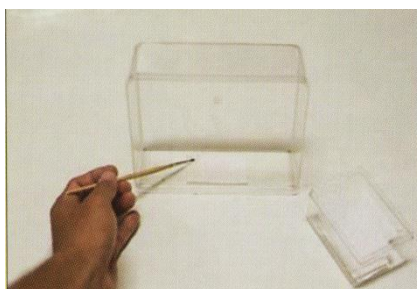


Method

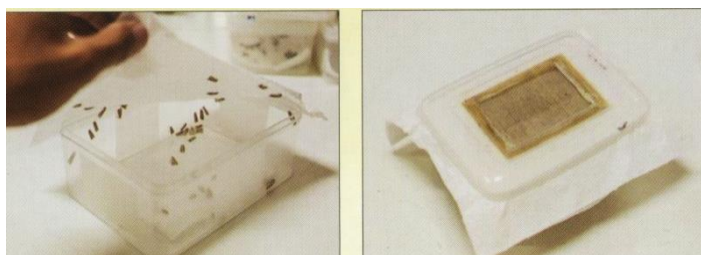
1. Catch black-headed caterpillar from the wild and grow it with coconut leaves. Separate the pupae and placed them inside plastic container. Wait for it to grow into adult.



2. Prepare a box for adult black-headed caterpillar to lay its egg by taking the plastic container with ventilated cover covered with screen and clean it. Take a small brush and dip it in honey. Use the brush coated honey to paint it on 3 small pieces of tissue papers. Then place the tissue papers on the 3 sides of the plastic container's wall. For the remaining wall, use tissue dabbed in small amount of water and sticks it on the side. Place a tissue paper on the bottom of plastic container where the eggs will be laid.



3. Take out the moth hatched from pupa and placed it inside the prepared plastic container from number 2. Each container should contain 25 pairs with 25 female and 25 male.



4. Place the box under the temperature of 28 degree Celsius for 1 – 2 days to let it lay eggs. After that, take the tissue and use scissor to cut it into small 1-1.5 cm pieces.



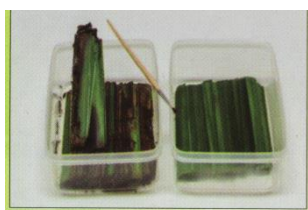
5. Clean the coconut leaves, then cut it into 10 centimeters long. Place 8 coconut leaves inside a plastic container. Take the tissue with eggs and place them between the coconut leaves.



6. The black-headed caterpillar will proceed to hatch from its eggs within 3 – 4 days. In the first few days after hatching, the larvae would stay together in group and are very fragile. Thus, changing coconut leaves should be done carefully.



7. Coconut leaves should be change every 5 days. Use small brush to gently move the larvae inside a container with new coconut leaves.



8. When 35 – 40 days have passed, select out those with body length of 2.5 centimeters in which they could be used as hosts.

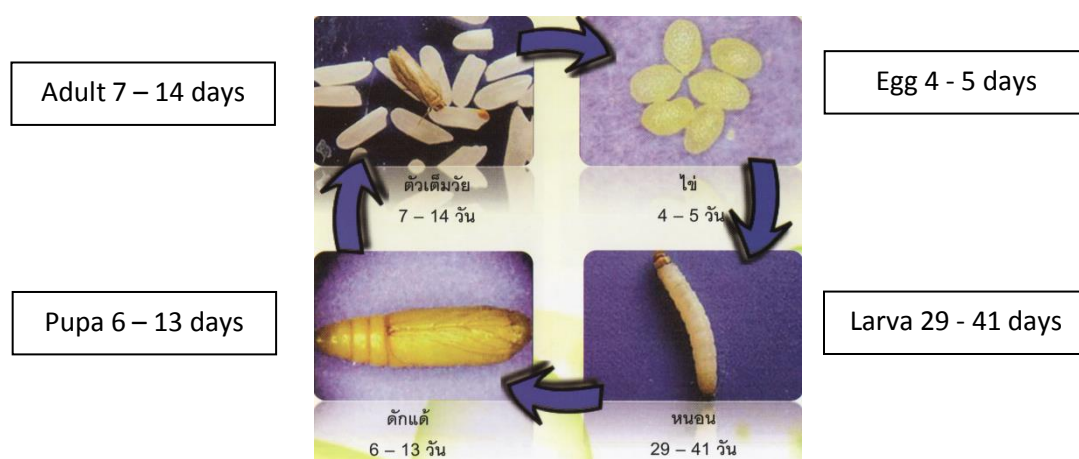


1.2 Rearing of Rice moth (*Corcyra cephalonica* Stainton)

Rice Moth

Rice Moth or *Corcyra cephalonica* Stainton is characterized by its brown and grey color. Its body length is around 1.2 – 1.5 centimeters. When in rest, the wings will close in parallel to its body. Female rice moth could lay up to 44 – 370 eggs. It would lay eggs individually and would hatch within 4 – 5 days. The larva has white color and would weave a web to cover its body for protection. The larva stage last for 29-41 days, proceeded by the pupa stage that lasts for 6 – 13 days.

