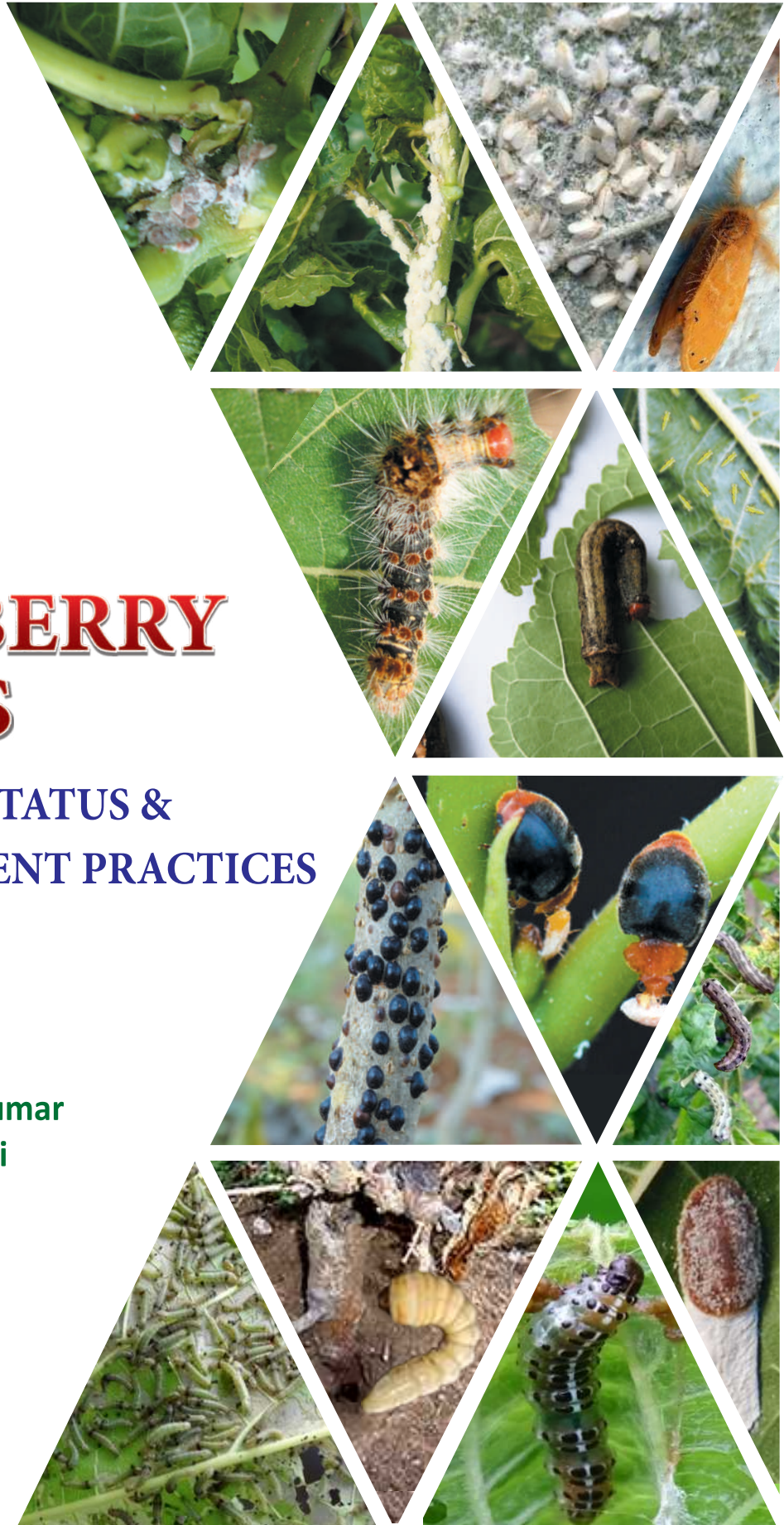




MULBERRY PESTS

CURRENT STATUS &
MANAGEMENT PRACTICES

N. Sakthivel
J.B. Narendra Kumar
N. Dhahira Beevi
M. Devamani
R.S. Teotia



CITATION
TITLE OF TECHNICAL BULLETIN
MULBERRY PESTS
CURRENT STATUS AND MANAGEMENT PRACTICES

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YEAR OF PUBLICATION : JULY 2019

WRAPPER DESIGN : J. Justin Kumar

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Published by

CENTRAL SERICULTURAL RESEARCH & TRAINING INSTITUTE

Central Silk Board, Ministry of Textiles, Government of India
Srirampura, Mysuru - 570 008.

e-mail : csrtimys@gmail.com website : www.csrtimys.res.in

July - 2019

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CENTRAL SERICULTURAL RESEARCH AND TRAINING INSTITUTE

CENTRAL SILK BOARD, MINISTRY OF TEXTILES

GOVERNMENT OF INDIA

Srirampura, Mysuru – 570 008



Dr. R.S. Teotia

DIRECTOR

FOREWORD

Mulberry, the food plant of silkworm is prone to attack by number of pests comprising largely with insects and few non-insect species. They cause reduction in mulberry leaf yield besides deteriorating its nutritional value and make unfit for feeding silkworm. Feeding pest affected leaves to silkworm often results in adverse impact on its growth and cocoon yield. Therefore proper management strategies need to be adopted to keep mulberry garden free from the pests for sustainable production of silk.

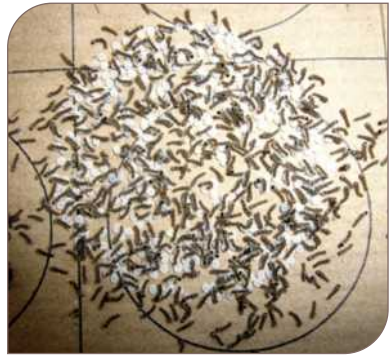
Chemical pest management practice is invariably preferred by the farmers as it yields visible result. But spray of highly toxic or long persisting insecticides is not recommended for mulberry garden due to their residual toxic effects to the silkworms and health hazards to the farmers on continuous use. Therefore adoption of IPM strategies with emphasis on non chemical methods like use of botanical formulations, natural enemies of mulberry pests, traps, water jetting etc., are advocated.

In recent past, the pest status in mulberry ecosystem is changed due to advent of high yielding mulberry varieties, more use of agronomical inputs clubbed with climate change. Therefore, thorough updated knowledge on the pests invading mulberry garden including their descriptions, mode of damage to plants, symptoms, seasons favoring their multiplications, alternate host plants, effective natural enemies, suitable IPM practices is essential. This technical bulletin fulfills all above information and intent on catering sericulture farmers, extension workers and entomologists.



[Dr. R.S. Teotia]

SERICULTURE



INTRODUCTION

Sericulture is an agro based industry which offers employment opportunity to about 8 million people in India. Mulberry (*Morus alba* L.), the food plant of silkworm (*Bombyx mori* L.) is cultivated over 2.3 lakh hectares and exploited greatly for silkworm rearing and production of silk. It is a perennial crop and maintained continuously for about 15-20 years. Silk productivity and profit of the farmers mainly depends upon the quantum as well as quality of mulberry leaves produced as the former influences on rearing capacity of silkworms *i.e.*, the quantum of larvae to be reared and the later plays vital role on their growth and development and silk yield. Therefore, regular agronomical practices *viz.* manuring, irrigation, weeding, pest and disease management *etc.*, are imperative in moriculture in order to improve the production of quality mulberry leaf.

Major pests of mulberry

Mulberry is prone to attack by number of pests and they cause abrupt reduction in leaf yield and deteriorate its quality. Feeding such leaves to silkworm results in adverse effect on the cocoon yield and silk quality. Though mulberry hosts hundreds of insect species, few of them *viz.*, leaf webber, *Diaphania pulverulentalis* Hampson (Lepidoptera: Pyralidae), mulberry thrips, *Pseudodendrothrips mori* Niwa (Thysanoptera: Thripidae), pink mealybug, *Maconellicoccus hirsutus* Green (Hemiptera: Pseudococcidae), papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), and spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) are causing severe damage and crop loss

whereas rest of them live in minor or secondary pest status below the economic injury level. But sudden outbreak of secondary pests is common phenomena in mulberry ecosystem under tropical conditions owing to various reasons.

Cause for pest flare-up on mulberry

The factors like intensive cultivation of mulberry, monoculture, excessive application of chemical fertilizers, luxuriant growth of mulberry plants, succulence of the leaves, absence of natural enemy complex in mulberry ecosystem due to indiscriminate application of toxic chemicals, climate change with poor showers followed by dry and hot weather often stimulate resurgence of pests or population build up of the minor pests or invite incidence of new pests from other crops and any of them outbreaks suddenly.

Classification of mulberry pests

Based on the phylum or class, mulberry pests are classified into two major categories called insect and non-insect pests. Insect pests are predominant in mulberry ecosystem whereas only few non-insect species like mites, snails, slugs, nematodes and millipedes are reported to be causing damage to mulberry plants occasionally. The insect pests of mulberry are mainly grouped into sap suckers, defoliators and borers based on their mode of feeding.

Sap suckers

Sap suckers are commonly known as sucking pests which have piercing and sucking type mouth parts with slender needle like stylet to pierce the plant cell from leaves or stems and suck the juice. In mulberry, the sap suckers deplete nutrient value of the leaves and cause stunted growth of plants. Majority of sucking pests

secrete honey dew which promote growth of black sooty mold, a type of fungus that pollutes the entire mulberry garden and makes the leaves unpalatable in case of severe incidence. Some sucking insects inject toxic materials into the plant while feeding, which leads to wilting of plants whereas few act as vector and transmit plant diseases. Common sap-feeders include thrips, mealybugs, whiteflies and scale insects. Among non-insect pests, few mite species are recorded on mulberry and they also suck the plant sap.

Defoliators

These insect pests possess the mouth parts especially adapted to biting and chewing of various plant parts mainly leaf and shoot tissues. These pests make shot holes in leaves, skeletonize them or defoliate the entire plants. Some common biting and chewing insect pests of mulberry are caterpillars, beetles and grasshoppers. The defoliators mainly reduce the availability of mulberry leaves for silkworm rearing.

Stem borers

This group contains fewer species mainly under the order of Coleoptera and are very important pests of mulberry. These pests are capable of boring into plant parts and destroy the tissues. Tunneling by the borers may kill branches but rarely whole trees due to interruption of nutrient and water transport. Borers infestation is very difficult to identify at initial stage as they typically leave only tiny sized entrance holes and most part of their life cycle is spent inside the tunnel. The symptom is visible only when the frass comes out from the entry points or sap oozes out of the holes. Controlling this pest with insecticides is difficult. Insecticidal sprays must be applied before the insect tunnels into the plant.

INSECT PESTS

A. SAP SUCKERS

1. Pink mealybug, *Maconellicoccus hirsutus* (Green)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Pseudococcidae; Genus: *Maconellicoccus*; Species: *hirsutus*.

Description and life history

Adults of both female and male are about 3 mm long. Females are pink in color with a white waxy covering and have no wings. Males have a pair of wings and two long waxy tails and are capable of flight. Female can reproduce parthenogenetically and each female lays approximately 350-600 eggs in an ovisac covered with cotton like mealy substance. The eggs will hatch in 6-9 days. Males have four nymphal instars while females have only three. Nymphal period lasts for 23-27 days and total lifecycle completes in a month period. There will be 10-12 generations in a year.

Alternate host plants

They are highly polyphagous and so far more than 350 host plants have been recorded in the world. Important host plants are hibiscus, beans, pumpkin, croton, chrysanthemum, citrus, grapevine, guava, coffee, sugarcane, soybean, mango, pigeon pea, maize, cotton, teak etc.

