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# Papaya mealybug and its management strategies



**National Centre for Integrated Pest Management**  
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Papaya mealybug, *Paracoccus marginatus* on mulberry, *Morus alba*

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## Papaya mealybug and its management strategies

### INTRODUCTION

The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) is a small polyphagous sucking insect with pest status that attacks several genera of host plants, including economically important tropical fruits, vegetables and ornamentals. Infestation of the mealybug appears as clusters of cotton-like masses on the above-ground portion of plants with long waxy filaments. Immature and adult stages of *P. marginatus* suck the sap of the plant and weaken it. The leaves become crinkled, yellowish and wither. The honey dew excreted by the bug and the associated black sooty mould formation impairs photosynthetic efficiency of the affected plants.

Papaya mealybug has caused havoc in agricultural and horticultural crops ever since its first report from Coimbatore in 2007. The insect assumed the status of a major pest in 2009 when it caused severe damage to economically important crops and huge losses to farmers in Coimbatore, Erode, Tirupur and Salem districts of Tamil Nadu. In the same year, standing mulberry crop over 1,500 hectares in Tirupur was destroyed by the pest leading to enormous financial losses to mulberry growers across the district.



Clusters of cotton-like masses of *P. marginatus* on papaya leaf (1); enlarged view of *P. marginatus* on pigeonpea (2)

