Pests of Pineapple and their Management

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Pineapple is one of the most important fruit crops of Kerala. It belongs to family Bromeliaceae. It grows in the soil and resembles epiphytes in that their roots are intolerant of poor soil aeration (Joy and Sindhu, 2012). This fruit is native to southern Brazil and Paraguay where its wild relatives occur. Portuguese had introduced the pineapple to India and Java, and the fruit, delighted with the climate that so closely mirrored its conditions of origin, spread throughout the Far East. The Indians carried it to the West Indies before Columbus arrived. In 1493, Columbus found the fruit on the island of Guadeloupe and carried it back to Spain and it was spread around the world on sailing ships that carried it for protection against scurvy. The Spanish introduced it into the Philippines and may have taken it to Hawaii and Guam early in the 16th Century. The pineapple reached England in 1660 and began to be grown in greenhouses for its fruit around 1720.

Figure 1. Pineapple (*Ananas comosus*)

Pineapples are infested by a variety of insect pests. Some pests that affect pineapple plants are mealy bugs, scale insects, thrips, fruit borer, bud moths, midgets, fruit flies, white grubs, beetles, weevils, termites and mites as described below. Mealy bugs are the most important insect pest of pineapple in many countries while others may reach threshold levels in certain favourable situations causing serious crop damage. Soil and climatic factors, crop stages and crop management practices affect the intensity of pest infestation. An integrated approach comprising prophylatic, cultural, mechanical, biological (use of bio-agents and bio-pesticides) and need based chemical measures is most ideal in managing most of the pests and keeping their population below the threshold level so as to avoid serious crop losses.

Pineapple Mealy Bug

Figure 2. Pineapple Mealy Bug

Source: www.bugwood.org, retrieved on 14 Oct 2013

Description and Identification

Mealy bugs belong to the class: Insecta, order: Hemiptera, Family: Pseudococcidae, Genus: *Dysmicoccus*, Species: *brevipes* - (cockerell). They appear as cottony, small, oval, soft-bodied sucking insects. They are in variety of forms, of which pink coloured ones are commonly referred to as pineapple mealy bug. They mainly inhabit on seed material (Bartholomew, *et al.*, 2003). These bugs have mobility only at younger stage (Carillo, 2011).

Adult mealy bugs are elliptical in shape and are identified with 17 pairs of wax filaments (Tanwar *et al*, 2007). They are soft-skinned insects with waxy secretions, which give their body surfaces a chalky appearance. They also have white, waxyfilaments of various lengths extending from the lateral margins of their bodies. They are mainly seen as colonies of more than 20. The first-stage (orfirst -instar) crawlers (0.6–0.7 mm) are typically the most active stage, and they move around the host plant seeking a place to get rested. Further they excrete honey dew which makes ants to get attracted and transport them to nearby areas. The honey excreta accumulated in large quantities may support the growth of sooty mould, *Capnodium* sp.

The adult stage produces afluffy wax mass which holds its golden-coloured eggs. Mealy bugs first appear on roots and hence it is difficult to tackle it at its early stages. The roots cease growing and result in collapse of the tissue. They are also found on the aerial parts of the plant, mainly in the leaf axils and on the developing fruit. Mealy bugs feed on plant sap in the phloem of their host plants.

Biology

Pineapple Mealy bugs are ovoviviparous *i.e.*, the eggs hatch within the female and give birth to larvae. The life cycle of *D. brevipes* was extensively studied (Ito, 1938). It includes three stages. Its life span counts to 95 days.

Eggs: These are minute, varying from 0.3 to 0.4 mm in length. Its development takes between three and nine days.

Larvae: The larval stage contributes to complete dispersal of the bugs since their body is extensively covered with hairs. Hence they

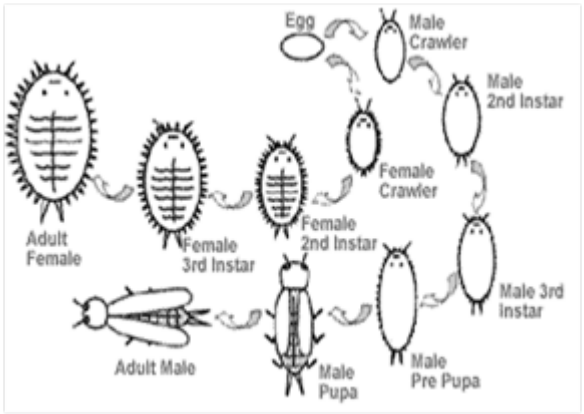

Figure 3. Life cycle of mealy bug
(Annecke and Moran, 1982)

are called crawlers. The larval period extends up to 40-50 days. The first, second and third instars of larval stages last for 10 to 26 days, 6 to 22 days and 7 to 24 days respectively. Larvae only feed as a first instar and in the early part of the second instar.