Life Cycle



Materials and Equipment

1. Plastic container 22x33x6 centimeters and has been drilled for air ventilation and covered in screen
2. Basket or nylon plastic
3. Aluminum tray
4. Fine rice bran
5. Broken-milled rice
6. Brown sugar
7. Honey

Method

1. Mixed the feed for rice moth.

Ratio

Fine rice bran 60 kilogram

Broken-milled rice 3 kilogram

Brown sugar 1 kilogram



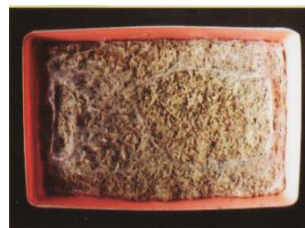
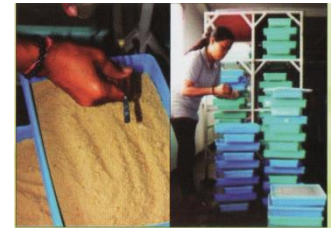
2. Baked the mixture in 180 degree Celsius for 8 hours long to get rid of insects in rice bran such as flour weevils and rice weevils.



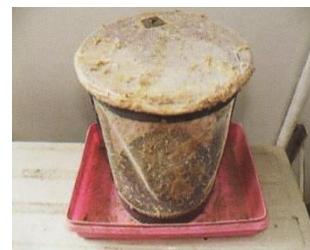
3. Take out the baked feed for rice moth and keep it inside plastic container by distributing it to 1 kilogram per container.



4. Sprinkle 0.5 gram of rice moth eggs all over the container with rice bran inside, then close the lid tightly to protect it from other insects. Keep it at room temperature between 28 – 30 degree Celsius for 28 – 30 days. After that, select out those bigger ones with body length of approximately 1.5 centimeters to rear *Goniozus nephantidis*.



5. Separate one portion of rice moth and let it grow until adult. Take the adult rice moth and place it inside a basket with nylon net as cover for breeding. After leaving it for a day, use brush to gently sweep out the eggs and place it on aluminum tray to further populate it. As for the rice moth eggs that would not be used yet, keep it by wrapping it in tissue paper and place it in the refrigerator with temperature between 6 – 10 degree Celsius for 1 week.



Step 2. Rearing of *Goniozus Nephantidis*

It should be breed using rice moth as host for 3 generation by alternating it using *Opisina arenosella* Walker as its host for 1 generation.

Material and Equipment

1. Host insect (black-headed caterpillar aging 35 – 40 days) or Rice Moth larva aging 35 – 40 days)
2. Plastic cylinder container with lid (2.5 cm diameter and 6 cm tall)
3. All-purpose foam size 1x1 centimeters
4. screen
5. Plastic container box 11x14 centimeters with drilled air ventilation and covered with organdy cloth
6. Honey 10% concentration
7. Brush
8. Tweezer
9. Paper 5x7.5 centimeters
10. Square basket or rack to place test tube with *Goniozus nephantidis*
11. Microscope or magnifying glass



Method

1. When male and female *Goniozus nephantidis* hatched from its pupa stage, leave them to breed inside the plastic cylinder container for 4 days. After that, carefully select out female *Goniozus nephantidis* that are larger than male and place them in separate plastic cylinder container.
2. Take black-headed caterpillar and place it inside the cylinder container with female *Goniozus nephantidis*. One black-headed caterpillar for each one female *Goniozus nephantidis*. Close the lid with screen covering it. A small piece of foam placed inside the container will be used to apply the honey for feeding.
3. Bring the cylinder container with *Goniozus nephantidis* and black-headed caterpillar, and place it inside a basket horizontally. Leave the female *Goniozus nephantidis* to lay eggs on the black-headed caterpillar for 4 days.
4. Use tweezer to gently take out black-headed caterpillar with *Goniozus nephantidis* eggs on it and place it on paper 5x7.5 centimeters in size. Fold the edges of the paper to turn it into a square-like tray. A total of 10 black-headed caterpillars will be placed in each of these paper trays. Keep these paper trays inside plastic container with air ventilation and covered with organdy cloth. After that, prepare new set of black-headed caterpillar for the female *Goniozus nephantidis* to infect the host by repeating the procedure on number 3 and 4 until the female *Goniozus nephantidis* dies.