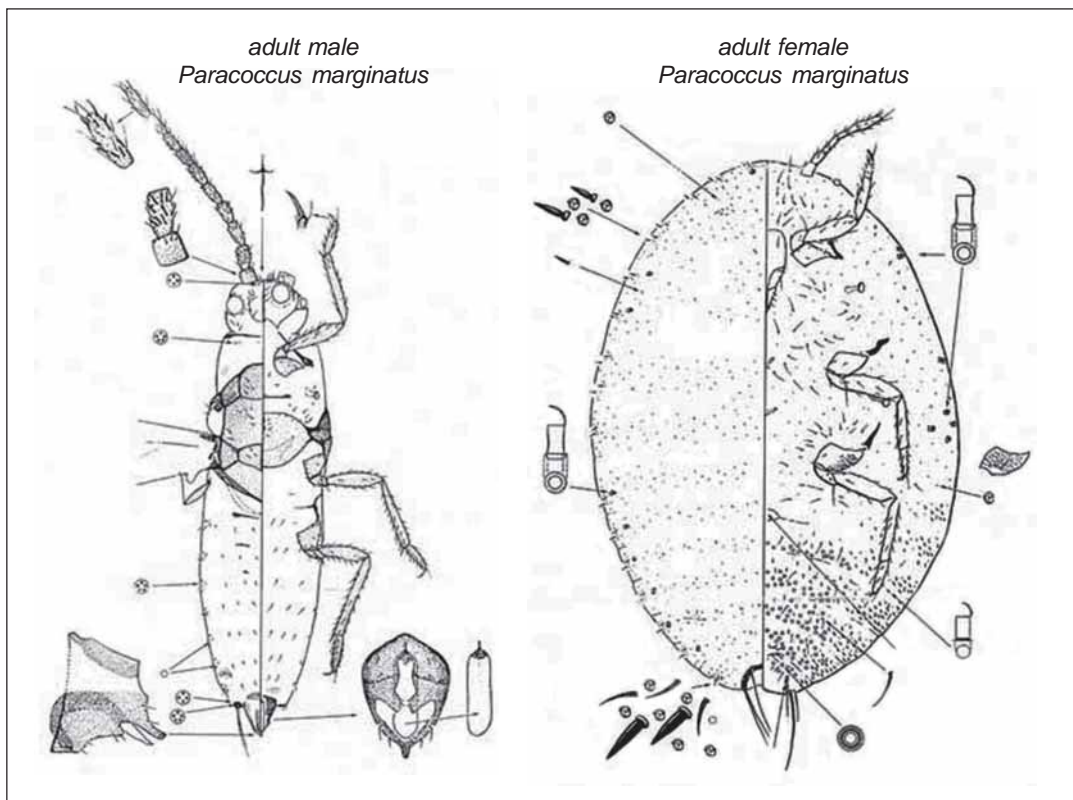
## ORIGIN AND DISTRIBUTION

The papaya mealybug is believed to be native of Mexico and/or Central America, where it never acquired the status of a serious pest, probably due to the presence of an endemic natural enemy complex. The specimens of the pest were collected first in 1955 in Mexico but it was described in 1992 from the Neotropical Region in Belize, Costa Rica, Guatemala, and Mexico. Papaya mealybug became a pest when it invaded the Caribbean region. Since 1994 it has been recorded in 14 Caribbean countries. The pest was recorded in Bradenton, Florida in 1998 on *Hibiscus* and by January 2002 it spread to 18 different plant species in 30 different cities. The establishment of this mealybug in Guam in 2002 and Palau in 2003 resulted in further spread to neighboring Hawaiian Islands in the Pacific. It was noticed in South and Southeast Asia during 2008–09. In India it was recorded in July 2007 at Tamil Nadu Agricultural University, Coimbatore and subsequently spread to neighboring districts. The pest has been reported in Coimbatore, Tirupur, Erode, Salem, Namakkal and Karur districts of Tamil Nadu. The pest is now spreading to other districts too. The pest has been recently noticed in other states such as Karnataka, certain parts of Andhra Pradesh and Malappuram and Thrissur districts of Kerala. The pest has now spread to Pune area of Maharashtra also and is likely to be reported from other parts of the country as well.

## MORPHOLOGY

- The adult female is yellow, approximately 2.2 mm long and 1.4 mm wide and is covered with a white waxy coating.
- A series of short waxy caudal filaments, less than 1/4<sup>th</sup> the length of the body exists around the margin.
- Adult males are pink, especially during the pre-pupal and pupal stages, but appear yellow in the first and second instars.
- Adult males are approximately 1.0 mm long, with an elongate oval body that is widest at the thorax (0.3 mm).
- Adult males have ten-segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and well-developed wings.
- Two characteristics that are important in distinguishing *P. marginatus* adult females from all other species of *Paracoccus* are: the presence of oral-rim tubular ducts dorsally restricted to marginal areas of the body, and the absence of pores on the hind tibiae.

- The female papaya mealybug can easily be identified by the presence of eight antennal segments, in contrast to nine in pink hibiscus mealybug, *Maconellicoccus marginatus*.
- Ovisac is three to four times the body length and develops ventrally beneath the body of the female.
- When pressed, the body fluid of yellow colour comes out.



(Source: EENY-302, Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, March 2008; Website <http://creatures.ifas.ufl.edu>. or <http://edis.ifas.ufl.edu>. Credits: D. Miller and G. Miller, USDA)

## HOST PLANTS

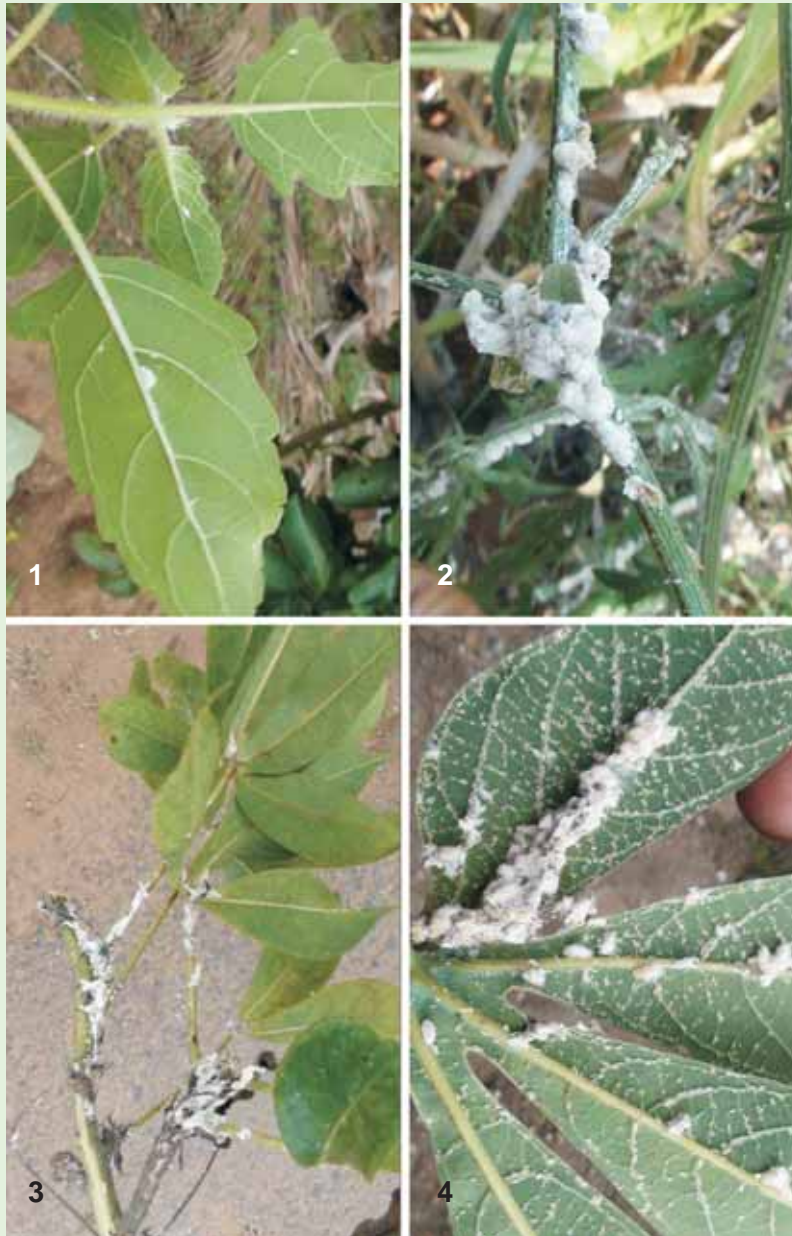
Heavy attack of papaya mealybug has been noticed on wider range of cultivated crops and weed hosts belonging to different families of plant kingdom. The following table provides the list of recorded hosts of *P. marginatus*.