Occurrence

They occur on mulberry throughout the year, but the incidence is high in summer months (March to August). Their population is negligible during rainy season.

Damage and symptoms

The nymphs feed by sucking the sap from tender leaves and stem portion. Hence the affected apical shoots show bunchy appearance due to curling of leaves, shortening of internodes and thickening of stem. This symptom is popularly known as 'Tukra' in India. In advance stages of infestation black sooty mould is developed in the affected area due to growth of fungus on the honeydew secreted by the mealybug. The pest makes both quantitative and qualitative loss in mulberry production due to retarded growth of plants and depletion in nutritional value of the leaves.

Management practices

- ✓ Clip off infested apical shoots and destroy by burning or dipping in soap solution.
- ✓ Do not grow alternate host plants of the mealybug in the vicinity of mulberry gardens.
- ✓ Spray 0.05% Dimethoate (36 % EC) 12-15 days after pruning. Safe period to silkworm is 20-25 days. During summer second dose of 0.2% DDVP (76% EC) 10 days after first spray is essential to avoid recurrence of the pest during growing phase of mulberry plants. Safe period is 15-17 days.
- ✓ Release predatory ladybird beetles *Cryptolaemus montrouzieri* @ 250 adults or *Scymnus coccivora* @ 500 adults /acre/ year in two split doses at an interval of six months.



Pink mealybug



C. montrouzieri feeding on pink mealybug

2. Papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Pseudococcidae; Genus: *Paracoccus*; Species: *marginatus*.

Description and life history

Eggs are greenish yellow and are laid in an egg sac. Nymphal stages of both male and female and adult female are yellow in colour but pupal and adult stages of male appear in pink. Adult female and egg sac are covered with thick waxy coating and hence its infestation can easily be observed with presence of clusters of cotton like masses.

Adult female is apterous, approximately 2.2 mm long and 1.4 mm wide. Adult males are approximately 1.0 mm length with an elongate oval body that is widest at the thorax (0.3 mm), have ten-segmented antennae and well developed wings. It reproduces sexually. Gravid female lays 108 to 296 eggs and incubation period ranges between 3-9 days. The nymphal stages of female and male exist for 12 to 17 and 17 to 21 days during summer and 21 to 22 and 22 to 30 days during winter respectively. A generation takes approximately one month to complete depending upon the environmental temperature.

Alternate host plants

The pest is polyphagous in nature having wider host range and reported to infest more than 80 host plants of about 25 genera including economically important crops *viz.*, papaya, tapioca, jatropha, hibiscus, avocado, citrus, cotton, tomato, egg plant, pepper, beans, peas, sweet

potato, mango, cherry, pomegranate, *Plumeria etc.*

Occurrence

Occurs throughout the year, but severity is more in summer months.

Damage and symptoms

It has piercing-sucking mouth parts and feeding on phloem sap of mulberry both from stem and leaf resulting in loss of moisture and decline in nutritional values. The pest also injects a toxic substance into the plants while feeding.

The symptoms appear on the leaves as chlorosis (yellowing), deformation (curling), pre mature drop, stunted growth followed by death of plants. Growth of dense black sooty mould on leaves over the honeydew excreted by the pest reduces the photosynthetic efficiency of the plants as well as pollutes entire mulberry garden in case of severe infestation.



Papaya mealybug



Affected garden

Management practices

- ✓ Clipping off the infested twigs and leaves and burning during early stage of infestation is the best method of eradication of the pest.
- ✓ All crop residues in the infested garden harbouring mealybug populations should be removed and burnt.
- ✓ Water jetting involves physical force which hits on the infested plant parts to dislodge and washout the insects so that the mulberry garden is kept free from the population of papaya mealybug.



Water jetting in papaya mealybug affected garden

- ✓ As soon as the pest is noticed, release exotic parasitoid, *Acerophagus papayae* or *Pseudleptomastix mexicana* @ 250 parasitoids / acre of mulberry garden. These parasitoids are most effective in controlling papaya mealybug successfully rather than spray of chemical insecticides.

3. Mulberry thrips, *Pseudodendrothrips mori* (Niwa)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Thysanoptera; Family: Thripidae; Genus: *Pseudodendrothrips*; Species: *mori*.

Description and life history

Mulberry thrips reproduce both sexually and parthenogenetically. Each female lays about 30-50 bean shaped whitish eggs measuring 0.25 mm in length and 0.10 mm in breadth on ventral surface of tender leaves which hatch in 6-8 days. The newly hatched first instar nymph is initially colourless and transparent with a pair of dark red compound eyes and gradually changes to light creamy yellow. There are two nymphal stages with 6-7 days. Second instar nymph measures about 0.70 mm length and 0.23 mm breadth. After nymphal stages, it enters into soil and become inactive and non-feeding stages called pre-pupa and pupa. The pupa is yellow coloured, characterized by two pairs of short wing pads. Adults are about 0.8 mm long. Female is yellow in colour, while male is darker. Total lifecycle is completed in 20-22 days with 15 generations in a year.



Nymphal stages of thrips

Alternate host plants

Very few plants like *Ficus*, *Tridax procumbens*, *Camellia sinensis*, *Leersia hexandra* are reported as alternate hosts of *P. mori*.

Occurrence

Occurs throughout the year, but incidence is severe in summer months (April – May) and least in rainy season (October-November).

Damage and symptoms

Nymphs and adults are found mainly on the underside of the leaf. They pierce the epidermis of mulberry leaves using their lacerating mouthparts and extract the plant sap. During laceration, they secrete saliva which coagulates the sap resulting in the formation of white streaks in the early stage followed by silvery blotches which are mixed with small black spots of thrips faeces. This symptom helps in distinguishing damage by *P. mori* from that caused by other mulberry pests. As the leaf tissue dries beneath the epidermis the silvery patches turn brown and become depressed. In acute cases serious drying of the leaf tissues results in leaf curl and these leaves shrink harden and ultimately fall. Stunting, leaf curling and deformation are also observed in severely affected gardens. Feeding thrips affected mulberry leaves to silkworm results in adverse impact on economic traits and cocoon yield.

Management practices

- ✓ Mulberry field should be thoroughly cleaned after harvest by removing small side branches, dead leaves and weeds in order to eliminate any developmental stages of thrips on them.



Symptom of thrips infestation



Thrips affected mulberry plant with stunted growth

- ✓ Periodical ploughing and digging of mulberry field helps in exposing the thrips pupae to hot sun and natural enemies.
- ✓ Water jetting or sprinkler irrigation is effective in reducing thrips population.
- ✓ Providing frequent irrigation helps in increasing the pupal mortality in soil thereby reducing the thrips emergence.
- ✓ Spray of 0.1% Dimethoate 30% EC (3ml/litre) 15 days after pruning. Safe period is 20-25 days.
- ✓ Release of *S. coccivora* @ 500 adults or *Chrysoperla* @ 1000 eggs / acre, a week after the insecticide spray.

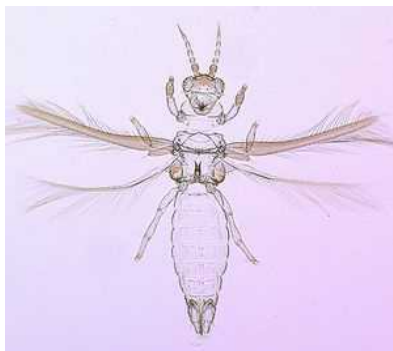
4. Thrips, *Pseudodendrothrips bhattii* Kudo

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Thysanoptera; Family: Thripidae; Genus: *Pseudodendrothrips*; Species: *bhattii*.

Description and life history

Both sexes of this species are macropterous. Body is white in colour except brown interocular area, lateral 1/3 of both sides of pronotum, lateral sides of mesonotum, median third of fore tibia. Antenna is 8 segmented and brown in colour. Segments I and II are darker than the other segments with pale colour in the basal portion. The forewing is grey and antennal segment I and II are distinctly darker than IV-VIII. It reproduces parthenogenetically. Life cycle has five stages viz., egg, two active nymphal stages and inactive pupal stage and adult. The nymphs feed actively on leaves. Second stage nymphs pupate mostly in soil. Adults also feed actively. Detailed life history of *P. bhattii* on mulberry is not available.



P. bhattii female from Japan
[M. Masumoto]
(https://thrips.info/wiki/Pseudodendrothrips_bhattii)

Alternate host plants

P. bhattii mostly infests *Morus* spp. However, its infestation is also recorded on potato and *Ficus*.

Occurrence

Occurs throughout the year, but incidence is severe in summer months (April – May).

Damage and symptoms

Like *P. mori*, nymphs and adults of *P. bhattii* are also found on the underside of the leaf and cause similar type of damage. They pierce the epidermis of mulberry leaves using their sucking mouthparts, suck the sap and deteriorate the leaf quality. Affected leaves show silvery or brownish patches. Severe infestation results in leaf curling and stunted growth of plants. Feeding thrips affected mulberry leaves to silkworm will adversely affect its growth and finally the cocoon yield.

Management practices

- ✓ Mulberry field should be kept clean without weeds and dry leaves.
- ✓ Expose the pupae of the thrips in soil to hot sun and natural enemies by ploughing.



Courtesy: A.V. Mary Josepha Shery

- ✓ Spray of strong jet of water or sprinkler irrigation is effective to washout the pest from the plants.
- ✓ Spray of 0.1% Dimethoate 30% EC (3ml/litre) 15 days after pruning. Safe period is 20-25 days.
- ✓ Release *S. coccivora* @ 500 adults or *Chrysoperla* @ 1000 eggs / acre, a week after the insecticide spray.

5. Spiralling whitefly, *Aleurodicus dispersus* Russell.

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Homoptera; Family: Aleyrodidae; Genus: *Aleurodicus*; Species: *dispersus*.

Description and life history

Each female lays about 40-70 pale yellow coloured eggs with a short pedicel on the underside of leaf. The eggs are laid along with deposit of waxy secretion in a characteristic spiralling pattern, hence the name 'spiralling whitefly'. Incubation period

is 4-6 days. There are four nymphal stages. The first instar nymphs are mobile (crawlers) and suck the sap from the tender leaves. Subsequent instars are immobile which are found on the underside of older leaves. They produce whitish waxy filaments and copious quantities of honey dew.

The final instar is the pupa from which adults emerge. The nymphal period exist for 14-20 days. The adult flies are 2 mm in length with white powdery wax material over the wings and whole body. Life cycle is completed in a month and has 10-12 generations per year.

Alternate host plants

Mango, custard apple, apple, papaya, banana, sweet potato, cassava, avocado, guava, citrus, capsicum, brinjal, tomato, pepper, rose, hibiscus, coconut, etc.

Occurrence

It is found to cause damage throughout the year with peak incidence during summer.



Spiralling whitefly affected mulberry plant & close up view

Damage and symptoms

Spiralling whitefly remains on ventral surface of leaves in colonies and cause direct feeding damage by sucking plant sap and indirect damage due to the honeydew and white waxy material produced by the insect. Adults and nymphs feed on plants by sucking plant sap from the leaf through a slender stylet which results in leaf curling, chlorosis, defoliation and stunted growth. Large amount of powdery wax material secreted by all the stages of pest is readily spread through wind, causing nuisance. The honeydew excreted by these insects will fall on the upper surface of the lower leaves which becomes a medium for developing sooty mould fungus, *Capnodium* sp. This in turn, interferes with photosynthetic process by not allowing enough light to reach the cytochrome tissues of the leaves.



Sooty mould on spiralling whitefly infested leaf

The sooty mould may also increase thermal absorption and raise leaf temperature, thus causing reduced leaf efficiency and further deterioration in the nutritional quality. Feeding spiralling whitefly infested mulberry leaves to silkworm will affect its growth and development which leads to adverse impact on cocoon production.