***Adults**:* Adult females have soft, convex, pinkish body. Also their body is surrounded by 17 pairs of wax filaments. Lateral wax filaments are usually less than one fourth as long as the breadth of the body, and those towards the back of the insect are one-half as long as the body. The prelarviposition period for adult females lasts for around 27 days. The larviposition (giving birth to larvae) period lasts for an average of 25 days. They give birth to about 234 progenies but may produce up to 1000 crawlers. She may then live for another 5 days before dying. Duration of adult female varies from 31-80 days with an average of 56 days (Balachowsky, 1957). There may be as many as 15 generations. Adult males are having a distinguishable number of eight antennal segments.

The species survives in cold as eggs or other stages, both on the host plant and in the soil. In warm climates, the insects stay active and reproduce round the year (Tanwar *et al*., 2007).

Nature of Damage

Mealy bugs become lethal when their population gets increased since the bugs suck the sap from leaves causing the plant to wilt.

They are dispersed by ants. The sugary secretions of the mealy bug attract ants and they carry them making it vast spread. Also the excretion of honey inhibits the plants ability to manufacture food, form chlorosis of underlying plant tissues and cause rotting and leaking of fruits. When fruits are infested they become entirely covered with white, waxy coating making it unfit for marketing. Leaves appear pale green to yellow streaks; tips become brown. The predominant symptom is wilting of leaves commencing from the leaf tips. Reddish-yellow colour manifests in the wilting areas. Mealy bug causes quick wilt (result in yellow or red leaves) under heavy infestation or slow wilt (no definite colour change) in mild attack due to root damage. (ncof.dacnet.nic.in/Books_on_Organic_Package_of_Practices/POP_NERegion.pdf).

Figure 4. (a) Mealy bugs infested pineapple sucker (b) Ant interaction with mealy bugs (c) Mealy bug Infested Pineapple fruit (d) Pineapple Mealy bug Wilt Associated Virus attacked pineapple field.

Source: a. www.forestryimages.org, b. ucce.ucdavis.edu, retrieved on 12 Oct 2013

Management

Mealy bugs infest commercial pineapple plantings worldwide, impacting pineapple production in several ways (Beardsley, 1993). Their greatest impact is associated with the disease mealy bug wilt of pineapple (MW) (Rohrbach *et al.*, 1988). They may infest developing plants and fruit, thereby becoming serious pests to the crop, reducing fruit quality and quantity by infuencing plant development (Carter, 1933). Mealy bug stripes appear in plants because of their feeding (Carter, 1967). They greatly affect the growth of young pineapple seedlings (Carter, 1962). Sometimes mealy bugs are found as contaminants in canned fruit and their presence on fresh market fruit may violate quarantine restrictions at port entrances.

Prevention*:* Pre-planting treatments are effective in controlling pineapple mealy bugs. Pineapple cultivation using five to six years old suckers should be avoided. Selection of healthy suckers is inevitable. Before planting, suckers can be dipped in insecticidal solution for about 5 minutes, for example a diazinon base (900 ml of commercial product/600 l of water/ha) or botanical extracts (1200 ml/600 l of water/ha) in organic agriculture (Carillo, 2011).

Biological Control**:** There are many natural enemies for this mealy bug and they can be introduced to mealy bug infested fields for their control. Some are discussed here.

*Rhinoleucophenga***:** A new species of *Rhinoleucophenga*, a potential predator of pineapple mealy bugs (Culik, 2009) was introduced in Brazil. They are larval predators of scale insects (Vilela, 1990; Grimaldi, 1993). *Rhinoleucophenga* species are present in areas such as Espírito Santo.

*Cryptolaemus montrouzieri***:** It is commonly called as the redheaded ladybird beetle or the mealy bug destroyer. It has been introduced in Karnataka to reduce large populations of pink mealy bug. The adult female lady bird beetle lays egg among mealy bug egg masses. The larvae of the beetle grow up to 1.3 cm in length and have wooly appendages of wax making them similar to mealy bugs. The beetle larvae feed on mealy bug eggs and young crawlers. The life span of the *C. montrouzieri* is two months within which they lay up to 400 eggs. It is capable of eating up to 5,000 mealy bugs in various life stages.

*Anagyrus kamali****:*** They are parasites from China and introduced in Karnataka for the control of pink mealy bugs. It feeds on mealy bug in two ways: (i) the female wasp punctures the bug and sucks the sap and (ii) it lays egg within the bug. When the egg matures it comes out of the bug's body. The entire process takes only half the entire life span of mealy bugs.

Anagyrus ananatis Gahan: These parasites help to control the alarming mealy bug populations leading to mealy bug wilt associated disease (Gonzalez-Hernandez, 1995). This strategy depends on the continued annual approval of the Environmental Protection Agency and the Hawaii Department of Agriculture which permit this product to be used on a special need basis.