Table: List of recorded hosts of papaya mealybug, *P. marginatus*

Host category	Botanical name	Common name	Family
Cultivated agricultural and horticultural crops	<i>Cajanus cajan</i> L.	Redgram	Leguminaceae
	<i>Carica papaya</i> L.	Papaya	Caricaceae
	<i>Ceiba pentandra</i> (L.) Gaertn.	Silk cotton	Malvaceae
	<i>Gossypium hirsutum</i> L.	Cotton	Malvaceae
	<i>Hibiscus rosa sinensis</i> L.	Shoe flower	Malvaceae
	<i>Jatropha curcus</i> L.	Jatropha	Euphorbiaceae
	<i>Manihot esculenta</i> Crantz	Tapioca	Euphorbiaceae
	<i>Morus alba</i> L.	Mulberry	Moraceae
	<i>Psidium guajava</i> L.	Guava	Myrtaceae
	<i>Lycopersicon esculentum</i> Mill.	Tomato	Solanaceae
	<i>Solanaum torvum</i> Sw.	Turkey berry	Solanaceae
	<i>Solanum melongena</i> L.	Brinjal	Solanaceae
	<i>Tectona grandis</i> L.	Teak	Verbanaceae
Weed hosts	<i>Abutilon indicum</i> L.	Country mallow	Malvaceae
	<i>Achyranthus aspera</i> L.	Latjira	Amaranthaceae
	<i>Cleome viscosa</i> L.	Wild mustard	Capridaceae
	<i>Commelina benghalensis</i> L.	Spider wort	Commelinaceae
	<i>Convolvulus arvensis</i> L.	Chandvel	Convolvulaceae
	<i>Euphorbia hirta</i> L.	Garden sprug	Euphorbiaceae
	<i>Phyllanthus niruri</i> L.	Hazardani	Euphorbiaceae
	<i>Leucas aspera</i> (Willd)	Dronapushpi	Lamiaceae
	<i>Ocimum sanctum</i> L.	Tulasi	Lamiaceae
	<i>Parthenium hysterophorus</i> L.	Congress grass	Asteraceae
	<i>Tridax procumbens</i> L.	Ghamra	Compositae
	<i>Trianthema portulacastrum</i> L.	Pig weed	Aizoaceae
	<i>Canthium inerme</i> (L.f.) Kuntze	Turkey-berry	Rubiaceae



## Host plants of papaya mealybug I



1. Tulasi 2. *Parthenium hysterophorus* 3. Silk cotton 4. Tapioca

## Host plants of papaya mealybug II



5. Papaya 6. Cotton 7. Guava 8. Teak

### Host plants of papaya mealybug III



9. Brinjal 10. Pigeonpea 11. Jatropha 12. *Hibiscus*

## DAMAGE SYMPTOMS

- Papaya mealybug infestation appears on above ground parts on leaves, stem and fruits as clusters of cotton-like masses.