Management practices

- ✓ Remove and destroy the infested leaves and install yellow sticky traps @ 75 per acre.
- ✓ Spray of a strong jet of water in the affected mulberry garden will help to reduce the pest population below economic injury level without applying any chemical insecticides.
- ✓ Spray 0.05% Dimethoate 30% EC (1.5 ml/litre) about 15 days after pruning and second spray with 0.15% DDVP 76% EC (2 ml/litre), one week after first spray (safe period 20-25 days).
- ✓ Release *S. coccivora* @ 500 adults or *Chrysoperla* @ 1000 eggs / acre, a week after the insecticides spray.
- ✓ Two parasitoids namely *Encarsia quadeloupa* and *Encarsia haitiensis* are known to parasitise *A. dispersus* in India.
- ✓ An egg predator *Axinoscymnus puttarudriahi* was identified and it could also be used to destroy the pest in egg stage itself.

6. Mulberry whitefly, *Dialeuropora decempuncta* (Quaintance & Baker)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Homoptera; Family: Aleyrodidae; Genus: *Dialeuropora*; Species: *decempuncta*.

Description and life history

Mulberry whitefly reproduces both sexually and parthenogenetically. The female lays 120-150 straw colored eggs on the under surface of tender leaf which hatch in 8-9 days. The nymphs are oval in shape and reddish yellow in color move about for a short time to settle down at a suitable place on the under surface of the leaves. They lose their legs during first moult and hence second and third instar nymphs are sedentary. The fourth instar nymph is considered as pupa which is opaque white in color and possesses red colored eyes. At this stage, it secretes deep blue colored thread like structures surrounding its body so as to deter the natural enemies. The nymphal stage lasts for 11-25 days. The

adult whitefly comes out of the pupal case through an inverted "T" shaped moulting suture leaving the pupal case on the leaf surface. The adults are minute and white in color. They have a pair of floury wings, covered with whitish waxy powder and typical black markings on the wings unlike spiralling whitefly, where such black markings are not seen. Males live for 4-8 days and females for 10-14 days. Total life cycle takes 30 - 45 days depending on the weather conditions.

Alternate host plants

Guava, custard apple, banana, citrus, *Abutilon*, brinjal, banyan, peepal, teak, cotton, papaya, pepper, *Plumeria*, rose etc.

Occurrence

The whiteflies are present throughout the year with high population in summer (March-June) and low during winter (October-January). The population is positively correlated with temperature and negatively correlated with humidity.



D. decempuncta on ventral side of mulberry leaves

Damage and symptoms

The adult and nymphal stages of whitefly infest lower surface of mulberry leaves, suck the sap, cause speckling, upward curling, yellowing of leaves, premature fall and retardation of growth. Majority of feeding damage is done by the first three nymphal stages. As the infested plant grows, the bottom leaves get covered with copper sulphate blue powdery substance. This is due to the presence of blue colored filamentous covering of the nymphal stages of the insect which develops on the ventral side of the mulberry leaf. The honeydew excreted by the insect leads to the development of sooty mould on the mulberry leaves. The leaves covered with black colored sooty mould and the blue powdery substance together make the leaves unsuitable for feeding to silkworm.

Management practices

- ✓ Remove and destroy the infested leaves and install yellow sticky traps @ 75 per acre.
- ✓ Spray of a strong jet of water in the affected mulberry garden will help to reduce the pest population below economic injury level without applying any chemical insecticides.
- ✓ Spray 0.05% Dimethoate 30% EC (1.5 ml/litre) on 15 days after pruning and second spray with 0.15% DDVP 76% EC (2 ml/litre) one week after first spray (safe period 20-25 days).
- ✓ Release *S. coccivora* beetles or *Micraspis discolor* @ 500 adults / acre.
- ✓ Two aphelinid parasitoids *Encarsia haitiensis* Dozier and *E. meritoria* Gahan are most promising.

7. Long - tailed mealybug

Pseudococcus longispinus
(Targioni-Tozzetti)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Pseudococcidae; Genus: *Pseudococcus*; Species: *longispinus*.

Description and life history

Adult females of long tailed mealybugs have 17 pairs of waxy filaments around the periphery and measures 3 mm long. On matured individuals the caudal filaments are as long as or longer than the yellowish to grayish body (unless the tail filaments are broken off). Overall length may be 6 to 7 mm. There is no external egg stage of the long tailed mealybug. The nymph is similar to the larger adult female except that the filaments around the edges are shorter. Sexual reproduction is obligatory. Unlike pink mealybug they do not produce egg sac. Each adult female lays about 100-240 eggs, but the eggs hatch as soon as they are laid giving an impression of that of ovoviviparous nature. They exude white waxy covering over the body giving mealy appearance. Male and female are differentiated after first moult. Female long-tailed mealybug nymphs undergo three instars whereas males undergo four. The adult male survives for 2-3 days only whereas the female live for 2-3 weeks. It is observed that they lay more than 90% eggs within first 15 days. Adult female is wingless, oval in shape, measures 3 mm long with short antennae and legs and has

17 pairs of waxy filaments around the periphery. Adult male is tiny measuring 1 mm length, with one pair of transparent wings and long antennae. They complete 4-6 generations in a year.

Alternate host plants

It has a wide host range and infests many cultivated plants including guava, coconut, citrus, mango, pigeon pea, potato, sugarcane, grapes, pear, persimmon, avocado, crotons, orchids, apple *etc.*

Occurrence

The pest occurs throughout the year.

Damage and symptoms

Both nymphs and adults suck the sap from the plant leading to reduced vigour which results in stunted growth of plants, reduction in leaf quality and leaf yield. The males feed only during the first and second instars. The third instar is the prepupal stage and lacks mouthparts. Female nymphs feed throughout all instars. The symptoms are chlorosis, deformation of leaves and premature fall.

Management practices

- ✓ Collection and burning of infested plant parts and pruned materials
- ✓ Avoid growing highly susceptible alternate host plants such as guava, hibiscus, crotons *etc.*, in the vicinity of mulberry gardens.
- ✓ Parasitic wasps, *Anarhopus sydneyensis* Timberlake, *Hungariella peregrina* (Compere) and *Anagyrus fusciventris* Girault can be released against the long tailed mealybug. *A. sydneyensis* is more promising in controlling this pest.
- ✓ Release predatory ladybird beetle *S. coccivora* @ 500 adults or Australian ladybird beetle *C. montrouzieri* Mulsant @ 250 adults/year in two split doses at an interval of six months .



Long-tailed mealybug

8. Jassid, *Empoasca flavescens* Fabricius

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Cicadellidae; Genus: *Empoasca*; Species: *flavescens*.

Description and life history

Adults are pale green or greenish yellow in color and about 3-4 mm in length. Body is wedge-shaped with whitish markings on the head and thorax. The head is prolonged forward as a smooth, flat, triangular structure with a pair of antennae possessing sensoria. The thorax is simple and abdomen is tapering at the posterior end. The hind legs have two parallel rows of spines which extend all along the hind tibiae. The wings are held like a roof over



Nymph & adult stages of Jassid

the abdomen. The nymphs resemble adults, but they lack wings until the fourth instar. Adults and nymphs move sideways. Female lays 20-30 eggs on the lower surface of the leaves below the epidermis. Eggs are pale yellow in color & elongated in shape. The egg hatches into nymph within 6-13 days. The nymph undergoes five instars and becomes adult in 8 to 22 days. Nymphal period is 19-27 days. Pupation takes place on the leaf itself. There are 10-12 generations in a year.

Alternate host plants

Castor, tea, okra, cotton, beans, brinjal, potato *etc.*, are prone to severe attack of jassid.

Occurrence

It is considered to be a minor or occasionally serious pest of mulberry. The insect remains active throughout the year, but maximum population build up occurs during November to January, that is mostly in the winter season.

Damage and symptoms

Both nymphs and adults damage the plant by sucking the sap of young leaves and tender shoots. At the time of sucking cell sap inject toxins in to the plant tissues. The early symptoms are the appearance of yellow or brown patches at the margin of the leaves followed by distortion of leaf veins. Finally, leaves curl upward becoming cup shaped, margins turn brown, dry and wither off prematurely. This characteristic symptom is known as "Hopper burn".



Hopper burn symptom in leaves



Jassid affected mulberry garden

Management practices

- ✓ Set up light traps and yellow sticky traps to destroy adult population.
- ✓ Sprinkler irrigation is effective in controlling the pest.
- ✓ Spray neem oil (3%) with fish oil rosin soap (2%). Safe period is 10-12 days.
- ✓ Spray of a strong jet of water in the affected mulberry garden help to reduce the pest population below the economic injury level.
- ✓ Cultivation of cluster bean, cowpea, black gram or groundnut as intercrops in mulberry encourage to buildup natural enemies like coccinellids and spiders.
- ✓ Spray 0.1% Dimethoate 30% EC (3ml/litre). Safe period is 25 days.

9. Black scale insect, *Saissetia nigra* (Nietner)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Coccidae; Genus: *Saissetia*; Species: *nigra*.

Description and life history

Adult female is 3-4 mm long and dark brown in colour. Body is elongate-oval and convex in shape. Reproduction takes place parthenogenetically. A female lays about 300-600 eggs. Eggs are white, later turn into reddish brown and hatch within 5-6 days. The first instar has functional legs and called as "crawlers". Immediately after hatching, they crawl around in search of a favorable spot to settle down and feed. It secretes a fibrous waxy material which hardens to form the scale. The female moult 3 times with 4 instars while male 2 times and have 3 instars. During first moult they lose their appendages. Immature stages are translucent yellow in colour. Nymphal period is 19-28 days. Adult males live for 6-11 days while females live for 9-18 days. It completes 3-6 generations in a year.

Alternate host plants

Attacks several crops like avocado, banana, chrysanthemum, citrus, coffee, cotton, crotons, guava, mango, pomegranate etc.

Occurrence

Though it is a minor pest, occurs throughout the year, but severe during summer months.

Damage and symptoms

Both nymphs and adults suck the plant sap from the leaf as well as apical tender stem portion. Feeding results in yellowing of leaves, stunted growth of plants and affected shoots start drying from the distal end.

The pest excrete copious amount of honey dew on which sooty moulds develop. This restricts photosynthesis and affects the nutritional value of the leaves. In case of severe infestation the black sooty moulds pollutes the plants of entire garden and make the leaf unfit for feeding silkworm. The movement of ants can also be noticed on the infested plants.



S. nigra infestation on stem



Heavily infested mulberry garden

Management practices

- ✓ Scrape the stem with the help of wooden plate to dislodge the insect.
- ✓ Swabbing the affected stem with diesel oil and soap emulsion (1:3 ratio) to dislodge the insect.
- ✓ Cutting and burning of infested plant parts.
- ✓ Spray strong jet of water to washout the crawlers and clean the sooty moulds.
- ✓ Spray 0.05% Dimethoate 30% EC (1.5 ml/litre) or 0.15% DDVP 76% EC (2 ml/litre). Safe period 12 & 15 days respectively.
- ✓ *Metaphycus helvolus* (Compere) is reported as effective parasitoid of *S. nigra*.

10. Soft scale insect, *Megapulvinaria maxima* (Green)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Coccidae; Genus: *Megapulvinaria*; Species: *maxima*.

Description and life history

Adult female is wingless, oval in shape, measures 4-5 mm length, dark brown in



M. maxima affected mulberry plant

colour with some black dots set in irregular, radiating rows near the margin of the body. Dorsum is powdered with a distinct external cottony white mealy secretion or wax covered egg sac measuring 10-20 mm. Adult male is winged and die within short period after emergence from pupal stage and hence rarely seen in the field. Adult female is capable of reproducing parthenogenetically. The eggs hatch into first instar nymphs called crawlers which are yellowish to orange in colour. The crawlers move to spread on plant leaving egg sac as well as blown by wind to other plants, settle down and begin feeding within a day or two. Settled nymphs may complete their life cycle in the same spot without moving and mature into adult. There are three instars in female and five in male. It takes 50-60 days to complete one generation and there will be 3-7 generations depending upon the environmental temperature.