Verticillium lecanii / *Beauveria bassiana:* Foliar spray of *Verticillium lecanii* or *Beauveria bassiana* (2×10^8 cfu/ml) at 5 g/ml per litre of water is effective during high humid months in reducing the population of mealy bugs (Tanwar *et al.*, 2007).

Cultural Control: Mealy bug spread can be minimized by the destroyal of ant population. The mealy bug infested fields must be prepared by removing all the plant residues and incinerating them. Also weeds present in the field support a hike in mealy bug population by giving them food resources. Also removal of alternate hosts like *Hibiscus*, custard apple, guava in and nearby crop is also essential. Use of sterile equipment when applying in an uninfested field is advisable.

C*hemical Control*: As a final attempt for the control of mealy bugs chemical practices are to be followed.

- Apply Chlorpyriphos (Hilban 20EC, 2.5 ml/l), Imidacloprid (Tatamida 200SL, 0.3 ml/l) or Quinalphos (Ekalux 25EC, 2 ml/l) at 500-600 l/ha.
- Indirect control of mealy bugs can be achieved by treating the soil either with 2.75 kg/ha of chlordane or heptachlor (2.25 kg/ha) to kill the ants.
- Basal portions of the planting materials have to be dipped in 0.02-0.04% methyl parathion as a prophylactic measure (megapib.nic.in/pppineapple.htm.)
- Locate ant colonies and destroy them with drenching of chlorpyriphos 20 EC at 2.5 ml/l or apply 5% malathion dust at 25 kg/ha (Tanwar *et al.*, 2007).
- Diazinon is applied once or twice to a few fields (2%). Also a preplant dip in diazinon doubles the shield (Sipes, 2000).

Scale Insects

Description and Identification

The pineapple scale, belongs to Order: Hemiptera, Family: Coccoideae, *Diaspis bromeliae* (Kerner), is likely to be found on upper leaf surfaces of pineapple leaves and fruit worldwide (Waite, 1993). It has varying appearance; some are very small organisms (1–2 mm) that grow beneath wax covers (some shaped like oyster shells, others like mussel shells), to shiny pearl-like objects (about 5 mm), to creatures covered with mealy wax. Adult female scales are almost always immobile (aside from mealy bugs) and permanently attached to the plant they have parasitized. They secrete a waxy coating for defense; this coating causes them to resemble reptilian scales or fish scales, hence their common name. Yellow spots may develop on leaves when scale densities are low (Waite, 1993). Other scales have been reported infesting pineapple but these are not normally a problem. The brown (or red) pineapple scale, *Melanaspis bromeliae*, is similar in appearance to *Diaspis bromeliae*, but it is a chocolate-brown colour with an elevated centre (Carter, 1967). Nigra scale, also known as black coffee scale, *Parasaissetia nigra*, may be found on pineapple (Zimmerman, 1948).

The group shows high degrees of sexual dimorphism; female scale insects, unusually for Hemiptera, retain the immature external morphology even when sexually mature, a condition known as neoteny. Adult males usually have wings (depending on their species) but never feed, and die within a day or two.

Figure 5. Left: Melanaspis bromeliae, Right: Diaspis bromeliae
Source: www.sel.barc.usda.gov, retrieved on 23 October, 2013

Biology

Scale insects have three distinct life stages (egg, immature, adult) and may complete several generations in a single year. The first instars of most species of scale insects emerge from the egg with functional legs and are informally called "crawlers". They immediately crawl around in search of a favourable spot to settle down and feed. There are many variations on such themes, such as scale insects that are associated with species of ants that act as herders and carry the young ones to protected sites to feed. In either case, many such species of crawlers, when they change their skins, lose the use of their legs. Only the males retain their legs and use them in seeking females for mating. The essentials of their reproductive systems vary considerably within the group, including hermaphroditism and at least seven forms of parthenogenesis.