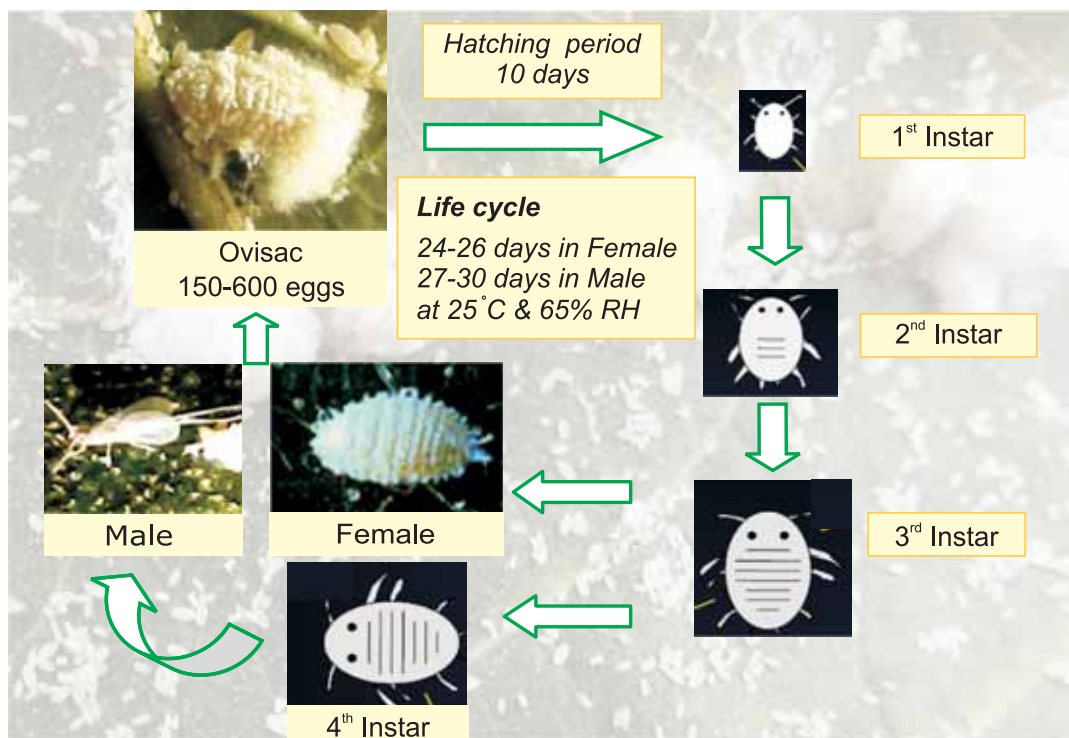
Symptoms of papaya mealybug infestation: 1. Dried plant 2. Chlorosis in mulberry leaves 3. Leaf deformation in mulberry 4. Waxy coating on papaya fruit 5. Crinkled leaf of papaya 6. Infestation on brinjal fruit 7. Malformed jatropha fruits

## Papaya mealybug and its management strategies

- The insect sucks the sap by inserting its stylets into the epidermis of the leaf, fruit and stem.
- While feeding, it injects a toxic substance into the leaves, resulting in chlorosis, plant stunting, leaf deformation or crinkling, early leaf and fruit drop, and death of plants.
- The honeydew excreted by the bug results in the formation of black sooty mould which interferes in the photosynthesis process and causes further damage to the crops.
- Heavy infestations are capable of rendering fruit inedible due to the buildup of thick white waxy coating.

### BIOLOGY

- Papaya mealybugs are most active in warm, dry weather.
- Females have no wings, and move by crawling short distances or by being blown in air currents.



Life cycle of papaya mealybug

- Females usually lay 100 to 600 eggs. Eggs are greenish yellow and are laid in an ovisac sac that is three to four times the body length and entirely covered with white wax. The ovisac is developed ventrally on the adult female.
- Egg-laying usually continuous over a period of one to two weeks. Eggs hatch in about 10 days, and nymphs or crawlers begin to actively search for feeding sites.
- Adult males may be distinguished from other related species by the presence of stout fleshy setae on the antennae and the absence of fleshy setae on the legs.
- Females have three instars whereas males have four instars. Males have longer development time (27-30 days) than females (24-26 days) at  $25\pm 1$  °C,  $65\pm 2$  %RH and 12:12 (L:D) photoperiod.
- Adult females attract the males with sex pheromones.
- Under greenhouse conditions, reproduction occurs throughout the year.