M. maxima

Alternate host plants

M. maxima has been recorded from plants belonging to 24 genera in 15 families. However more incidences occur in Neem and *Jatropha*.

Occurrence

This pest occurs in mulberry garden generally from August to February while peak incidence is found in October and November. It is more prevalent in hilly regions.

Damage and symptoms

Soft scale insect infests both leaves and twigs. Infestation of *M. maxima* can easily be identified by the presence of white scabs on the leaves and twigs. Nymphs and adult females ingest the plant sap by inserting its threadlike mouth part which causes depletion of nutrient value of the leaves. A large amount of honeydew secreted by the pest invites fungal growth and development of black sooty mould on the leaf surface which interferes with the photosynthetic activities and reduces plant vigour.

Management practices

- ✓ Prune the infested shoots and destroy by burning.
- ✓ Spray strong jet of water to washout the crawlers and clean the sooty moulds.
- ✓ Spray 0.05% Dimethoate 30% EC (1.5 ml/litre) or 0.15% DDVP 76% EC (2 ml/litre). Safe periods 12 & 15 days respectively.
- ✓ Releases of predators like coccinellids and *Chrysoperla* control this coccid effectively.

B. DEFOLIATORS

11. Leaf webber, *Diaphania pulverulentalis* Hampson

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Pyralidae; Genus: *Diaphania*; Species: *pulverulentalis*

Description and life history

The young caterpillar binds the leaflets together with silky secretion, settle inside, and devours the soft tissues of the leaf surface and so the pest is popularly called as leaf webber. During monsoon, the moths emerge from the pupae present in the soil, lay 1 or 2 eggs on the apical portion of each shoot. Total fecundity ranges from 80-150. The eggs are flat, pinkish in color and hatch in 5-7 days. The grown up larva with black head is greenish brown with black markings on the lateral and dorsal regions of body segments. The larval period lasts for 10-15 days after which they pupate in dry leaves or grass at the base of the plant. Pupae are dark brown in color and last for 8-10 days. Adults are greyish white in colour with brown stripes on the forewings and each measures about 10 mm in body length. The life cycle is completed within 29 days.

Alternate host plants

Mustard, turnip, radish, red beet, bean, soyabean.

Occurrence

The infestation is observed on the onset of monsoon *i.e.* from June and lasts up to February. Peak period of infestation is November to February.

Damage and symptoms

It is a major defoliator pest known to cause extensive damage to mulberry in Karnataka, Andhra Pradesh and Tamil Nadu. The infestation is observed in mulberry plantations from 12 days through 70 days after pruning. The target area of the leaf webber is the apical portion of the mulberry shoot. The larva binds mulberry leaf blades in tender shoot portion by silken thread hide inside and devours the soft green tissues of the leaf surface. Grown up caterpillars feed voraciously on tender leaves and its faeces can be seen over the leaves below the infested shoot. As this pest devour/ damage the apical shoot portion, growth of plants is affected which leads to adverse impact on leaf production.

Management practices

- ✓ Clip off infested portion along with the larva into polythene bag and destroy by burning or dipping in 0.5% soap solution (5g of soap in 1 litre of water).

- ✓ Collect and burn the dry leaves to destroy pupae.
- ✓ Install light traps @ 1-2 trap/acre to attract adult moths and destroy them.
- ✓ Plant dry sticks in all the sides of the garden to attract birds which feed on the larvae.
- ✓ Deep ploughing exposes pupae to sun light and natural enemies.
- ✓ Flood irrigation help to kill pupae.
- ✓ Spray 0.076% DDVP 76% EC (1 ml / litre) 12 to 15 days after pruning or leaf harvest. safe period is 15 days.
- ✓ Release *Trichogramma chilonis* egg parasitoids from 5th day after chemical spray @ 1 Trichocard /acre / week for 4 weeks.
- ✓ Release of larval parasitoid *Bracon brevicornis* @ 200 adult wasps.
- ✓ Release pupal parasitoid *Tetrastichus howardii* @ 1 pouch /ac. After the release of these parasitoids, no insecticides should be sprayed in the garden.



Leaf webber on mulberry

12. Cutworm, *Spodoptera litura* (Fabricius)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Noctuidae; Genus: *Spodoptera*; Species: *litura*.

Description and life history

Adult moth is stout. Fore wings dark with a strongly variegated pattern and paler lines along the veins. Hind wings white with margins having brown colour. The female moths lay eggs in clusters of 200-300 on the underside of leaves and cover them with thick brown scales. Eggs hatch in 4-5 days. The larva is hairless and variable in colour. Final instar caterpillars are 50 mm in length, pale greenish brown in color, stout, cylindrical with transverse and longitudinal grey & yellow bands. The older larvae are night-feeders (nocturnal) and are usually found in the soil around the base of plants during the day. The larval period lasts for 2-3 weeks. They form dark brown pupa in earthen cocoon in the soil which lasts for 2 weeks. The moths are stout, dark with waxy white markings having a brown colour. They are attracted towards light during night. Life cycle takes 30-40 days to complete with 8 generations in a year.

Alternate host plants

Cutworm is a polyphagous pest with a wide host range. Important host plants include tobacco, tomato, castor, beet root, carrot, cauliflower, capsicum, potato, radish, cotton, soyabean, cabbage, chickpea, sun flower, mustard, okra, maize, sorghum *etc.*



Different stages of *S. litura*

Occurrence

The cutworm incidence occurs from August to February, mainly in winter season.

Damage and symptoms

The caterpillars attack shoots of young mulberry plants and cut them, hence the name cutworm. The cut portion of the shoot dries up and falls off. They also feed on mulberry leaves voraciously. In heavily infested mulberry gardens, the plants are seen without branches and sometimes with dried leaves.

Management Practices

- ✓ Collect and destroy egg masses and young caterpillars.
- ✓ Plough infested garden and dig near the base of mulberry plants to expose the pupae present in the soil to sunlight and predators.
- ✓ Install light traps to attract and kill the adult moths.
- ✓ Use Spodolure, a pheromone trap @ 2 lures/acre twice at an interval of 15 days from 25th day after pruning to attract and kill male moths
- ✓ Spray 0.15% DDVP 76% EC (2 ml/litre) during evening hours, 20 days after pruning. Safe period is 15 days.
- ✓ *S. litura* is known to be attacked by many natural enemies at various life stages. However release of the egg parasitoid, *T. chilonis* is most promising.

13. Bihar hairy caterpillar, *Spilosoma obliqua* Walker

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Arctiidae; Genus: *Spilosoma*; Species: *obliqua*.

Description and life history

Bihar hairy caterpillar is a major pest in south India. The female moth lays about 1200 green eggs in clusters on the underside of leaves which hatch in 5-7 days. Body of the newly hatched larvae is dull white in color with small dense hairs and the head is black in color. The anterior

and posterior part of the caterpillar is black and the middle part is yellowish brown in color. Fully grown caterpillar attains 5 cm in length. The larval stage takes 27-31 days out of which final instar itself is 5-7 days. Pupation takes place close to mulberry plants in loose soil or leaf litter and it is dark brown in color and measures 2 cm in length. The moth emergence takes place in about 12-14 days. The adult moths are light brown in color with brick red abdomen and having black dots on dorsal side arranged in rows. The wings also possess scattered black dots. The life cycle is completed in about 45-50 days.



S.obliqua

Alternate host plants

It is a polyphagous pest with a wide host range. Important host plants include amaranthus, cowpea, jatropha, groundnut, jute, sunflower, castor, cotton, green gram, bengal gram, maize, sunnhemp etc.

Occurrence

Incidence of Bihar hairy caterpillar, *S. obliqua* in mulberry starts with the onset of monsoon. It occurs throughout the year in certain pockets. Peak infestation is seen during March to April and July to November.

Damage and symptoms

Gregarious young caterpillars feed upon the chlorophyll layer mostly on the under surface and skeletonize the leaves. However, late age caterpillars are voracious feeders, consume entire leaf and cause loss by way of defoliation. In severe cases, only stems are left behind.

Management practices

- ✓ Collect the egg masses, caterpillars, affected leaves and destroy them by dipping in 0.5% soap solution or by burning.
- ✓ Follow deep ploughing or digging so as to expose the pupae present in the soil to predatory birds and scorching sun.
- ✓ Flood irrigation also helps in destroying the pupae in the soil.
- ✓ Install light traps to attract and kill the adult moths.
- ✓ Spray of 0.1% Dimethoate 30 % EC (safe period 20 days) or 0.15% DDVP 76% EC 20 days after pruning (safe period 15 days).
- ✓ Release *T. chilonis* @ 4 cards per acre, a week after the spray of insecticide. Do not spray any insecticide after the release of parasitoids.

14. Tussock caterpillar, *Euproctis fraterna* (Moore)

Taxonomic position

Phylum : Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Lymantriidae; Genus: *Euproctis*; Species: *fraterna*.

Description and life history

The adult moth is yellowish with pale transverse lines with black spots on the forewing. The abdomen has tufts of hairs all over and a long pre anal tuft. It lays eggs in groups on the lower surface of the leaves. The egg period is 4-10 days. The caterpillar possesses red head with white hairs around and a long tuft and a reddish brown body with hairs arising on warts and a long pre- anal tuft.

There are six larval instars. The larval period last for 13-29 days. It pupates in a silken cocoon in leaf folds which lasts for 9-25 days. The larva over-winters during winter season. There are 6 generations in a year with one generation taking about 44-84 days.

Alternate host plants

It is a polyphagous pest which infests castor, cotton, sunflower, hibiscus, pear, sesame, brinjal, okra, red gram, cowpea, pomegranate, mango, chikoo, ber, apple, jack, cinnamon, citrus, guava, coffee, tea, cocoa, rose wood, sal, teak, papaya, etc.

Occurrence

The pest is active throughout the year but its activity is reduced in winter.



Different stages of *E. fraterna*

Damage and symptoms

The neonate caterpillars feed gregariously on the epidermal tissues of the leaves by scraping the chlorophyll content resulting in the skeletonization of leaves. Later they cause the damage by feeding on the entire leaves. There may be a complete defoliation of plants, in case of severe infestation, the branches are seen without leaves.

Management practices

- ✓ Collect the caterpillars along with affected leaves and destroy by burning.
- ✓ Install light traps to attract and kill the adult moths.
- ✓ Spray of 0.1% Dimethoate 30 % EC (safe period 20 days) or 0.15% DDVP 76% EC 20 days after pruning (safe period 15 days).



Defoliation by *E. fraterna*

15. Moringa hairy caterpillar,
Eupterote mollifera Walker

Taxonomic position

Phylum: Arthropoda; Class: Insecta;
Order: Lepidoptera; Family: Eupterotidae;
Genus: *Eupterote*; Species: *mollifera*.

Description and life history

It is a destructive and specific pest of moringa in South India, hence commonly known as moringa hairy caterpillar. Adults are large sized moths with light yellowish-brown wings having faint lines. Moths appear with onset of monsoon and lay eggs in clusters on leaves and tender stems. Egg period lasts for 9-13 days. Fully grown caterpillars are brownish in colour with dense hairs. Hairs cause skin allergy on contact. Larval stage has 4 moults and it takes about 68 days to pass through 5 instars.

Pupation takes place in a soft thin cocoon made up of silk secreted along the hairs of the caterpillars. Pupa is dark brown in colour and measures 18-20 mm in length. Pupal stage lasts for 35-60 days. Only one generation in a year.