5. Leave the container with *Goniozus nephantidis* inside for 1 week until it enters the pupa stage. Then, take out the remains of the black head caterpillar by observing those turning black and dispose of it.
6. Take the paper tray with *Goniozus nephantidis* pupae and place it inside transparent plastic tube with air ventilation covered with organdy cloth, and a small piece of foam inside.
7. After around 1 week, when *Goniozus nephantidis* enter adult stage, place some honey into the foam inside the test tube to feed it. When all of them left pupa stage which would take around 1 – 2 days, leave them to breed for another 4 days before continuing to use them as breeder for the next generation or to distribute them into coconut field.



Making use of *Goniozus nephantidis*

In India and Sri Lanka, it is advised to release adult *Goniozus nephantidis* to control *Opisina arenosella* Walker in mildly affected area with the ratio of 500 *Goniozus nephantidis* per Rai. The *Goniozus nephantidis* should be release every month when the sun is setting. The more *Goniozus nephantidis* are released the faster the result.



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Asecodes hispinarum for controlling *brontispa longissima*

Brontispa longissima (Coconut hispine beetle)

Brontispa longissima also commonly known as Coconut Hispine Beetle is a species originated in Indonesia and Papua New Guinea. It was found widely spread in Thailand in the provinces of Prachuap Khiri Khan, Chumphon, Surat Thani and Nakhon Si Thammarat since 2004.

Life Cycle of *Brontispa longissima*

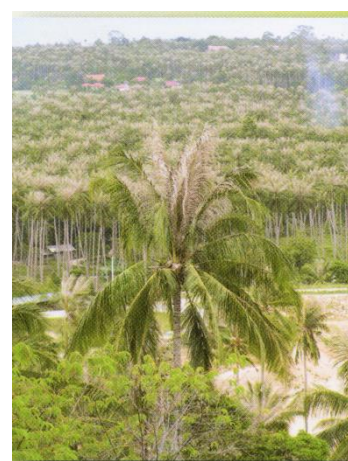
When female *Brontispa longissima* underwent breeding process, it would lay eggs individually or in group. Each group consists of 2 – 5 eggs. The egg stage lasts for 2 – 6 days with the average of 4.2 days if fed with mature coconut leaves.



Larva Stage	20 – 23 days	Average	21.56 days
Larva shedding	4 – 5 times		
Pupa Stage	2 – 7 days	Average	4.7 days
Adult female life span	13 – 134 days	Average	54.8 days
Adult male life span	21 – 110 days	Average	65.2 days

Characteristic of Affected Areas

Both the larvae and fully grown *Brontispa longissima* inhabit coconut leaves even when the leaves are not mature yet. They destroy coconut trees by eating the surface of the leaves. When affected young coconut leaves become mature and unfold itself, the leaves will have light brown color. If the coconut leaves have been continuously destroyed, the top most part of its leaves which are light-brown in color could be perceive as white when seen from afar. Thus, local people would refer to them as “grey-haired coconut trees”.



Since coconut trees have tall trunk, the use of chemicals pesticide to control *Brontispa longissima* is quite difficult and unsafe for farmers and environment. Thus, with the help of Food and Agriculture Organization of the United Nations and Nong Lam University, Vietnam, the Department of Agriculture decided to import *Asecodes hispinarum* from Vietnam to control *Brontispa longissima* in Thailand.

Asecodes hispinarum

Asecodes hispinarum are small in size with body length of 0.5 – 0.7 millimeters and have two pairs of transparent wings. Adult male has small elongated abdomen while female has bulb-like abdomen with a needle-like organ for laying eggs beneath its stomach. The *Asecodes hispinarum* would only attack *Brontispa longissima*.



Male



Female

Adult female *Asecodes hispinarum* use its needle-like organ to penetrate the body of *Brontispa longissima* to lay eggs. When the eggs hatched, it would feed on the hosts' body fluids, which in turn, would cause it to move slowly and consume less coconut leaves, and eventually die. The remains of *Brontispa longissima* are characterized by its hard and flat surface with dark brown appearance called "mummy". The mummy would contain 23 – 128 *Asecodes hispinarum*'s pupae with the average of 50 per mummy.



Rearing Method

The method can be divided into two steps.