#### FACTORS RESPONSIBLE FOR HIGH POPULATION BUILDUP

- With rapid development, high survival rate, and enormous reproductive capacity, *P. marginatus* population could potentially reach a high level.
- Wax layer and waxy fibres over the ovisac and body of mealybug nymphs and adult females protect them from adverse environmental conditions and routine chemical pesticides.
- Availability of alternate hosts / weeds around fields not cared by cultivators.
- Movement of crawlers through air, irrigation water or farm equipment helps in fast spread of the mealybug from infested field to healthy fields.
- No phytosanitation: free movement of infested fruits, vegetables and other material between States.
- Intensive cropping system.
- Wider acceptability of hosts by papaya mealybug and its subsequent adaptability on them.
- Ant association: providing protection from parasitoids and predators and aiding in dispersal of the pest.
- Piecemeal pruning of mulberry crop provides sufficient time for migration and settlement of crawlers from the old infested crop to the pruned crop.

- In certain crops like tapioca or cotton, stems which often carry mealybug infestation are stocked in the farm for propagation or other purposes. These stocks, near the newly planted crop act as reservoirs of papaya mealybug.

### MODE OF DISPERSAL

- Healthy plants can be infested from mealybug infested plants as juvenile mealybugs can crawl from an infested plant to another plant.
- Small 'crawlers' get readily dispersed by wind, rain, irrigation water, birds, ants, clothing, and vehicle, etc.
- The wax, which sticks to each ovisac and nymphs, also facilitates passive dispersal by equipment, animals or human beings.
- The female mealybug is not active and unable to fly. In fact, human beings greatly facilitate in the transport of these mealybugs.
- Long-distance movement is aided through transport of infested planting material and fresh fruits and vegetables from one end of a farm to the other or even across the country.
- Ants, attracted by the honeydew, have been seen carrying mealybugs from plant to plant.

### ASSOCIATION WITH ANTS

Mealybugs are known to offer ants with their sugary excretion (honeydew) and in return ants help in spreading the mealybugs and provide protection from predator ladybird beetles, parasites and other natural enemies. Ants also keep the papaya mealybug colony clean from detritus



Association of ant, *Oecophylla smaragdina* with papaya mealybug on jatropha (left) and custard apple (right)

that accumulate in the secreted honeydew, which may be harmful to the colony. Species of ant, *Oecophylla smaragdina* has been found attending papaya mealybug, feeding on honeydew on jatropha, papaya and other plants.

### ASSOCIATION WITH OTHER SPECIES OF MEALYBUGS

Papaya mealybug on guava, teak and other plants has been found associated with other species of mealybugs. Two tailed mealybug, *Ferrisia virgata* was the most



Association of papaya mealybug with other species of mealybug on guava: a. Guava fruit infested with complex of mealybugs b. Association with two tailed mealybug *F. virgata* at Coimbatore c. Association with *F. Virgata* and *Maconellicoccus hirsutus* at Peramblur



common species of mealybug found associated with *P. marginatus* in Coimbatore districts of Tamil Nadu on guava and teak. In Perambalur district of Tamil Nadu, guava leaves as well as fruits were found infested with a complex of mealybugs. In this mealybug complex the population of *F. virgata* was the highest followed by *P. marginatus* and *Maconellicoccus hirsutus*. Details of identification of other important species of mealybugs are furnished as annexure.

## MANAGEMENT STRATEGIES

Mealybug control often involves the control of attendant ants that are important for the proper development of mealybugs. Without the ants, mealybug populations are small and slow to invade new areas and the field would be free of a serious mealybug infestation. Therefore, management of mealybugs often includes the control of ant species.

For management of mealybugs, it is important to know the species present as management programs for the various mealybugs may differ. Plant protection products are of limited effectiveness against mealybugs because of the presence of waxy covering of its body. Management of mealybug involves the following tactics:

### Cultural and Mechanical

- Monitoring and scouting to detect early presence of the mealybug
- Pruning of infested branches and burning them
- Removal and burning of crop residues
- Removal of weeds/alternate host plants like *Hibiscus*, *Parthenium* etc. in and nearby crop
- Avoiding the movement of planting material from infested areas to other areas
- Avoiding flood irrigation
- Prevention of the movement of ants and destruction of already existing ant colonies
- Sanitization of farm equipment before moving it to the uninfested crop
- Application of sticky bands or alkathene sheet or a band of insecticide on arms or on main stem to prevent movement of crawlers
- Preventive: In tapioca, stems are stocked for propagative purpose in the farms. These planting materials often carry mealybug infestation, if the previous year's

crop was already infested. Generally, before planting, setts, in parts, are soaked for 1 hr in dichlorvos (76%EC; @10 ml/litre of water) to disinfest the mealybugs. But the major drawback in this methodology is that the treatment of planting material by chemical insecticide is done only in parts as per the requirement, and therefore, the chances of the movement of crawlers of mealybug from the main stock to the newly planted crop always exist. The stock near the tapioca fields acts as a reservoir of papaya mealybug. There is a need that in the infested areas of all the planting material before stocking should be treated with chemical insecticides. A small barrier of insecticide dust (chlorpyriphos 1.5% dust or malathion 5% DP) can also be made around the stocks to check the movement of crawlers as well as ants from/to the stock.