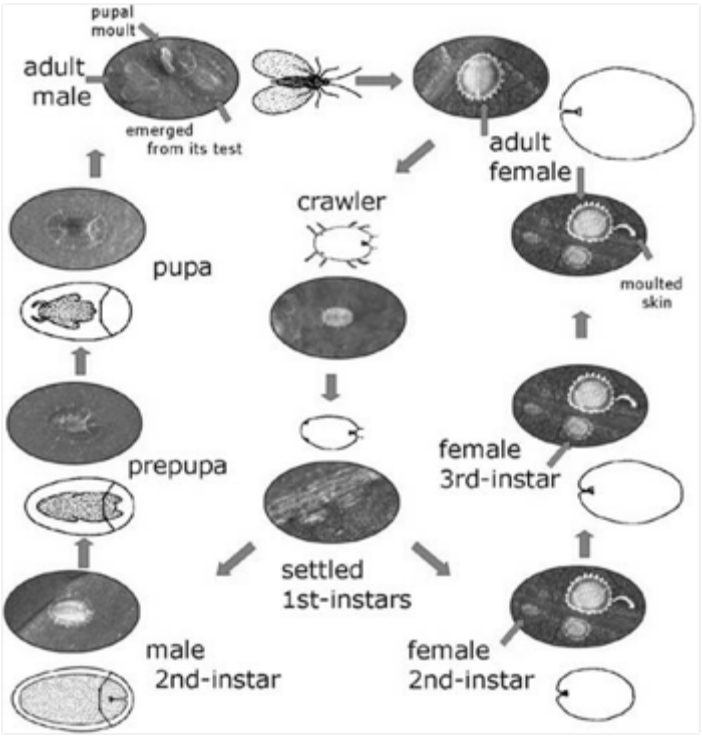

Figure 6. Life cycle of Scale insects
Source: www.landcareresearch.co.nz, retrieved on 23 Oct 2013

Eggs: Adult females produce eggs beneath the scale covering or in a

cottony material, and in many cases spend the cold winter months in this stage.

Larvae: Tiny six-legged crawlers emerge from the eggs, move to newer growth on the plant, insert their mouthparts and begin to feed. A scale-like covering produced from waxy filaments and feces then forms over each individual scale.

Adults: Scale species are identified by the colour and shape of the covering. The covering protects scales from predation by other insects and from insecticides. The male scale is often a slightly different shape than the female and passes through a tiny, winged stage. The casual observer seldom sees winged stages. Females are wingless and usually remain in one place after inserting their mouthparts into plant tissues.

Nature of Damage: A symptom of an attack is rust coloured spots. The insect is found beneath secretion, which serves as a shield. In the case of this insect the scale or protective armor is made up partly of a waxy secretion of the insect and partly of molted skins. The insect itself in the adult stage is quite well buried beneath the epidermis of the plant and hence there is necessity of combating the pest in its early stages. During periods of large populations, some scales become so abundant that an infested plant tissue is totally encrusted with insects.

Management

***Biological Control*:** This pest may be biologically controlled by natural enemies (Waite, 1993). Tiny wasps, including *Aphytis chrysomphali* (Mercet), *Aphytis diaspidis* (Howard) and *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae), parasitize the scales, resulting in scale death (Zimmerman, 1948). Ladybirds, such as *Rhyzobius lophanthae* Blasid. and *Telsimis nitida* Chapin (Coleoptera: Coccinellidae), also prey upon the scales (Carter, 1967; Waite, 1993).

At the same time, a few scale insects are biological pest control agents in their own right, such as various species of *Dactylopius*, the cochineal genus, that attack pest species of Opuntia.

C*hemical Control*: A light, superior oil/insecticide mixture as for mealy bugs may be applied just as plants begin to grow to control emerging crawlers. This time period usually lasts only a few days, so timing is critical. The oil must be applied before leaves open, yet late enough so that this mixture will kill the crawlers. The best time to apply any insecticide is when crawlers are present, as this stage does not have a protective covering, and is therefore vulnerable to almost any chemical registered for this use. Several conventional insecticides and insecticidal soaps are registered for crawler management. The plant must be thoroughly covered to kill the crawlers with one application. Systemic insecticides, applied as a foliar spray, can help control adult scale insects during the growing season. Each situation is unique, so it is important to know which scale species is present overly successful or practical control.

Thrips

Figure 7. Left: Thrips tabaci, Right: Frankliniella occidentalis
Source: ecoport.org, retrieved on 23 Oct 2013

Description and Identification

Thrips belongs to the Order: Thysanoptera (Thrips), Family: Phlaeothripidae, *Holopothrips ananasi* known as pineapple thrips causing serious damages to pineapple (Cavalleri and Kaminski, 2007). As many as 39 species of thrips have been reported worldwide in and around pineapple fields (Sakimura, 1937; Carter, 1939; Petty, 1978d). These are small (1.5 mm long), slender, brown insects with pale yellow hind wings that appear as a yellow line down the back of the body when the insect is at rest. Adult thrips have characteristic wings; the transparent wings have a fringe of hairs around the outside edge standing out in the same plane as the wing. *Thrips tabaci, Frankliniella schultzei* are also considered as important pests of pineapples. The blossom thrips feeds mainly on flowers and its feeding results in the development of "dead-eye" in the fruit. Thrips feeding on the crown of fruits results in concentric ring patterns developing on crown leaves. Thrips are mobile and are able to ride great distances with wind. Water and high moisture seem to be very important for thrips. If there are moisture places thrips will readily move into these like, mulched areas. Thrips remain active the year round.