Step 1. Rearing of *Brontispa longissima*

1. Raise *Brontispa longissima* larvae inside a plastic container (15x10x6 centimeters). The cover should have air ventilation and is covered with net cloth to prevent them from escaping.
2. Raise fully grown adult *Brontispa longissima* inside plastic container (30x22x9 centimeters). The cover should have air ventilation and is covered with net cloth to prevent them from escaping.
3. Cut coconut leaves into 10 x 12 centimeters. Place 25 – 30 of them over one another and use rubber band to tie them into bundle.

4. Take out *Brontispa longissima* from destroyed coconut leaves and separate the adult and larvae apart. Raise them separately inside the prepared plastic containers. As for the pupa, keep them together inside the container with larvae and wait for it to grow.
5. Take out the eggs from the container with adult *Brontispa longissima* every 2 – 3 days and distribute them on the prepared coconut leaves tied with rubber band. Wait for the eggs to hatch approximately 3 – 4 days.
6. When the eggs hatched, gently take out approximately 300 larvae and placed them inside plastic container with a tied bundle of coconut leaves. Raise them and change the coconut leaves every 5 – 7 days or when the leaves turn brown.
7. After around 15 – 17 days, the larvae will enter stage 4 and would have 1 centimeter in length which is ideal for rearing *Asecodes hispinarum*.



Step 2. Rearing of *Asecodes hispinarum*

1. Separate the mummy where *Asecodes hispinarum* have emerged and leave it for 2 – 3 hours. They will be used to destroy the new set of larvae and adult *Brontispa longissima*.
2. Select out 80 *Brontispa longissima* larvae in stage 4 and place it inside a plastic container with 3 – 4 coconut leaves. Stick a piece of tissue paper soaked in 20% concentrated honey on the side of the container to feed *Asecodes hispinarum*. After that, place the *Asecodes hispinarum* that will serve as breeder.
3. The *Asecodes hispinarum* would immediately attack *Brontispa longissima* larvae once released inside the container. Place the container on the rearing shelf for 3 – 4 days.
4. Take out the infected *Brontispa longissima* larvae from 4 -5 containers and raise them together in a new separate container. Place coconut leaves tied in bundle to serve as food for infected larvae that are still alive. The infected larvae would die slowly and eventually turn into mummy in 7 – 10 days after the infection started.
5. Take out the mummified larvae every day and keep a record when it was taken out.
6. Group the mummy into 2 parts. Around 10% of the first part would be used as breeders. Keep them in plastic tube and cover it tightly with each tube containing 2 mummy. The rest of the 90% would be use to release and control *Brontispa longissima* in coconut plantation.

Releasing *Asecodes hispinarum*

1. Keep 5 of 7 – 9 days old mummy and place them in plastic tube with cover to protect it from ants and other insects. Drill around 3 – 4 holes on the side of the tube, 1 at the bottom of the tube to release water and 1 on the cover to insert rope for hanging.
2. Take the tube and hang it near the top of coconut tree as much as possible. For each rai, 5 – 10 mummy will be released and should be done 3 -5 times leaving 7 – 10 days gap in between for each release. The more *Asecodes hispinarum* are released the faster the result.
3. When *Brontispa longissima* are under control, release additional *Asecodes hispinarum* once in a while for 5 – 6 times to prevent it from spreading again.



Information: Amphorn Winothai

Compilation: Patchareewan Chongchitmate

Published date: May 2015

Anagyrus lopezi for controlling *Phenacoccus manihoti*

Phenacoccus manihoti (cassava mealybug)

Cassava mealybug also known as "*Phenacoccus manihoti*" is native to and originated in South American countries like Brazil, Chile and Bolivia and came to spread in Thailand.

Characteristic of Infestation

Cassava tree that has been infested with *Phenacoccus manihoti* has a curly leaf and bud, and arching stem. The length between node and internode are reduced. The infestation could happen to new bud of cassava tree or the young tree and cause it to die. In the case of mature cassava trees, it could affect and reduce the quality and quantity of its yield.



Anagyrus lopezi

Anagyrus lopezi is a small (1.2 – 1.4 mm), black, parasitoid wasp originated in Argentina, Brazil, Bolivia and Paraguay. It has two pairs of transparent wings. The important characteristics use to distinguish male and female are its antennae. Male antennae are slim, long and dark with small fur surrounding it. As for female, the antennae have white stripes, and are flatter and bigger.



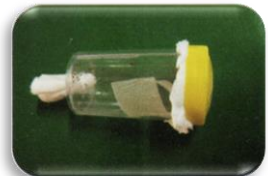
The Plant Protection Research and Development Office, Department of Agriculture has coordinated and received aid from International Institute for Tropical Agriculture (IITA-Benin) to send *Anagyrus lopezi* for research and use to control the spread of *Phenacoccus manihoti* in Thailand.