Alternate host plants

In addition to moringa, it is recorded on castor, wild cabbage, *Acacia arabica*, tamarind and nerium.

Occurrence

Occur generally during August to February.

Damage and symptoms

Larva seen in groups on the stems and they feed gregariously by scraping the bark and gnawing foliage. Severe infestation leads to defoliation of the plants and branches of plant without leaves are noticed in the garden.

Management practices

- ✓ Collect and destroy egg masses and caterpillars.
- ✓ Set up light trap @ 1trap / ha to attract and kill adults immediately after rain
- ✓ Use burning torch to kill congregating larvae on the trunk.
- ✓ Spray of 0.1% Dimethoate 30% EC (safe period 20 days) or 0.15% DDVP 76% EC, 20 days after pruning (safe period 15 days).



E. mollifera

16. Noctuid moth, *Tiracola* sp.

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Noctuidae; Genus: *Tiracola*.

Description and life history

There are 11 species documented in the genus *Tiracola* world wide, out of which only two species are documented so far from India i.e. *Tiracola plagiata* Walker, and *Tiracola aureata* Holloway on several crops. However, the species recorded first time on mulberry in Tamil Nadu did not

match with the documented species in India and further examinations needed for species level identification. The adult moths are brown with a light and dark pattern as well as dark patches on the costa of each forewing. The hind wings have plain brown fading towards the bases. Female moth lays cream colored eggs in patches on the underside of tender leaves and sometimes on the leaves situated in the middle portion of the plants. Neonate larvae are mottled black with white hairs. The dorsal region of grownup larva is light brown in colour with irregular white patches and mottled black



Tiracola sp. (Larva, pupa and adult moth)

mid dorsal line. Head and thoracic legs are dark orange or red in colour. Sub dorsal bands are mottled black. There is a light yellow or pale orange sub spiracular line widened below the spiracle. There is a hump on the dorsal portion of 8th abdominal segment. It pupates in a sparse earthen cocoon in the soil (subterranean). The pupa is brown in colour with four spines at the tip of the abdomen. Life cycle of this pest is not yet studied. However life cycle of other species (*Tiracola grandirena*) revealed that egg, larval, pre-pupal and pupal stages occupy 6, 25, 21 and 12.7 days respectively.

Alternate host plants

Not recorded

Occurrence

It is an occasional pest. According to the field level observations the pest seems to be seasonal and may undergo pupal diapause like other noctuids such as *Helicoverpa armigera*. Further studies are required to confirm this hypothesis.



Defoliation by *Tiracola*

Damage and symptoms

Neonate larvae are gregarious in nature and feed by scraping the leaves for 2-3 days. Later they spread to other branches through wind by hanging with silken thread secreted from the mouth, feed voraciously and defoliate completely leaving the mid rib and veins of the leaves.

Management practices

- ✓ Manual collection and destruction of egg masses, gregarious neonate as well as grown up larvae from the infested garden.
- ✓ Encourage predatory birds (especially Indian Myna *Acridotheres tristis*, black drongo *Dicrurus macrocercus* etc.) to feed on the larvae. Arrange ropes over the garden to attract them to sit and trace out the larvae. In addition, place few water bowls in the mulberry gardens which also attract the birds.
- ✓ Deep ploughing in the affected mulberry gardens helps to expose the subterranean pupae to the birds and other natural enemies.
- ✓ Set up light traps to attract and kill the moths.
- ✓ Spray of 0.1% Dimethoate 30% EC (safe period 20 days) or 0.15% DDVP 76 % EC, 20 days after pruning (safe period 15 days).
- ✓ Parasitization by *Cotesia tiracolae* was recorded under field conditions against this pest.

17. Wasp moth, *Amata passalis* (Fabricius)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Arctiidae; Genus: *Amata*; Species: *passalis*.

Description and life history

It is also known as sandal wood defoliator. Adult males are long with slender abdomen and females are stout bodied. The body length ranges from 36 to 44 mm with brownish black wings. The forewings have seven transparent spots. Each female lays about 500 round shaped eggs. The eggs are glued on to the ventral side of mulberry



Wasp moth, *A. passalis*

leaf and hatch in a week. Neonate larvae are dull white in color with thin brownish hairs all around the body and late age larvae are brownish in color. The larval period lasts for 32 days comprising of eight instars. First and last instar larvae measure 1.97 ± 0.06 mm and 29.29 ± 2.52 mm in length. Pupation takes place inside the leaf folds within silken web. The pupa is pinkish in color measuring 14-18 mm from which moths emerge in 10-12 days. The species breeds throughout the year and passes through 6-11 generations in a year.

Alternate host plants

A. passalis, a defoliator of sandalwood in India is also known to occur on various other host plants viz., pigeon pea, cowpea, pulses and ornamental plants.

Occurrence

A. passalis is native to India and Sri Lanka. It occurs mainly from February to August.

Damage and symptoms

The young caterpillars are active and they feed by scraping the chlorophyll layer of the leaf. Late age larvae feed on entire leaf. Branches of mulberry are left with no leaves.

Management practices

- ✓ Collection and destruction of egg masses and young gregarious caterpillars.
- ✓ Spray of 0.1% Dimethoate 30% EC (safe period 20 days) or 0.15% DDVP 76 % EC, 20 days after pruning (safe period 15 days).



***A. passalis* larva**

18. Wingless grasshopper,
Neorthacris acuticeps nilgriensis
Uvarov

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Orthoptera; Family: Acrididae; Genus: *Neorthacris*; Species: *acuticeps nilgriensis*.

Description and life history

As the name indicates, the adult grasshoppers are wingless, however, as the hind legs are very strong they are capable of jumping to a long distance. Females are larger than males. Each female lays 6-8 egg pods (each egg pod with 8 to 18 eggs) in soil at a depth of about 3 inches. They hatch in about 28-31 days. The nymphs take 90-95 days to become adults which live for 45-60 days. Thus the total life cycle takes 5-6 months.

Alternate host plants

Sunflower, finger millet, groundnut, beans, potato etc.

Occurrence

Incidence of this pest coincides with onset of monsoon and continues till post monsoon periods. However, peak infestation occurs during October and declines subsequently with no occurrence from January till onset of monsoon.

Damage and symptoms

Both nymphs and adults feed voraciously on sprouting buds and leaves of mulberry. Sometimes, they also feed on green bark of affected plants. Branches of plants without leaves are observed in the mulberry garden in case of severe incidence.

Management practices

- ✓ During early morning hours, they are less active and hence can be collected and destroyed.
- ✓ Deep ploughing immediately after the onset of monsoon to expose egg masses to sunlight and predators.
- ✓ Field sanitation by keeping mulberry garden free from weeds which serves as alternate host plants.
- ✓ Spray 0.076% DDVP 76 % EC (1 ml/litre) on mulberry foliage to kill the nymphs and adults. If infestation is severe, need second spray, 10 days after first spray. Safe period is 15 days.
- ✓ While spraying, take precaution to see that they will not jump and escape to neighbouring mulberry gardens. For this, spray in concentric circle manner for few rounds so that they will be trapped in some corner.



N.acuticeps nilgriensis

19. May-June beetle, *Holotrichia serrata* Fabricius

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Scarabaeidae; Genus: *Holotrichia*; Species: *serrata*.

Description and life history

May-June beetles are also known as cock chafer beetles or root grubs or white grubs. The beetles look dark brown in daylight with grey coloured hair all over the body. The abdomen is white. When disturbed and in bright light, they change their colour to light brown and regain their original colour in darkness. The adults are stout and measures 2.5-3 cm in length and 1- 1.5 cm in width. The female lays white colored round eggs individually rolled into earthen balls in the soil at a depth of about 10 cm. Fully grown up grubs are white in color with brownish head and prominent thoracic legs and the length of the grub measures about 56 to 60 mm. The larval development takes about a year with three instars. Pupa is creamy white and semicircular and it lasts for 15 days. After the receipt of first showers they emerge from the soil. The beetles are nocturnal in habit and conceal themselves in the soil during day time.

Alternate host plants

Neem, ber, grapes, guava, moringa, mango, *Melia azadirachta*, rose, *Acacia*, Jamun, fig, *Ficus religiosa*, *Ailanthus*, tamarind, *Cassia fistula*, groundnut, maize, jowar, potato, bajra, sweet potato, tapioca, chilly, sugarcane, tobacco, coffee etc.

Occurrence

Their infestation coincides with the onset of monsoon and an occasional pest to mulberry crop in south India.

Damage and symptoms

The early hatched grubs initially feed on organic matter and later start feeding on roots or rootlets thereby causing damage to the host plants. The adult beetles are observed feeding on the foliage. During night time, adult beetles enter into mulberry garden in swarms and feed voraciously on the foliage, leaving only the stem portion. It appears as cow grazing and lot of small black faecal pellets appear below the plants.



H.serrata

Management practices

- ✓ After first monsoon keep a vigil for adult beetles in the mulberry garden. Collect them and destroy by putting in kerosene solution.
- ✓ Installation of light trap and collection of adult beetles during night in kerosene mixed water.
- ✓ Tying up of few fresh neem branches (with leaves) to mulberry plants in different parts of the garden to attract the adults followed by their collection and destruction.
- ✓ Ploughing just before monsoon helps in exposure of various stages of the pest to natural enemies.
- ✓ Spray 0.2% DDVP 76% EC (2.5 ml/litre) with a safe period of 15 days preferably during evening hours.
- ✓ Drench the soil with 0.2% Chlorpyrifos 20% EC to kill the grubs.

20. Green weevil, *Mylocerus viridanus* (Fabricius)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Curculionidae; Genus: *Mylocerus*; Species: *viridanus*.

Description and life history

The female lays 150 to 350 eggs superficially in the soil over a period of 20-90 days and the grubs hatch out in 4-8 days. Grubs pass through 4 instars in a period of about 40-75 days and pupate in soil. Adult weevils are greenish white in color measuring 5 mm to 15 mm. They complete 3-5 generations in a year.

Alternate host plants

Groundnut, bhendi, finger millet, brinjal, maize, sorghum, etc.

Occurrence

The weevils are found throughout the year but, more prevalent during summer season.

Damage and symptoms

Adults feed on leaves and buds whereas the grubs feed on the underground parts of plant. In case of severe attack plants wilt and dry up. Irregular serrated margin on the leaves are observed from the feeding by adults.



Weevil damage on mulberry

Management practices

- ✓ Ploughing helps in exposing all the life stages of weevils to scorching sun and natural enemies mainly the birds.
- ✓ Flood irrigation immediately after digging or ploughing helps in killing the eggs, grubs and the pupae.
- ✓ Apply Neem cake @ 500 kg/ha at the time of pruning of mulberry plants.
- ✓ Soil drenching with Chlorpyrifos 20% EC (2ml/litre) at the root zone help in reducing their population as well as damage.
- ✓ As many weeds serve as alternate host plants mulberry garden should be kept weed free.

C. BORERS

21. Mulberry longhorn beetle, *Apriona germari* Hope

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Cerambycidae; Genus: *Apriona*; Species: *germari*.

Description and life history

This stem borer beetle is known as longhorn beetle as its antennae are long and chain-like. They are dark grey colored beetles and medium to large in size (up to 40 mm in length). However, body of female is longer than that of male. They emerge between July and October months, feed on young shoots and survive for about 80 days. They mate on the trunks few days after emergence and the female lays eggs (size: 5-7 mm) either on the trunk or in the

crevices of the bark, which hatch in about 7-10 days. The grub is apodous, creamy white in color, with a chitinized brown mark on the prothorax. The grubs start burrowing under the bark and feed on the woody portion. The grub stage lasts for 1 to 2 years depending on climatic conditions and it attains a body length of about 60 mm when fully grown. The body is cylindrical and milky white. They pupate at the end of the tunnel which is blocked by a mass of chewed wood fragments.