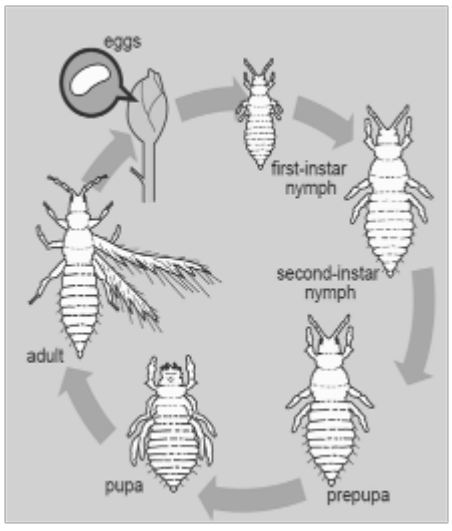

Figure 8. Life cycle of Thrips
Source: www.cep.unep.org, retrieved on 23 Oct 2013

Biology

The life cycle of thrips is unique and fast.

Eggs: Females have a saw-like structure that helps to make an incision in plant tissue for egg laying. Usually eggs are laid into incisions in the epidermis of the leaves and stems of young plants. Eggs are elliptical, white, approximately 0.02 cm in length, placed singly, just under the epidermis of succulent leaf, flower, stem or bulb

tissue. They are whitish at deposition and change to an orange tint as development continues. It will hatch within 4 to 10 days. Hatching young will immediately begin to suck sap and fluids containing nutrition.

Larvae: Larvae as well as the adult insects pierce the leaves and swallow the sap. Pupation takes place in the ground. The emerging adult is about 1 mm long and has a yellow-brown colour with dark cross stripes on the body. There are two larval stages and besides the adults they are the only damaging stages. Larval development is completed in about 9 days. There are two non-feeding stages called the prepupa and pupa. They do not feed and occur primarily in the soil. Combined prepupal and pupal development is completed in 4-7 days.

Adults: Adults are 0.02 cm long. Their body colour ranges from pale yellow to dark brown; wings are unbanded and dirty grey. In Hawaii, this species has a darker form during the rainy season. Males are wingless and exceedingly rare. Females live for about two to three weeks and each can lay about 80 eggs. Mating for reproduction is not necessary. Females produce only female offspring without mating. Females can produce up to 80 eggs, that is why large populations can be generated within a short period. The entire life cycle is estimated as three weeks producing 5-10 generations in a year.

Nature of Damage

Thrips feed on the plant sap by damaging the leaves. The typical appearance of the damage is a silvery-flecked leaf surface which in severe cases turns brown. These leaves can not sufficiently photosynthesise. Small black spots on the leaves, the excrements of the insects, are a sign of thrips infestation. Most thrips rest tightly against leaf veins or in crevices. They are primarily active during the daylight hours. Thrips are responsible for the transmission of many fungal and viral diseases in plants. When infestations are heavy, people and animals will be troubled with stinging thrips. These can also have positive effects on plants. A few species prey on destructive mites and scale insects, resulting in the formation of leaf mould. A few others may aid in the pollination of flowers. These are preyed upon by many insects (including other thrips), mites, birds, salamanders and lizards. Heavy rains, winds and dust are, however, probably as destructive to thrips as are predators. Natural parasites are minute parasitic wasps (Eulophidae) that attack the larvae.

Thrips feed by piercing individual cells and sucking the contents. These cells lose their normal colour, and when many adjacent cells are damaged, the tissue appears as whitish spots or silvery spots or streaks. In advanced injury the leaves take on a blasted appearance. As is common with many thrips species, onion thrips deposit small dark specks of excrement on the surface of tissue where they feed. Substantial damage can be done to young plants especially to varieties grown in seed beds.

Besides direct damage caused by feeding of larvae and adults, this pest is also important as a vector of tomato spotted wilt virus and has been involved in transmitting the disease in pineapple, tomatoes and certain other crops.

Management

Prevention: Thrips are most infestive during drought but not in rainy seasons. Irrigation might reduce thrips population. They move by wind. Establishment of windbreaks reduces thrips population. Recommended economic threshold for small scale farmers is when 20% of the plants are infested with thrips.

***Biological Control*:** Plants that have a natural repellence to thrips are citronella, garlic and pyrethrum. A spray made of garlic and pepper will control thrips. Two bulbs of garlic and some hot chilli peppers should be blended in some water. After blending the solid parts should be filtered. Add water up to 5 litres and this solution can be applied. Mix 2 kg of fresh plant material of *Andrographis paniculata* with 250 ml of water and grind it well. Add 21 litres of cow urine and 10 g of crushed dried chilli fruits. Add 10 litres of water and leave the solution for some time. Filter the solution and it is ready for spraying. Wash fresh roots of *Derris eliptica* and cut them into short pieces of 5 cm length. Add small amount of water and pound the roots until they are finely shredded. Filter the solution. Dilute with soap and water at a ratio of 1 part soap: 4 parts root solution: 225 parts water. Apply immediately.

Cultural Control: Remove weeds, Follow crop rotation, Mulching reduces thrips infestation considerably, Plough deep after harvest to bury the pupae.