The parasitoid *Anagyrus lopezi* should be immediately released in the plantation once the infestation and spread of *Phenacoccus manihoti* have been identified. Fast release of parasitoid is more effective and advantageous during the early period of infestation before it worsens.

Rearing Method

Method 1 – Rearing using *Phenacoccus manihoti* raised on Cassava

1. Plant 8 inches long cassava stem in a flower pot with each pot containing only two stems. Let it grow for 6 weeks.
2. Release the eggs of *Phenacoccus manihoti* on top of cassava leaves. Let the eggs hatched until it reach stage 3 or around 21 – 25 days old.
3. Take 8 pots of cassava tree and place it inside a cage for raising insects. Then release 40 pairs of *Anagyrus lopezi* and leave it for 11 – 15 days. When *Phenacoccus manihoti* dies it will turn into mummy.
4. If adult *Anagyrus lopezi* is found flying out of mummy, use insect aspirator to catch it.



Method 2 – Rearing using *Phenacoccus manihoti* raised on pumpkin



1. Collect cassava tree tops that have been infested with *Phenacoccus manihoti* and place it together on top of a tray.
2. Choose pumpkins that are still green and not too young. Place them atop of the infested cassava tree. Leave it for 3 – 7 days depending on the number of *Phenacoccus manihoti* found on the cassava tree top.
3. Take out the pumpkin from number 2 and place them inside a cage for raising insect. Then release for 40 – 50 pairs of *Anagyrus lopezi*.
4. The parasitoid *Anagyrus lopezi* would attack *Phenacoccus manihoti* that were raised on the pumpkins. Leave it for 11 – 15 days. The *Phenacoccus manihoti* will eventually die and turn into mummy. When adult *Anagyrus lopezi* is found flying out of the mummy, use insect aspirator to catch it.
5. Segregate the adult *Anagyrus lopezi* based on their sex. Count and place them in a separate container for release or for further breeding.



Method of *Anagyrus lopezi* Storage

In general, *Anagyrus lopezi* has a life span of 2 – 3 days when not fed. It could live for 7 – 12 days when fed with honey with 10% concentration and if kept under controlled temperature of 15 degrees Celsius, it could live for 21 – 30 days.



The effectiveness of controlling *Phanacoccus manihoti* is at its best, when *Anagyrus lopezi* that have freshly emerged from mummy are released, however, those kept for a long time are not as effective. It is advised not to store them for more than 14 days since it would reduce its ability to effectively control *Phanacoccus manihoti*.

Releasing *Anagyrus lopezi*

- It should be released in cassava plantation.
- For effective release, place the container with *Anagyrus lopezi* inside near cassava tree top where *Phanacoccus manihoti* are found.
- Let the *Anagyrus lopezi* spread around the plot. The rate of release should be 50 – 100 pairs per Rai. If the infestation is severe, increase the number to 200 pairs per Rai.
- Avoid spraying chemical pesticides near the area where *Anagyrus lopezi* have been released.



Evaluation of Success

- Check the decrease of slimy fluid drops on cassava leaves.
- Check the appearance of *Anagyrus lopezi* flying around cassava tree top where *Phanacoccus manihoti* was found after two months.
- Check the new bud of cassava tree for the reduction of curled symptoms.
- Collect samples of cassava tree top where *Anagyrus lopezi* are found to be flying around and note their number.



Information: Amphorn Winothai

Compilation: Patchareewan Chongchitmate

Published Date: September 2011

Lacewing

Neuroptera: Chrysopidae



Lacewing (Neuroptera: Chrysopidae) is an important insect for controlling mealy bug in cassava. The green lacewing *Plesiochrysa ramburi* are most commonly found in cassava field. The larvae of green lacewing like to eat mealy bugs and are capable of eating all types of mealy bugs in all stages.

Important characteristic

Egg – The eggs are elongated and green, and are attached at the end of white stem at 3 – 4 days old.

Larvae – The larvae has fur around its body. When eating mealy bugs the powder would get stuck on its body making it look identical to mealy bugs. Its head have a horn like used for catching its prey to absorb nutrients. A single larva could consume up to 300 – 800 mealy bugs. The larvae stage lasts for 10 – 13 days.

Pupa – The pupa is white and round. It can be found attached to different parts of the plant. The pupa stage last for 9 – 11 days.