a. Tapioca stems stocked in field for planting b. Papaya mealybug infested sticks  
c. Closer view of a mealybug colony on a node

### Biological control

- Natural enemies of the papaya mealybug include the commercially available mealybug destroyer *Cryptolaemus montrouzieri*, ladybird beetles, lacewings, hover flies, *Scymnus* sp. and certain hymenopteran and dipteran parasitoids. Conservation of these natural enemies in nature plays important role in reducing the mealybug population.
- In the nature, lepidopteran predator, *Spalgis epius* (Lycaenidae) is a well known representative of carnivorous butterfly feeding on various species of

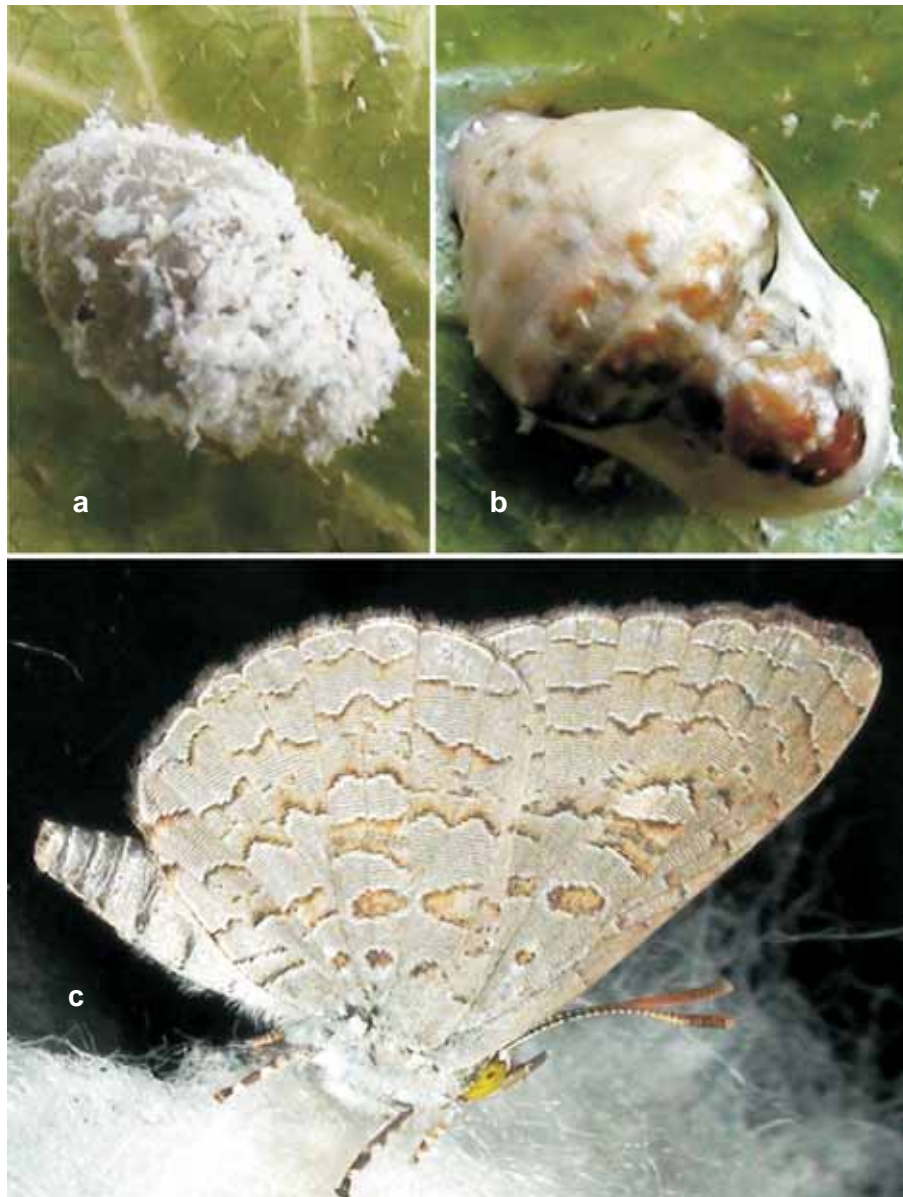


*Cryptolaemus montrouzieri* larva (Left) and adult (Right)