***Chemical Control*:** A soap spray will kill thrips which needs to be repeated twice a week.

Pineapple Fruit Borer

Figure 9. Fruit borer *Strymon megarus*
Source: neotropicalbutterflies.com, retrieved on 23 Oct 2013

Description and Identification

It belongs to Order Lepidoptera and Family Lycaenidae. The pineapple fruit borer, *Strymon megarus*, is a pest that affects pineapple fields from Mexico to Argentina. Fruit borer affected fruits show alteration in their shape and galleries in the pulp.

S. megarus is present in all pineapple growing regions causing yield losses that vary according to pest population and environmental conditions. All pineapple varieties are affected. Recent evidence, however, has indicated that the insect is able to attack fruits even after the dry petal stage and to affect developing slips as well.

The pineapple fruit borer is considered as one of the principal pests of pineapple in Brazil. The larvae bore into the fruit causing holes and uneven fruit development. Damage from this pest varies greatly but can reach more than 90% and drier climates seem to favour borer attack. In most cases fruit borer attacks occur during flowering and formation of the fruit, though this borer can attack slips and rarely act as a leaf miner.

Biology

Eggs: Eggs are white, circular and slightly flat and approximately 0.8 mm in diameter.

Larvae: Larvae complete their development within the fruit. Burrowing and feeding activities produce visible damage in the form of frass production and a sticky, gummy exudate.

Adults: The reddish coloured caterpillar penetrates the inflorescence and remains in the tissue for 15 days, tunnelling and destroying the tissue. After this phase it moves to the base of the peduncle changing into a pupa 12 mm long and 5 mm wide with a brown colour and a few dark spots and emerges 7 to 10 days later as a butterfly. As the caterpillar destroys the tissues of the inflorescence a resin coloured liquid gum is exuded from between the fruitlets, which in contact with the air becomes reddish coloured and as it solidifies, turns dark brown. The adult moth has a greyish upper wing surface and a cream colour underneath with a wingspan of 28 mm to 35 mm. The adult can be found during the day or night, flying in a rapid and haphazard fashion. Eggs are laid on flowers from emergence to the end of flowering.

Figure 10. Life cycle of fruit borer
Source: www.cep.unep.org, retrieved on 23 Oct 2013

Management

***Biological Control*:** Based on the results of this study, *Bacillus thuringiensis* appears to be an acceptable biological alternative to carbaryl for control of *S. megarus* on pineapple.
***Chemical Control*:** Apply Chlorpyriphos (Hilban 20EC, 2.5 ml/l) at 500l/ha to control the borer.

Banana Bud Moth

Figure 11. Banana Bud Moth
Source: http://itp.lucidcentral.org/id/palms/sap/Moths_and_Butterflies.htm, retrieved on 28 Sep 2013

Description and Identification

Banana Bud Moth belongs to the order: Lepidoptera, Family: Tineidae, *Opogona sacchari* (Bojer) is native to the humid tropical and subtropical regions of the world infecting banana, pineapple, sugar cane and some ornamental crops. They were originally reported from the Mascarene Islands in the Indian ocean by Bojer in 1856 (Davis *et al*, 1990). The levels of *O. sacchari* infestation vary with location, age of the plant and propagation material. The larvae bore the plant base making an

easy path for fungi and bacteria. Also it produces carbohydrate based exudates on the fruit surface (Vorsino, 2005).

The identification of the pest can be easily achieved by the characteristic features of the developmental stages. The larvae appear as dirty-white and somewhat transparent and have a bright reddish-brown head with one lateral ocellus (small eye) at each side and clearly visible brownish thoracic and abdominal plates. They measured 21-26 mm in length having a diameter of 3 mm. The presence of older larvae can be detected by characteristic masses of bore-meal and frass (excreta) at the openings of bore-holes. The pupae are brown coloured and are of 10 mm and formed in a cocoon of 15 mm size. As the maturation progresses the pupae works itself to move to the next adult stage. The adult is nocturnal and having a length of 11 mm with a wing span of 18-25 mm. They are bright yellowish brown. The forewings may show longitudinal darker brown banding and in the male a dark-brown spot towards the apex. The hind wings are paler and brighter (Süss, 1974; Aguilar and Martinez, 1982). When they are at rest their antennae are pointed forwards.