A. germari

Alternate host plants

Important alternate host plants of these beetles are fig, jack, apple etc.

Occurrence

They occur throughout the year.

Damage and symptoms

During egg laying the stem tissues are partially damaged and hence twigs easily break due to wind. The grubs make tunnel all along the branches just beneath the bark or in the wood. All along the main gallery frass expulsion holes are visible at intervals. Severely attacked plants may die.

Management practices

- ✓ Infested shoots should be removed and destroyed by burning.
- ✓ Inject 0.1% DDVP 76% EC into the frass holes to kill the grubs.
- ✓ Swab the trunk and branches with a paste of 0.1% malathion 50% EC to avoid egg laying.

22. Mango stem borer, *Batocera rufomaculata* DeGeer

Taxonomic position

Phylum: Arthropoda; Class: Insecta;
Order: Coleoptera; Family: Cerambycidae;
Genus: *Batocera*; Species: *rufomaculata*.

Description and life history

The adults are 3-5 cm in length, dark with a fine greyish vestiture, pronotum with 2 kidney shaped orange yellow spots, the basal third of the elytra with numerous black tubercles and several yellowish spots that are variable in number and shape. Fully grown grubs are cream colored with a dark brown head and are up to 10 cm long. The female cuts the tree bark and lays eggs singly into these cuts and cover with a viscous fluid. Fecundity ranges from 150-200. Eggs are shiny white in colour, oval shaped and measuring 5-7 mm long.

Egg hatches within 10-15 days. On hatching the neonate grubs initially feed under the bark and then start to tunnel into the sapwood of the trunk. The grub lives for long time of about one year and hibernate in winter inside the dry shoot. When climate warms up they become active and pupate

inside the stem, then adult emerge in May – June by a short tunnel running to the exterior and making a circular exit hole and start egg laying from July to August. The maximum life recorded for the adult is eight months. The adults can travel considerable distance and have good dispersal ability. A generation takes more than one year.



Courtesy:[https://en.wikipedia.org/wiki/B.rufomaculata#/media/File:B.rufomaculata_\(De_Geer\)](https://en.wikipedia.org/wiki/B.rufomaculata#/media/File:B.rufomaculata_(De_Geer))

Alternate host plants

Mango stem borer is a polyphagous pest distributed worldwide and infesting number of horticultural crops and forest trees including mango fig, guava, jack fruit, pomegranate, apple, avocado, cashew nut, durian, eucalyptus, rubber etc.

Occurrence

Damage of this borer on mulberry is noticed throughout the year.

Damage and symptoms

Once the grub enters into the shoot, it starts feeding voraciously and creates tunnel inside the stem by boring towards upward direction. The grubs, because of their size make large tunnels of about 2-3 centimeters which interfere with sap flow

and affect foliage yield at initial stages, then wilting of shoots appears and finally the plant dries. The symptoms of *B. rufomaculata* infestation in mulberry confuses with the symptoms of root rot. However, the frass ejected from the grub boring is occasionally visible in few plants. The grub requires stem girth of at least 6-7cm diameter to successfully develop into an adult. Therefore, it is much prevalent in older mulberry garden than younger ones which have thin stumps. In severely affected garden the exit holes of adults are often visible on the stem just above the ground level.

Management Practices

The mango stem borer feeds internally and thus difficult to identify their presence as well as to control, once it enter the mulberry

stem /shoot. It is also because that dry shoots does not carry the pesticides to reach the grub. However following management practices need to be adopted to check the pest.

- ✓ Keep the mulberry garden clean and follow recommended package of practices.
- ✓ Exclude alternate host plants in the vicinity of mulberry garden.
- ✓ Monitor the presence of adult beetles in mulberry garden during summer and monsoon seasons. Collection and destruction of the beetles before egg laying helps to avoid infestation of grubs.
- ✓ Set light traps to attract the adult beetles.



Batocera grubs tunnel in trunk & exit hole



Mortality of plants in Batocera affected mulberry garden

- ✓ Collect and destroy the grubs which are exposed out at the time of weeding or ploughing.
- ✓ Mechanically remove the grubs from the infested trunk holes by using iron wire or hook.
- ✓ Prune and destroy the affected branches and paste the cut ends with 5% Copper Oxychloride (50 g / litre).
- ✓ Clean the holes and insert cotton wick soaked in a solution of 0.5% DDVP 76% EC (5ml/ litre) and close the holes with mud plaster. The fumigant action of DDVP kills the grubs inside the trunk.
- ✓ Two sprays on the trunk portion with 0.04% Chlorpyriphos 20% EC (2ml/ litre) at fortnightly intervals with onset of monsoon in summer (May-June) especially to the mulberry gardens in the vicinity of mango orchard.

23. Shoot borer, *Oberea artocarpi* Gardner

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Cerambycidae; Genus: *Oberea*; Species: *artocarpi*.

Description and life history

The adult beetle is about 20-25mm in length, orange-yellow in color with long antennae and distal two third of elytra and the last abdominal segment are jet black in color. It has univoltine life cycle. Before laying eggs they make step like girdling pattern on the tender stems between 3rd and 7th inter nodal region. Eggs are elongated, orange colored and measure about 3 mm in length. It hatches in 3-6 days and newly hatched grubs feed on the dead

apical portion. Later it bores into the stem. The grub makes small holes at intervals in the stem to discard the excreta and food waste. The grubs have a translucent cream coloured body and light brown head. The grub feeds for a period of 4-5 months after which pupates in a chamber constructed at the base of plugged larval tunnel.

Alternate host plants

The adult beetles are known to feed on the leaves of jack and *Ficus*, whereas in the case of mulberry grubs are the damaging stage.

Occurrence

They occur after pre-monsoon showers in the month of May. They are distributed in the southern sericulture states.

Damage and symptoms

It girdles and destroys the apical tender leaves. It bores into the stem and makes the seed cuttings unfit for propagation. As the attack advances, twigs shows die back symptom.



O. artocarpi & its damage on mulberry
Courtesy A.V. Mary Josepha Shery

.Management practices

- ✓ Cut and burn the affected portion.
- ✓ Install light traps in the affected garden.
- ✓ Clean the holes and insert cotton wick soaked in a solution of 0.5% DDVP 76% EC (5ml/ litre) and close the holes with mud plaster. The fumigant action of DDVP kills the grubs inside the trunk.

24. Stem girdler, *Sthenias grisator* (Fabricius)

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Coleoptera; Family: Cerambycidae; Genus: *Sthenias*; Species: *grisator*.

Description and life history

The adult beetles are stout with long antennae and well developed mandibles. Female girdles the bark of the stem at night and deposit eggs beneath it. The eggs hatch in a week and the grubs tunnel into the branches and feed. They pupate inside the tunnel and the life cycle is completed in about 7-8 months.

Alternate host plants

Major alternate host plants are casuarina, mango, jack, crotons, grapes etc.

Occurrence

It is noticed throughout the year.

Damage and symptoms

Girdling of the young or green stem and subsequent wilting are the main symptoms of infestation. Such stems get dried up which enable the grubs to tunnel into the dry wood. Such affected branches will die soon.

Management Practices

- ✓ Cutting and burning of affected branches.
- ✓ Swab the trunk and branches with a paste of 0.1% malathion 50% EC to avoid egg laying.



Adult beetle on mulberry stem



Mulberry stems attacked by *S. grisator*

D. SOIL INHABITING INSECT PEST

25. Termites, *Odontotermes sp.*

Taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Isoptera; Family: Termitidae; Genus: *Odontotermes*.

Description and life history

Termites or white ants are soil inhabiting social insects. They are found in all types of soils but frequent in sandy and red loamy soils. They live in colonies with different casts such as workers, soldiers and queen. The queen has a very large abdomen and lays about 75,000 eggs in a day. Eggs hatch in 24 to 90 days. Duration of development of young ones vary with casts and environmental conditions. The reproductive casts mature in 1-2 years and there will be only one queen per colony which lives for 5-10 years.

The queen is fed by the workers and is confined to royal chamber with king. The king's life is very shorter than that of queen. When the king dies, a new one replaces it. The workers usually develop from fertilized eggs but remain stunted as they feed on ordinary food. The workers perform all the

works except reproduction and defence. The soldiers develop from unfertilized eggs and remain under developed. They defend the colony against enemies such as ants and other predators.

Alternate host plants

Termites are highly polyphagous insects attacking all most all the agricultural, horticultural and forest tree plants.

Occurrence

They occur when rain recede or from October onwards and continues till the onset of monsoon rains.

Damage and symptoms

Termite damage is mainly observed in rainfed gardens. In mulberry nursery and new plantation, they attack below ground portion. They feed on the bark and hard wood. Hence, cuttings dry up and no sprouting takes place. In old plantations, they first infest the dry twigs. Later they slowly move to live twigs. They form foraging galleries inside the main stem and extending below the ground. In case of pruned plants they form a sheath around the twigs and feed on them. Thus they affect the sprouting buds.



Termite attack on mulberry plants

Management practices

- ✓ Remove the dead and dried twigs and leaves.
- ✓ Flood irrigation help in keeping termites away.
- ✓ Locate the termite mounds if any nearby mulberry gardens and destroy by breaking mounds and kill the queen. When once the queen is killed or destroyed the colony gets abandoned by them.
- ✓ Prepare a solution of Chlorpyrifos 20% EC @ 3ml/litre and pour into the mound followed by closing the mound hole with wet earth.
- ✓ In established plantation, soil drenching with 0.1% Chlorpyrifos 20% EC to be practiced.
- ✓ Treat the mulberry cuttings with 0.1% Chlorpyrifos 20 % EC solution before planting.

NON INSECT PESTS

26. Giant African snail, *Achatina fulica* Bowdich

Taxonomic position

Phylum: Mollusca; Class: Gastropoda; Order: Stylommatophora; Family: Achatinidae; Genus: *Achatina*; Species: *fulica*.

Description and life history

Giant African snails are large in size (long, narrow and conical in shape, reaching a length of 20 cm), with a light brown shell to protect the body, having brown and cream bands alternatively lined. The shell size attains up to 5-10 cm. They are nocturnal in habit and hide beneath fallen leaves, inside peeled off mulberry bark or under stones during day time and come out from hiding places during night to attack host plants and cling to the dorsal and protected surfaces of leaves. Though bisexual in nature, self reproduction is not possible. They are active during rainy season. They start laying eggs beneath the soil, dried leaves or any debris 2-3 weeks after mating. Eggs are round, yellowish in color, surrounded by mucus substance and are laid in groups of 30 to 300 eggs. They lay about 1000 eggs during their life time of about 3 to 5 years with 2-13 egg clutches. The young ones attain maturity in about 9 weeks. They



Snails collected from mulberry garden

undergo hibernation and aestivation during adverse climatic conditions.

Alternate host plants

Snails are highly polyphagous and nominated as one among 100 'world's worst' invaders. They have a wide host range and infest crops such as coffee, mango, papaya, rubber, teak, tea, coconut, sunflower, maize, gram, onion, garlic, peas, beans, bell pepper, brinjal, pumpkin, cucumber, cabbage, cauliflower, bhendi, banana, sweet lime, marigold etc.

Occurrence

Though snail activity is noticed from August to January (mostly during rainy season), their incidence is severe from October to December. Their occurrence is also noticed in climatic conditions with high humidity (>80%) and moderate temperature (9 - 29°C) which are more congenial for the population build up.

Damage and symptoms

Giant African snails feed on tender leaves, tender bark & stem and cause damage. The infested leaves show circular holes in the centre. Such damage results in stunted growth of mulberry besides leaf yield loss. It is also established that when mulberry leaves from snail infested gardens are provided to silkworms, they consume very less leaves due to presence of mucus like substance on the leaves secreted by the pest which affects cocoon production.