Natural enemies of papaya mealybug:  
a. *Scymnus* sp. b. Dipteran parasitoid parasitizing papaya mealybug  
c. Mealybug mummy containing parasitoid

pseudococcids and coccids. *S. epius*, being the dominant predator, feeds efficiently on the ovisacs, nymphs and adult of papaya mealybug. Newly hatched larvae of *S. epius* are pale pink in colour and remain inside the mealybug ovisac devouring the eggs of the mealybug. The creamy white



*Spalgis epius*: a. Pre pupa b. Pupa c. Adult butterfly

second instar larvae come out of the ovisac. As the larvae of *S. epius* is slug like coated with wax coating and camouflaged with mealybug population, therefore, it is very difficult to distinguish the predator from its prey. The total life cycle lasts for  $14.83 \pm 0.44$  days with the larval life span of  $9.83 \pm 2.39$  (I instar:  $2.5 \pm 0.5$  days; II instar :  $1.75 \pm 0.25$  days; III instar :  $1.41 \pm 0.38$  days; IV instar :  $2 \pm 0.5$  days; V instar :  $2.1 \pm 0.76$  days). The larvae pupate on the under surface of the leaves to form the characteristic rhesus monkey face chrysalis. The pupal period is about  $5.45 \pm 0.50$  days. Ex situ confinement studies have shown that the fifth instar larvae consumed as much as 18 to 26 ( $22.33 \pm 3.21$ ) ovisacs and 112 to 132 ( $121.66 \pm 8.86$ ) nymphs and adults of the mealybugs. During the whole larval period the predatory larvae devoured about 42 to 53 ( $48.15 \pm 4.08$ ) ovisacs and 196 to 222 ( $210.99 \pm 10.77$ ) nymphs and adults of *P. marginatus* (Thangamalar *et al.*, 2010).

- There is a need to conserve the native predators of the pest. Australian ladybird beetle (*C. montrouzieri*) predate on mealybugs, eating 3,000-5,000 mealybugs in various life stages and is released @ 10 beetles per tree or @ 5000 beetles/ha.
- When high activity of *S. epius* and other natural enemies is observed, care should be taken to delay spraying operations and measures should be taken to conserve them.
- Exotic parasitoids/predators such as *Anagyrus loecki* Noyes and Menazes, *Acerophagous papayae* Noyes and Schauff and *Pseudleptomastrix mexicana* Noyes and Schauff (Hymenoptera: Encyrtidae) were released in Sri Lanka in May 2009 (imported from Puerto Rico) and resulted in 95 to 100% control of the papaya mealybug in some parts of that country by August 2009. There is a need to introduce such exotic parasitoids in India to contain the pest without harming the environment.

### Chemical control

- Locate ant colonies and destroy them with drenching of chlorpyrifos 20 EC @ 2.0 ml/litre of water.
- Regular monitoring of the crop for mealybug infestation and its natural enemies .
- Spot application of insecticide immediately after noticing mealybug on some plants in the crop field.

- If the activities of natural enemies are not observed, use of botanical insecticides such as neem oil (1 to 2%), NSKE (5%), or Fish Oil Rosin Soap (25g/litre of water) should be the first choice .
- Chemical control is only partially effective and requires multiple applications.
- Apply recommended chemical insecticides as the last resort such as profenophos 50 EC (2 ml/litre), chlorpyrifos 20 EC (2ml/litre), buprofezin 25 EC (2 ml/litre), dimethoate 30 EC (2 ml/litre), thiomethoxam 25 WG (0.6 g/ litre), imidacloprid 17.8 SL (0.6 ml/litre)
- Spray profenophos @ 2 ml / litre on stumps immediately after pruning in mulberry followed by second spray, 15 days after pruning, with dichlorvos @ 2 ml /litre along with azadirachtin (10000 ppm) @ 1 ml /litre. Stickers should always be added in spray solutions.
- Avoid repeating the use of the same chemical insecticide as there are chances for development of resistance in the pest.
- Drenching soil with chlorpyrifos around the collar region of the plant to prevent movement of crawlers of mealybug and ant activity is useful.
- Insecticide resistance and non-target effects on natural enemies make chemical control a less desirable control option.