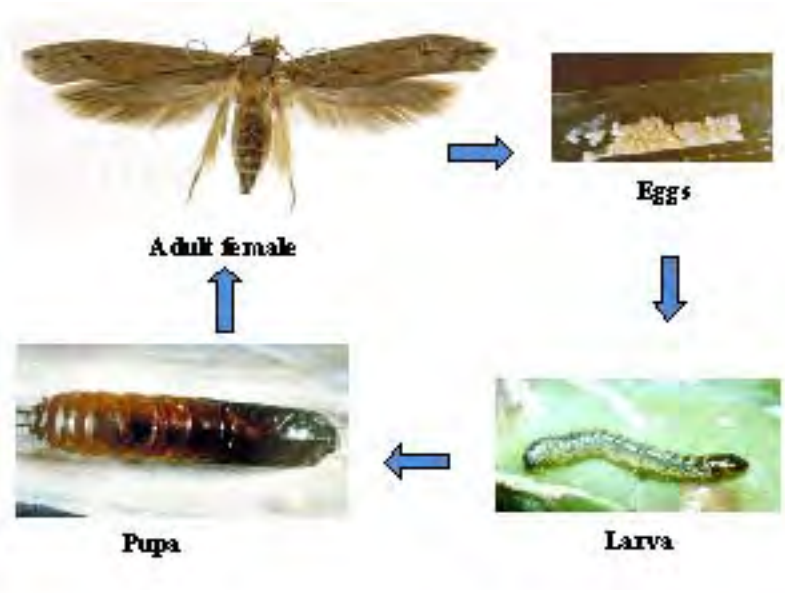

Figure 12. Life Cycle of Banana Bud Moth

Biology

The life span of banana bud moth lasts for three months. Similar to all other arthropods they also go through the stages like eggs > larvae > pupae > adult.

Eggs: The eggs are hatched in 12 days.

Larvae: The eggs develop to larvae within 50-60 days. They are mobile and avoid light. The organism is infectious at this stage. It has seven instars of growth.

Pupae: This stage lasts only for 20 days.

Adult: Its life is only for 6 days (Veenenbos, 1981).

The life span totally depends on temperature and it gets shortened at warmer conditions causing only eight generations per year (Giannotti *et al.*, 1977; Heppner *et al.*, 1987).

The females lay eggs in crevices of the plant tissue. It lays approximately 200 eggs.

Nature of Damage

The infestations of banana bud moth are exclusively dependent on optimal conditions of soil moisture, age and type of planting material, temperature, relative humidity, limited insecticide usage etc.

a. Banana bud moth's larvae normally feed on decaying plant parts and further infesting surrounding healthy tissue. Also it attacks leaves and thus destroying the xylem tissues causing the leaves to wilt.
b. The total growth of the plant retarded and further the whole plant perished.
c. A secondary infection of plant parasites and fungal pathogens make the effect more critical.
d. When they attack on mature fruit they bore into the peel of the fruit causing exudation of secondary metabolites like gum.

Management

Chemical control: The control of the pests is mainly by the application of suitable chemicals which has been successful in several European countries. The adult moths can be controlled by placing dichlorvos strips (one strip per 30 m^3, for 3 months). Thus the adult moths can be eradicated before they lay eggs. The pest infested poly house must be cleared and the soil should be steamed to eliminate all the pupae (Billen, 1987).

Sugar cane midget

Figure 13. Sugar Cane Midget
Source: bugguide.net/node/view/451773/bgimage, retrieved on 28 Sep 2013

Description and Identification

The sugar cane midget (Order: Lepidoptera, Family: Noctuidae, Genus: *Elaphira,* Species: *nucicolora)* also takes the common names like Thecla moth, Elaphira moth etc. Their main hosts are sugar cane and pineapple. It is mainly found in South-Eastern United States, South America, Oahu, Maui and Hawaii regions (Py *et al.*, 1987; Sanches, 1999). The females lay eggs on the inflorescence before anthesis. No eggs are laid in the fruit. The larvae formed infest the fleshy areas of the fruit and feeds within the developing inflorescence. They dig varying holes in the developing fruit. This cause deformed fruit development with no appeal (Py *et al.*, 1987). The attack of larvae causes exudates of gum on the fruit called gummosis which become hard when contact with air. This can easily bring out secondary infections with pathogens like *Fusarium*

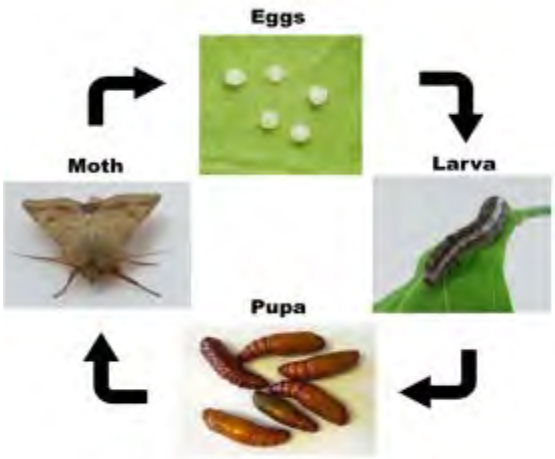

Figure 14. Life Cycle of Sugar Cane Midget

moniliforme var. *subglutinans* (Collins, 1960). The pupae are dark brown coloured. The caterpillar is nearly uniform in colour with dark fuscous, variegations in black. Adults have a wing spread of 12.7 cm.

Biology

Life cycle involve eggs, larvae, pupae and adult stages.

Eggs*:* The females lay single eggs. They hatch in five days.