Management practices

- ✓ Hand pick different stages of snails and destroy by burning or immersing in 25% salt solution (1 kg salt in 4 litre of water).
- ✓ During rainy season, in the evening hours heaps of wet gunny sacks or papaya stem waste may be placed near the hide outs in the mulberry garden. Next day morning the snails hiding below these may be collected and destroyed by immersing in salt solution.
- ✓ Regularly remove the debris and unnecessary waste materials from the garden and maintain cleanliness to avoid snail population build up.
- ✓ Deep ploughing helps in exposing snails and their egg masses present in the soil to their natural enemies.
- ✓ Snails do not move on dry areas. Hence areas surrounding their hiding places may be kept dry by spreading materials like saw dust, ash *etc.*
- ✓ Use bran bait (Rice bran, jaggery & Methomyl @ 60:6:1 ratio) to attract and kill the snails.
- ✓ Snail-kill (2.5% Metaldehyde) pellets may be spread in mulberry garden in alternate rows (2 to 3 pellets per spot) during evening hours in rainy season or after irrigation. Next day collect the dead snails available near these pellets and destroy. This process may be continued for a week or so.
- ✓ Metaldehyde pellets may also be placed near their hiding places, compost pits, dumping yards for suppressing snail population. About 2 kg Metaldehyde pellets are required per acre of mulberry garden. Metaldehyde is found to be non-toxic to silkworms.

27. Black Slug, *Laevicaulis alte* (Ferussac)

Taxonomic position

Phylum: Mollusca; Class: Gastropoda; Order: Systellommatophora, Family: Veronicellidae; Genus: *Laevicaulis*; Species: *alte*.

Description and life history

Slugs are soft bodied, dorsally black and ventrally brown, 4 cm long. Its skin is slightly tuberculated. The central keel is beige in colour. This slug has a unique, very narrow foot, juveniles have 1 mm wide foot and adults have foot of 4 or 5 mm wide. The tentacles are small 2 or 3 mm long and they are only rarely extended beyond the edge of the mantle. Eggs are laid in groups (38 to 80 eggs) and arranged in the form of bead. Freshly hatched young ones feed on the leaves by making small holes. It leaves behind a salivary, shining and slimy material wherever it crawls.



L.alte

Courtesy: https://en.wikipedia.org/wiki/Tropical_leatherleaf#/media/File:Laevicaulis-2.jpg

Alternate host plants

Coffee, tea, cotton, rice, beans, tomato, cucumber, apple, spinach, carrot etc.

Occurrence

The slugs occur mostly during rainy & winter seasons and also common in mulberry gardens situated nearby canals and swamps.

Damage and symptoms

Presence of mucus on plant parts affects the quality of foliage. Presence of shot holes on leaves caused due to feeding by slugs. Drying of shoots due to scraping of bark of the stems.

Management practices

- ✓ Soil application of lime powder (20kg/ac) dehydrates the slug and brings about mortality.

28. Millipede, *Phyllogonostreptus nigrolabiatus* (Newport)

Taxonomic position

Phylum: Arthropoda; Class: Diplopoda
Order: Spirostreptida; Family: Harpagophoridae; Genus: *Phyllogonostreptus*; Species: *nigrolabiatus*.

Description and life history

Millipedes are the macro-fauna that are commonly occurring in the leaf litter and soil horizons. They often play important role in the breakdown and decomposition of plant litter. They were reported for the first time as pests of mulberry from Maddur Taluk, Mandya district, Karnataka state during the year 2012. They are the least explored in tropical countries and more so in India. They are long, cylindrical bodied and segmented creatures with head, trunk

and a pygidial segment that contains the anus. Due to their lack of speed and inability to bite or sting, their primary defense mechanism is to curl into a tight coil, exposing only the hard exoskeleton and secreting an irritating poisonous liquid from the pores of their body. They have 20 to more than 100 segments with two pairs of legs per segment except for the first segment behind the head which does not have any appendages at all. They generally feed on decaying leaves, dead plant matter and soil containing organic matter, by moisturizing the food with secretions and then scraping it with the jaws. They have separate sexes. Males can be differentiated from females by the presence of one or two pairs of legs modified into gonopods on the seventh segment and are used to transfer sperm packets to the females during copulation. Males also possess one or two penises which deposit sperm packets onto the gonopods. In female the genital pores open into a small chamber or vulva which is used to store the sperm after copulation. Eggs are usually laid in the warmer months.



P.nigrolabiatus

Young millipedes take 2 to 5 years to fully mature and lay 10 to 300 eggs at a time in one clutch, fertilizing them with the sperm stored in the vulva just before oviposition. Some species also reproduce parthenogenetically. They simply deposit the eggs on moist soil or organic detritus. Hatchlings are legless. They moult several times and with each consequent moult, they add segments and legs to their body. They survive for one to ten years.

Alternate host plants

Millipedes are detritivores and feed on decomposing vegetation, faeces, or organic matter mixed with soil. They mostly inhabit forest floors and cultivated fields. Paddy, maize, horse gram, groundnut, sorghum, cotton, tobacco, cashew, green gram, chilly, pepper, clove *etc.* are the important host plants

Occurrence

They occur throughout the year but common during rainy season.

Damage and symptoms

Superficial peeling of bark of mulberry plants. They feed on entire mulberry leaf leaving behind only petiole.

Management practices

- ✓ Hand pick the millipedes and bury deep in to the soil.
- ✓ Trenches may be dug around the garden in which millipedes get trapped. They can be collected and shifted to nearby forest land or buried deep in to the soil.
- ✓ In most of the cases they are found to be harmless and can be pests under some circumstances only.

29. Red spider mite, *Tetranychus ludeni* (Zacker)

Taxonomic position

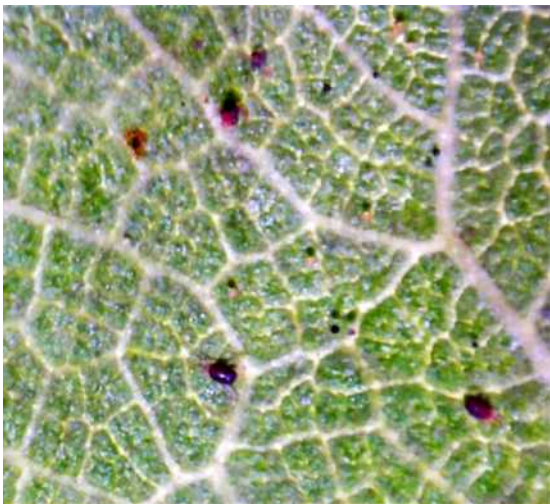
Phylum : Arthropoda; Class: Prostigmata; Order: Acarina; Family: Tetranychidae; Genus: *Tetranychus*; Species: *ludeni*.

Description and life history

So far 15 species of mites are found to infest mulberry out of which *Tetranychus ludeni*, *T. equitorius*, *T. telarius* and *Aceria mori* are the important ones. They are also known as spider mites and are found on almost all the plant parts like leaves, buds, scales, nodes and apical shoots. Adult female lays about 30-70 spherical red colored eggs on the lower surface of the leaves which hatch in 2 to 6 days. The nymphs are pinkish, greenish or orange in color depending on the species whose development takes about 10-12 days. Adults live for 7 to 12 days.



Male & female mites



Mites on mulberry leaves

Alternate host plants

Brinjal, cotton, okra, *Amaranthus*, beans, citrus, water hyacinth, chrysanthemum.

Occurrence

Although mites occur throughout the year, their incidence is severe during summer months.

Damage and symptoms

Both nymphs and adults cause similar type of damage. They suck the plant sap by piercing their stylet mouth parts into the tissue. The affected plant part turns greyish white and finally withers. Infested leaves also show white speckles at the place of feeding which later turns into large patches. Infested plants are often covered with

extensive fine webbing. The undersurface of infested leaves show silken thread spun across them under which they crawl and also lay eggs.

Management practices

- ✓ Clip off affected portion and destroy by burning.
- ✓ Use sprinkler irrigation to dislodge the population.
- ✓ Spray 0.5% Formathion (safe period 25 days).

30. Root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood

Taxonomic position

Phylum: Nematoda; Class: Secernentea; Order: Tylenchida; Family: Meloidogynidae; Genus : *Meloidogyne*; Species: *incognita*.

Description and life history

M. incognita overwinters in the form of egg in the affected roots and soil. It can survive in the soil without host plant for about 6-12 months. The life cycle is completed passing through three stages viz., egg, larva and adult. Egg and larva are the main sources of infection. Eggs are ellipsoidal and larvae are vermiform. Larvae invade the roots through root tips by making the hole with the help of their stylets. They start feeding on the parenchymatous cells of the root. While feeding larvae inject the salivary secretion containing proteolytic enzyme that leads to the enlargement of cells resulting in galls / knots in the roots.

The larvae undergo three moults and mature into adults. The male is cylindrical worm-like transparent with stripes across the body while the female is pear-shaped with elongated pyriform body. Reproduction is mostly by parthenogenesis. Each female lays 300-500 eggs covered with gelatinous substance. It has six generations in a year and one life span is completed within 30-40 days.

Alternate host plants

It has a wide range of host plants and attacks more than 2000 species of plants including almost all agricultural, horticultural, oilseeds, ornamental, plantation and other crops.

Occurrence

Widespread throughout the year and more prevalent in sandy soils under irrigated conditions.

Damage and symptom

The incidence and intensity of this nematode is reported to be very high in red sandy soil followed by red loamy soil, while in black cotton soil the incidence is found to be very poor. Considering the farming practices, high incidence and intensity are found under irrigated mulberry gardens while poor or negligible incidence are noticed under rainfed conditions. The magnitude of crop loss depends up on the population density of the nematode present in the soil. It also reduces the nutritive value of leaves particularly protein content which is an important nutrient for silkworm growth.

Severely affected mulberry plants show stunted growth with marginal chlorosis and necrosis of leaves. Knots / galls formed on the roots are spherical with varying size. Young galls are very small and yellowish white while old ones are big and blackish brown in colour. Due to this infection vascular tissues and cortex of roots are disorganized, hampering the translocation of water and minerals from soil to aerial parts of the plants.



Mulberry root affected by nematodes



Chlorosis & stunted growth due to nematode attack in root.

Management practices

- ✓ Use nematode free saplings for new plantation
- ✓ Deep digging and soil solarization during summer exposes the nematode eggs and larvae leading to desiccation.
- ✓ Soil amendment with oil cakes like Neem/ pongamia @ 2 MT/ha year in 4 equal split doses at 3 months interval
- ✓ Intercropping with plants like marigold, sesame or sunhemp reduces root galls and egg masses of nematode
- ✓ Apply Bionema (*Verticillium chlamydosporium*) mixture @ 200 g / plant around the exposed roots of affected plant (Bionema mixed with neem oil cake and FYM in the ratio of 1:24:200) for 3 times in a year at an interval of 4 months during cultural operations.
- ✓ Apply Nemahari, a plant based eco friendly formulation @ 40 kg/ha (mix 40 kg Nemahari with 400 kg FYM) in 3 split application on 70 and 150 days after first application.

EFFECTIVE ECO-FRIENDLY PEST MANAGEMENT IN MULBERRY

Water Jetting Technology

Spray of strong jet of water is one of the components of IPM which is generally recommended to manage the sucking pests like thrips, aphids, mites etc., in agricultural and horticultural crops. In this method the pests are dislodged and washed-out from the plants and hence the pest population is kept below economic injury level. Though this practice is



effective and eco-friendly, could not become popular as it is laborious to fetch bulk quantity of water and the process is time consuming and costly.