Adult – The adult has 2 pair of transparent wings with long antenna and green body. When in rest, the wings would close along its body. The adult could live approximately 20 – 30 days.



lacewing

mealybug

Rearing Method

Lacewing could be produce in large quantities. There are two steps as follows:

Step 1 – Rearing mealy bugs

1. Prepare pumpkin
2. Place the pumpkin inside a box. There should be 4 – 5 pumpkins per box. Place mealy bugs on the pumpkin.
3. Close the box with white thin cloth.
4. After 30 days, the mealy bugs would grow into fully adult stage which will then be used to rear lacewings' larvae



Step 2 – Rearing Lacewing

1. Prepare food for adult lacewing (honey and yeast) and place it inside box for rearing adult lacewing.
2. Take adult lacewings with the ratio of male is to female 40:60 and place them inside the prepared box in number 1. Close the box with white thin cloth for adult lacewings to mate.
3. Change the box with adult lacewing every 3 days since it would contain the eggs of the lacewing.
4. Take the pumpkin with mealy bugs and place it inside the box with lacewings larvae so that it would become food for the larvae. Place tissues that are cut in strips, then close the box with white thin cloth.
5. After 12 – 15 days, collect the pupae out of the box with lacewings larvae. The pupae would turn into adult around 9 – 11 days.



Usage

- When breakout are found, release lacewing larvae stage around 3 -4 larvae per plant.
- Lacewing can be released in every stage and should be released continuously.
- Use of chemicals are prohibited.

Information and arranged by:

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Earwigs spp.

Earwigs

Earwigs are small insect under the order of Dermaptera with over more than 1,000 species. Its body is long and flat (4 – 15 mm.). The tails are shaped like pincers that can be used for catching prey, protection, building nest and mating. Some have wings and others don't. For those with wings, the front pair wings are shorter in length compared to its body, while the back wings are found folded under the front wings.

Earwigs are decomposers. They like to stay in dark and damp places such as beneath decomposing leaves and trees. They can be found commonly in farming field such as sugar cane, maize, and vegetables. They are nocturnal and can move fast. They prey on eggs and larvae of different types of insects that are small in size.

The Department of Agriculture, Thailand produced and used the following types of earwigs for biocontrol: *Proreus simulans* Stallen and *Euborellia annulipes* (Lucas)

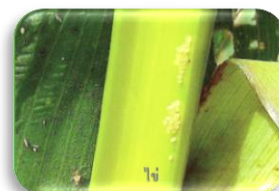
Proreus simulans Stallen

Proreus simulans Stallen are important in controlling different type of pests especially in maize. It can be used to control corn stemborer, corn earworm, aphids, caterpillar and eggs of different insects. They can control corn stemborer which are hard to get rid of using chemicals.



Life cycle

Eggs – Female adults would lay around 10 – 30 eggs in group on the leaves or under the ground. The eggs appear to be smooth and round and are white. The color would change from white to yellow and then brown in order. The egg stage is around 5 – 6 days.



Larva – Larva has three stages. Larva in stages one and two are white in color and the end of its abdomen is black. When entering second stage, it would grow white wings. Third stage larva would change to color yellow and the tails would turn brown. The larva stage is around 40 – 50 days.



Adult – Adult size is 1.5 – 1.7 cm. The body is brown in color with its head red. It has long antennae and yellow front wings. The tail has a mix of brown and black. Male has small bump on its inner tail and female has smooth tail. The adult stage is around 50 – 60 days.

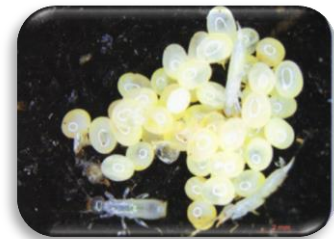
Euborellia annulipes (ringlegged earwigs)



Euborellia annulipes are capable of eating insect eggs and other different insect pests such as sugarcane borer, aphids, and other small insects that can be found commonly in farm. They are nocturnal and usually hide in rock, log and plants.

Life cycle

Eggs – Adult female would lay around 30 – 60 eggs in group under the ground or leaves. The eggs are oblong and white. The eggs color would change from white to yellow then brown. Female can lay up to 240 eggs. The egg stage is around 6 – 8 days.



Larva – Larva has three stages. Newly hatched larvae are white and then it would turn to dark brown. The appearance of larvae in each stages are similar except for their color and the body size that would grow bigger as it get older. The larva stage is around 50 – 60 days.

Adult – Adult size is 1.6 – 1.8 cm. and does not have wings. The body is long, flat and brown. Females are a bit larger than males. The antennae are black and have 17 sections wherein the third and fourth sections away from the tip of antennae are pale in color. The legs are long and yellow and have brownish circle. The tails are shaped like pincer and are a mix of brown and black. Male have small bump inside the tail while females don't. The adult stage is around 2 -3 months.