### Phytosanitary measures

It is relatively easy to detect mealybugs by inspection, so the basic requirement that imported consignments of plants for planting should be free from the pest can be fulfilled by inspection. Monitoring the movement of fresh farm produce, including flowers, between countries as well as between States of our country is the first step in controlling any spread within the region. This applies to both the import/export trade and to passenger traffic. *M. hirsutus* was added in 2003 to the European and Mediterranean Plant Protection Organization (EPPO) A1 Action List, and endangered EPPO member countries have recommended regulating it as a quarantine pest. Similar case is required for papaya mealybug.

### GUIDELINES AND CAUTIONS

- Do not move any plant material with suspected mealybugs to pest free fields. Moving infested plants is the fastest way to spread the pest.
- After pruning, the cuttings of infested shrubs or trees lying around must be immediately burnt.

- Do not shake or scatter the infested material.
- Proper phytosanitation of planting material, harvested produce etc., before moving to other States is required.
- Intensive regular survey would be necessary to find out efficient parasitoids/predators/pathogens of the pest.
- Piecemeal harvesting of mulberry crop need to be avoided/monitored for preventing spread of the pest.
- Do not spray any chemical insecticide unless mealybug infestation is confirmed; unnecessary spraying may destroy natural enemies which keep mealybug populations under control.
- Follow the waiting period of 2-3 weeks after the last spray to release the mealybug destroyers. Water infested plants well before releasing mealybug destroyers.
- Predator beetles should be released in spots having adequate mealybug population to ensure the best effectiveness.
- Apply safer pesticides like dichlorvos, chlorpyrifos, fish oil rosin soap, azadirachtin, buprofezin etc. during the activity of ladybird beetle.
- If chemical control is chosen, always wear protective clothing and safety gear.

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## IDENTIFICATION OF IMPORTANT SPECIES OF MEALYBUG

- 1. Striped mealybug or two tailed mealybug (*Ferrisia virgata*):** The species is associated with aerial portion of host plant. The body is grey in colour and covered with very long waxy filaments and is provided with long tails. Two dark stripes are present on dorsum and body fluid is of light color. This species produces egg mass or ovisac.
- 2. Longtail mealybug (*Pseudococcus longispinus*):** Anal wax filaments are as long as the body and appear as long tails; 2<sup>nd</sup> to last pair of wax filaments is also long; dorsal median stripe is present on abdomen.
- 3. Citrus mealybug (*Planococcus citri*):** Body is yellow to pink in colour, covered with medium sized slightly curved waxy filaments and is not pyramid shaped. One dorsal median stripe is present on the back in adults and body fluid is clear. Anal filaments are less than one-eighth the length of the body. This species produces an egg mass or ovisac which is irregular and remains under body of the female.
- 4. Solanum mealybug (*Phenacoccus solani*):** The body is covered with very short waxy filaments. Long tails and stripes on the body are absent. This species does not produce an egg mass or ovisac.
- 5. Pink sugarcane mealybug (*Saccharicoccus sacchari*):** The insect is light pink in color and occurs underneath leaf sheaths on sugarcane. Adult females are provided with mobile legs.
- 6. Pineapple mealybug (*Dysmicoccus brevipes*):** This insect is associated with roots of host plants. Body color is light pink to grey and is provided with 17 pairs of wax filaments.
- 7. Pink mealybug (*Maconellicoccus hirsutus*; synonyms- *Phenacoccus hirsutus*):** Mealybug colonies contain immature as well as mature females. Larger mealybugs are darker in color and covered with significantly more white waxy material. There is very little wax on the body, no long tails or waxy projections around the edge, no stripes and this mealybug produces an egg mass. Ovisac is irregular and beneath the body. When squashed, a pink to red fluid is observed.



- 8. Solenopsis mealybug (*Phenacoccus solenopsis*):** The insect is provided with short to medium sized waxy filaments around the body, anal filaments about 1/4<sup>th</sup> length of the body and the two dark stripes on either side of the middle “ridge” of the body. Long glassy rods are present on the back. This species produces an egg mass or ovisac.
- 9. Mango Mealybug (*Drosicha mangiferae*):** The females can be identified by their flat shape, covered with white mealy powder.

## Major species of mealybug



**Two tailed mealybug**  
*Ferrisia virgata*



**Longtail mealybug**  
*Pseudococcus longispinus*



**Citrus mealybug**  
*Planococcus citri*



**Solanum mealybug**  
*Phenacoccus solani*



**Pink sugarcane mealybug**  
*Saccharicoccus sacchari*



**Papaya mealybug**  
*Phenacoccus marginatus*



**Pink mealybug**  
*Maconellicoccus hirsutus*



**Solenopsis mealybug**  
*Phenacoccus solenopsis*



**Mango mealybug**  
*Drosicha mangiferae*