Hence, a simplified and user-friendly water jetting system is developed for mulberry garden in which a portion of irrigation water is diverted in order to get uninterrupted supply of adequate water for effective jetting. This technology is highly effective against all major sucking pests of mulberry viz., pink mealybug, *Maconellicoccus hirsutus*, papaya mealybug, *Paracoccus marginatus*, mulberry thrips, *Pseudodendrothrips mori*, spiralling whitefly, *Aleurodicus dispersus*, mulberry whitefly, *Dialeuropora decempuncta*, jassid, *Empoasca flavescens* and mites causing severe damage on leaf yield and quality.

Biological Method

Mulberry ecosystem is ideal to implement biological control of pests because of its perennial nature. Moreover, the usage of high potent insecticides on a crop like mulberry is practically impossible due to their sensitivity to silkworms. Therefore, the biological method plays a significant and indispensable role in managing key pests of mulberry. Some of the effective predators and parasitoids for successful management of important insect pests of mulberry is given below.

Sl. No.	Name of the insect pest	Name of the biocontrol agent	Numbers to be released / ac/ crop
1.	Pink mealybug <i>Maconellicoccus hirsutus</i>	Predators A) <i>Cryptolaemus montrouzieri</i> (or) B) <i>Scymnus coccivora</i>	250 adults 500 adults
2.	Papaya mealy bug <i>Paracoccus marginatus</i>	Parasitoids A) <i>Acerophagus papayae</i> (or) B) <i>Pseudleptomastix mexicana</i> (or) C) <i>Anagyrus loecki</i>	250 adults
3.	Thrips <i>Pseudodendrothrips mori</i>	Predator <i>Chrysoperla</i> spp.	1000 eggs
4.	Spiralling whitefly <i>Aleurodicus dispersus</i>	Predators A) <i>Axinoscymnus puttardriaahi</i> B) <i>S. coccivora</i>	250 adults 250 adults
5.	Leaf webber <i>Diaphania pulverulentalis</i>	Parasitoids A) <i>Trichogramma chilonis</i> - egg B) <i>Bracon brevicornis</i> - larval C) <i>Tetrastichus howardii</i> - pupal	4 cc of eggs 200 adults 1lakh adults in 3 splits



1A



2A



2B



2C



5A

SELECTED REFERENCES

- Aiswariaya, K.K., Manjunatha, M., Mohan, Naik, I. (2007) Biology and host range of spiralling whitefly. *Karnataka Journal of Agricultural Sciences*. 20(1): 149– 152.
- Anusha, H. G. and Bhaskar, R. N. (2015) Sucking pests of mulberry: A review. *IOSR Journal of Agriculture and Veterinary Science*, 8(8): 1-3.
- Bandyopadhyay, U. K., Sahu, P. K., Raina, S. K., Santhakumar, M. V., Chakraborty, N. and Saratchandra, B. (2000) Studies on the seasonal incidence of the whitefly, (*Dialeuropora decempuncta* (Q. & B.) causing leaf curl on mulberry in relation to abiotic factors. *International Journal of Industrial Entomology*, 1 (1) : 65-71.
- Dandin, S. B., Jayaswal, J. and Giridhar, K. (2000) Hand Book of Sericulture Technologies. Central Silk Board, Bangalore, Karnataka (India).
- David, B.V., Ramamurthy, V.V. (2011) Elements of Economic Entomology 6th Edition, Namrutha Publications, Chennai, Tamil Nadu.
- Geetha, T., Mahalingam, C.A. and Murugan, N. (2015) Biology of mulberry thrips, (*Pseudodendrothrips mori* Niwa) under Tamil Nadu climatic condition *International Journal of Agricultural Science and Research*, 5(2):19-26.
- Govindaiah, Gupta, V.P., Sharma, D.D., Rajadurai, S. and Naik, V.N. (2005) Mulberry crop protection. Central Silk Board Publication, Bangalore.
- Jadhav, A. D., Dubal, R.S., Bagade, R. P., Sanadi Reshma, A., Kamble, P.L., Belgumpe, S and Sathe, T.V. (2016) Giant African snail, *Achatina fulica* Bowdich a destructive pest of V₁ mulberry (*Morus alba* L.) A new report and control strategies from Kolhapur, Maharashtra, India. *Biolife*, 4(1):184-188.
- Mani, M. (2010) Origin, introduction, distribution and management of the invasive spiralling whitefly *Aleurodicus dispersus* Russell in India. *Karnataka Journal of Agricultural Sciences*, 23(1):59-75.
- Narendra Kumar, J.B., Shekhar, M.A and Qadri, S.M.H. (2011) Giant African snail in Mulberry: Physiology and management. *Indian Silk*, 1 (12): 4-5.

- Narendra Kumar, J.B. and Shekhar, M.A. (2012) Management of giant African snail infesting mulberry. *Annadata*, 7(2): 23.
- Narendra Kumar, J.B., Sreenivas, B.T., Divya, S.H., Mathur, V.B., Shekhar, M.A. and Qadri, S.M.H. (2012) Outbreak of new species of white fly in irrigated mulberry gardens of Karnataka. *Indian Silk*, 3 (old 51) (7 & 8): 8 – 11.
- Narendra Kumar, J.B., Sreenivas, B.T., Shekhar, M.A., Divya, S.H. and Mathur, V.B. (2012) Millipedes infesting mulberry in Mandya district. *Indian Silk*, 3 (51 old) (1): 4-6.
- Narendra Kumar, J.B., Sreenivas, B.T., Divya, S.H. and Shekhar, M.A. (2013) New white fly species *Dialeuropora decempuncta* Quaintance (Homoptera: Aleyrodidae) infesting mulberry in Karnataka. *Insect Environment*, 19(2): 108-109.
- Rajaduari, S. and Thiagarajan, V. (2003) Mulberry sap sucking insects. *Indian Silk*, 8: 5-8.
- Ravikumar, J., Sakthivel, N. and Balakrishna, R. (2010) Incidence of black scale insect in mulberry. *Indian Silk*, 1(1): 4-5.
- Sakthivel, N., Punithavathy, G. and S.M.H. Qadri (2009) Record of natural enemy Complex of spiralling whitefly, *Aleurodicus dispersus* Russell (Homoptera: Aleyrodidae) infesting mulberry in Tamil Nadu. *Insect Environment*, 15(2):80-82.
- Sakthivel, N., Mukund V. Kirsur and Balakrishna, R. (2010) Predatory fauna of papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink infesting mulberry. *Insect Environment*, 16 (3): 115-117.
- Sakthivel, N., Mukund V. Kirsur, Punithavathy, G. and Balakrishna, R. (2010) Papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) on mulberry in Tamil Nadu. *Insect Environment*, 16 (3): 117-118.
- Sakthivel, N. and Qadri, S.M.H. (2010) Efficacy of certain insecticides and botanicals against mulberry thrips, *Pseudodendrothrips mori* Niwa (Thysanoptera: Thripidae). *Indian Journal of Entomology*, 72(2): 152-154.
- Sakthivel, N. and Qadri, S.M.H. (2010) Incidence of papaya mealybug on tapioca in Tamil Nadu, *Indian Silk*, 1(5-6): 8-9.

- Sakthivel, N., Balakrishna R. and S.M.H. Qadri (2011) Comparative efficacy of water jetting and chemical measures against major sucking pests of mulberry and their safety to natural enemies. *Journal of Biopesticides*, 4 (2): 219-230.
- Sakthivel, N., Punithavathy, G. and Qadri, S.M.H. (2011) Evaluation of different insecticides and botanicals against spiralling whitefly infesting mulberry. *Indian Journal of Sericulture*, 50(2): 98- 102.
- Sakthivel, N. and Balakrishna, R. (2012) Record of long-tailed mealybug, *Pseudococcus longispinus* (Targioni-Tozzetti) [Hemiptera: Pseudococcidae] on mulberry. *Insect Environment*, 17(2): 60-61.
- Sakthivel, N. (2013) Effectiveness of three introduced encyrtid parasitic wasps (*Acerophagus papayae*, *Anagyrus loeckii* and *Pseudleptomastix mexicana*) against papaya mealybug, *Paracoccus marginatus* infesting mulberry in Tamil Nadu. *Journal of Biopesticides*, 6(1): 71-76.
- Sakthivel, N., Ravikumar, J., Helen, S.M. Chikkanna and Bindroo, B.B. (2014) Incidence of soft scale insect, *Megapulvinaria maxima* (Green) on mulberry in Tamil Nadu. *Indian Silk*, 4 & 5 (12-1): 4-5.
- Sakthivel, N., Narendra Kumar, J.B., Sivasubramonian, T., Chikkanna and Sivaprasad, V. (2015) New record of *Tiracola* sp. (Lepidoptera: Noctuidae) as a pest of mulberry from Tamil Nadu, India. *Current Biotica*, 9(1): 74-77.
- Sakthivel, N., Chikkanna, Narendra Kumar, J.B. and Sivaprasad, V. (2017) *Batocera rufomaculata* De Geer: A new stem borer pest of mulberry. *Indian Silk*, 8(5-7):4-6.
- Selvaraju, N.G. and Sakthivel, N. (2011) Host plants of papaya mealybug (*Paracoccus marginatus* Williams and Granara de Willink.) in Tamil Nadu. *Karnataka Journal of Agricultural Sciences*, 24(4): 567-569.
- Sengupta, K., Kumar, P., Baig, M. and Govindaiah (1990) Handbook on Pest and Disease Control of Mulberry and Silkworm. United Nations Economic and social commission for Asia and the Pacific, Bangkok, Thailand. Pp. 17-40.

- Sengupta, K., Govindaiah and Kumar. P., (1991) Diseases and Pests of Mulberry and their Control. Central Sericultural Research and Training Institute, Srirampura, Mysore - 570 008.
- Seni, A. and Sahoo, A.K. (2014) Biology of the papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) *International Journal of Agriculture, Environment & Biotechnology*,7(4):875-881.
- Shery, A.V.M.J. and Bindroo, B.B. (2013) *Oberea artocarpi* Gardner (Cerambycidae - Coleoptera) an emerging pest on mulberry in Kerala and Karnataka. *Insect Environment*, 19(3): 191-192.
- Shery, A.V.M.J. (2014) The predominant thrips species infesting mulberry in Karnataka, India. *Insect Environment*, 20(3): 88-92.
- Singh, R.N., Maheshwari, M. and Saratchandra, B. (2005) Biology and control of whiteflies in sericulture. *Insect Science*, 12(6):401 – 412.
- Singh, R.N., Samson, M.V. and Datta, R.K. (2000) Pest Management in Sericulture. Indian Publishers Distribution, Delhi.
- Singh, R.N. and Saratchandra, B. (2011) Sericultural Entomology. A.P.H. Publishing Corporation, New Delhi.
- Singh, T. and Singh, P.K. (2013) Mulberry Crop Protection. Discovery Publishing House (DPH) Pvt. Ltd., New Delhi.
- Sunil Kumar, T., Narayanaswamy, T.K. and Manjunatha, H.A. (2018) Mulberry defoliating insect pests and their management. *International Journal of Current Innovation Research*, 4(5): 1228-1231.
- Tyagi, K. and Kumar, V. (2011) A new record of pest species *Pseudodendrothrips bhattii* Kudo (Thysanoptera; Thripidae; Dendrothripinae) from India. *Indian Journal of Entomology*. 73(4):296-297.
- Vijaya Kumari, N. (2014) Eco-friendly technologies for disease and pest management in mulberry-A Review. *Journal of Agriculture and Veterinary Science*. 7(2):01-06.



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Designed & Printed by

SRI KRISHNA PRINTERS

71/2, Vasagasalai Street 3rd Cross, Ponnammampet, Salem - 636 001.
Mob : (+91) 76019 34729 e-mail : krishnaprintersslm@gmail.com



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Central Silk Board, Ministry of Textiles, Government of India

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