Rearing Method

Materials and equipment

1. Plastic container
2. Black rice husk ash
3. Water sprayer
4. Small container for placing food
5. Animal feed such as cat food or dog food
6. *Corcyra cephalonica* (Stainton) eggs



Pulverized cat food



Container for rearing earwigs

Rearing method

1. Bake black rice husk ashes at 100 degree Celsius for 3 hours or dry it under the sun for two days while turning it in each day to get rid of insects.
2. Take the baked black rice husk ashes and place then inside a container 3 -4 cm thick. Spray water over the area.
3. Place 40 adult earwigs in each container (10 males and 30 females or in the ratio of 1:3). 50 – 60 days old female will start laying eggs in group of 30 – 60 eggs. Female earwigs would lay eggs 4 -5 times in its total lifetime.
4. Feed them with pulverized cat food (40 grams per container) and alternate it with 10 grams of *Corcyra cephalonica* (Stainton) eggs or other small insects.
5. Make sure to keep the container damp by spraying water on black rice husk ashes and change their feed every 3 days to prevent spoiling.



Shelf for rearing earwigs

Caution

- Since female earwigs are very protective of their eggs, disturbing them by taking the eggs for rearing may cause stress to female earwigs and resulting to them eating their eggs. Therefore, it is advised to wait until larvae reached 7 – 14 days old then separate them into new container.
- Newly hatched larvae should be fed with pulverized feed until it reaches 2 weeks then proceed to feed it as outlined in number 4.
- Earwigs can be released into the field or can be further mass reared when it reaches 30 – 40 days old.

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Trichogramma spp.

The Use of Trichogramma spp. to Control Insect Pests

Trichogramma spp. is an insect under the order, Hymenoptera Suborder Aprocrita and it's in the superfamily, Chalcidoidea Family Trichogrammatidae.

Trichogramma spp. are very small in size and fully adult are 0.5 millimetres in size. The general characteristics of *trichogramma spp.* are its red eyes, with fine fur on its wings. The eggs are laid in straight manner. The larvae and pupae stage will take place inside the insect pests' eggs. Female *trichogramma spp.* can destroy many different types of larvae egg of butterfly pests aging not over 2 days old. The infected eggs would turn dark in color around 3 -4 days after the infection. The adult *trichogramma spp.* then would emerge from the infected eggs within 8 days.



How does trichogramma spp. destroy insect pests?

Female adult *trichogramma spp.* that have undergone mating will have bigger stomach area compared to male. Female *trichogramma spp.* would use its antennae to come in contact with the eggs of insect pests not over 1 – 2 days old. It will use its organ for laying eggs to penetrate the insect pests' eggs around the top area or the side. One egg could hold up to 1 -4 *trichogramma spp.* eggs depending on the type of insect pest. *Trichogramma spp.* larvae have the characteristics of a sacciform, its mouth resembles a pair of hook and would feed on the nutrients inside the eggs' embryo part. The larvae have 3 stages and then it would enter its pupa stage and emerge as adult. It can be observed that 3-days after the eggs are infected with *trichogramma spp.* it would turn dark and will not hatched into larvae instead, when 8 days have passed, the adult *trichogramma spp.* would emerge out of the infected eggs. Adult *trichogramma spp.* would feed on flowers and plants' pollen. Then it would lay its eggs on insect pests' eggs. A single female *trichogramma spp.* could lay on 5 – 30 eggs.

Trichogramma spp. can be used to control insect pests in cash crops

Trichogramma spp. can be used to control eggs of many different kinds of butterfly insect pests such as *F. pyralidae*, *F. Arctiidae*, *F. Lymantridae*, *F. Noctuidae*, *F. Papilionidae*, *F. Eucleidae*, *F. Saturniidae*, *F. Pieridae*, *F. Plutellidae*, *F. Hesperidae*

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Use of *Trichogramma spp.* to control insect pests

1. A survey on the insect pests' eggs should be made on the field.
2. The period for maturing of *trichogramma spp.* should be considered and correspond with the egg stage of insect pests.
3. Release of *trichogramma spp.* to cover the field area should be above the wind direction.
4. The appropriate number of *trichogramma spp.* for release is 20,000 – 30,000 per rai.
5. The rate of *trichogramma spp.* maturing into female is higher than 60%.
6. Releasing *trichogramma spp.* should not be done under rainy or windy weather condition.
7. The type of *trichogramma spp.* eggs chosen for controlling insect pests' eggs should have high efficiency.
8. The container used to place *trichogramma spp.* eggs should be capable of protecting the eggs from being destroyed by other insects and providing shelter from rain.
9. *Trichogramma spp.* should be released after 16.00 hrs onwards.
10. The release spot should have 15 – 20 meters space in between. One rai should not have more than 6 spots.
11. The *trichogramma spp.* eggs should mature within 1 – 5 days after release.

Rearing Method

There are 2 steps for mass producing *trichogramma spp.*

Step 1 – Rearing rice moth as host

Equipment and Materials

1. Separate rooms for rearing rice moth eggs, larvae, and mature rice moth. Room for storing and cleaning equipment. Room for rearing *trichogramma spp.*
2. Shelf for rearing insects to place plastic or wooden container.
3. Plastic container with approximate size 22 x 33 x 6 cm for placing rice bran.
4. Insect aspirator complete with rubber tube and container for storing adult rice moth.
5. Nylon basket with 30 cm diameter and 60 cm in length for storing adult rice moth to lay eggs.
6. Wooden frame for *trichogramma spp.*
7. Liquid glue, brush, test tube and aluminium tray
8. Ultraviolet light bulb with cabinet. The light bulb should be placed 15 cm away from the surface of the cabinet.
9. Oven with temperature between 20 – 100 degrees Celsius and an incubator with controlled temperature between 0 – 20 degrees Celsius for storing eggs and *trichogramma spp.* eggs.
10. Fine rice bran, honey, cotton sheet (use sugar and yeast in cases where larger quantity production is desired)
11. *Trichogramma spp.* eggs for rearing together with rice moth and its eggs. Personnel required to conduct the mass rearing.

Rice moth rearing method

1. Take mature rice moths and larvae into the laboratory for mass rearing.
2. Take the rice bran and baked it in the oven at 70 – 80 degrees Celsius for 7 – 8 hours in order to rid of insects that are found in the rice bran such as rice moth, flour beetle, and rice weevil. Then leave it to cool and place 1 kg of it inside a plastic container. The container should not be thicker than 3 cm.
3. Sprinkle rice moth eggs throughout the area, approximately 2,000 eggs per 1 kg of rice bran. Close the lid tightly. The lid should have air ventilation and covered with steel gauze to prevent are insects from entering. Store the container in room temperature 25 – 30 degrees Celsius with relative humidity 75 – 80%.
4. After 4 -5 days, the rice moth eggs will hatch and it would take about 45 – 60 days for it to mature.
5. When rice moths matured, take it to another room and use the insect aspirator to suck it out. The process would not take more than 5 minutes. After that take the mature rice moths and store it in a room for separating the eggs.
6. When 24 hours have passed, take the basket with mature rice moths and use the brush to separate the eggs out and placed them on an aluminium tray. Clean the eggs and separate 80% of them for rearing *trichogramma spp.* and the other 20% will be used for rearing rice moth.

Step 2 – Rearing of *trichogramma spp.*

1. Prepare a paper where the rice moth eggs will be sprinkled. Make a grid 1 x 1.5 inch per square with a total of 7 x 8 squares per 1 piece of paper.
2. Apply liquid glue in the area prepared and sprinkle rice moth eggs through a sieve. There should be around 2,000 eggs per square.
3. Take the paper with rice moth eggs on it and place it inside the cabinet with ultraviolet/UV sterilizer for 15 minutes to destroy the embryo cells of rice moth.
4. Take the paper and stick it on the wooden frame then place the *trichogramma spp.* Place the cotton sheets dipped in honey with the ratio 1:5, and then turn it towards the light every six hours.
5. Leave it for 4 – 5 days for the *trichogramma spp.* to parasitize the rice moth eggs. The affected rice moth eggs would turn darker. Then after 8 – 9 days, the mature *trichogramma spp.* would emerge out of the eggs.
6. The eggs affected by *trichogramma spp.* then can be used to control insect pests by releasing it into area to target the outbreak of insect pests.

***Trichogramma spp.* releasing method**

Take the sheet of paper with rice moth eggs already parasitized by *trichogramma spp.* for 7-days and sew to attach it to a plant. This process should be done after 16.00 hrs. A solution for preventing ants should be applied around the paper. 30,000 *Trichogramma spp.* should be released per rai wherein each rai should have 6 spots with 15 meters in between. If the *trichogramma spp.* are not yet scheduled for release, then it should be kept in a storage with 10 – 13 degrees Celsius to slow down its growth and delay it up to 2 weeks. However, the rate of hatching would be reduced if kept for more than 2 weeks.

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