Figure 15. Sugar Cane Midget Larvae Infesting the Fruitlets
Source: microbials.valentbiosciences.com, retrieved on 28 Sep 2013

Larvae*:* The eggs develop into larvae. They take 23 days in the life span. They are up to 7.6 cm in length. *Pupae:* This stage takes five days.

Adult*:* This stage lasts for ten days.

Nature of Damage

The larvae form galleries in the fruit The galleries open door for the attack of *Fusarium subglutinans*. The fruit pulp is attacked by the pest producing colourless appearance of the fruit pulp. The pest scrape the fruit rind and exudates gum called as gummosis.

Management

***Cultural Control*:** Strict monitoring required after forcing done. Hence applications must be intensified by the time.

Biological control: The aizawaii strain of *Bacillus thurigiensis*, has produced excellent results in combating this pest.

Pineapple Fruit Fly

Figure 16. Pineapple Fruit Fly
Source: www.mrjacksfarm.com/dnn/Resources/PestControl/tabid/634/Default.aspx, retrieved on 14 Sep 2013

Chemical control: The chemicals like diazinon, chlorpyrifos or lambda-cialothrin can be applied with suitable recommendation from the Agronomist (Carrillo, 2011).

Description and Identification

Pineapple fruit flies (Order: Diptera, Family: Richardiidae, Genus: *Melanoloma*, Species: *canopilosum*, *viatrix*) are found mainly in Paraguay and Peru**.** Their main host is *Ananas comosus* (pineapple) infecting the plant part, fruit (Bello, et *al*., 1997; Julca, *et al*., 1992). They are mostly neotropical in nature. Their distinctive features can be explained by their different life stages. The eggs are white and are tapered at the ends with a length of about 1.2 mm. They appear in colonies. The larvae develop are yellowish white, vermiform and

devoid of legs. Their total length is approximately 9.5 mm which is made up of 11 segments. Of which three pairs are at the thoracic region and there is a head region and the eighth at the abdominal region. The head region has small retractable cone shape with internal mandibular hooks. The first segment of the thorax has a pair of anterior spiracles with short extensions 12 to 14 digits. At the caudal region pair of posterior spiracles present. Each of them has three openings surrounded by esclerotizada. At the outward area from them form a series of projections in the form of hairs called inter spiracular processes. The larvae mainly inhabit at the shell and fleshy part of the fruit. The pupae are reddish brown, cylindrical capsule also with 11 segments. They project to a length of 5 mm with a diameter of 1.8 mm. The spiracles present are distinctive in nature and have well defined cephalic area. Adult grows up to 5- 6.5 mm long having wingspan of about 1 cm. They are black coloured with abundant micropubescecias. They have wide and short scuttellum. They presents with thorny hind femora of equal thickness. Their wings are clear devoid of any protrusions. It has a dark spot along its entire length. This extended to the wing margin and divide at the subcosta. The radial vein appears dark and cubitoanal cell is somewhat round (Arevalo and Osorio, 1995).

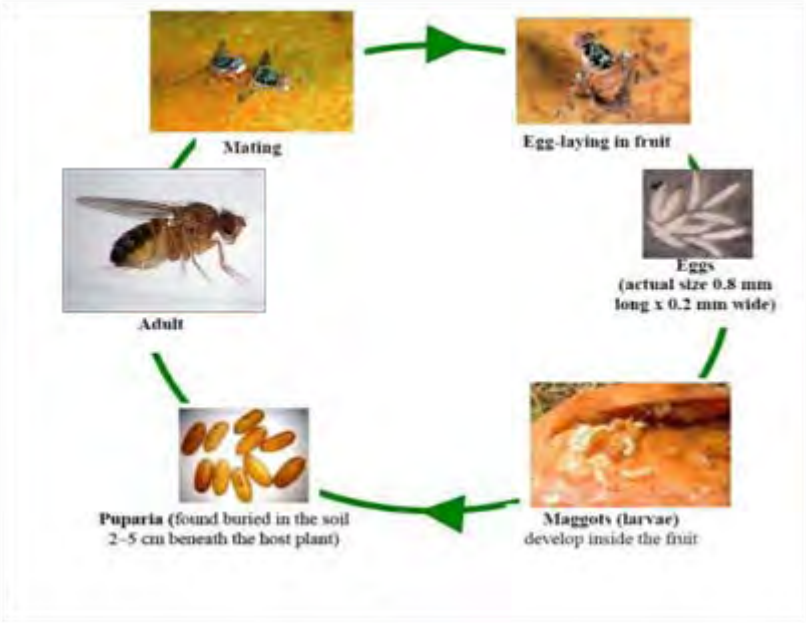

Figure 17. Life Cycle of Pineapple Fruit Fly
Source: www.infonet-biovision.org/default/ct/93/pests, retrieved on 14 Sep 2013

Biology

The life cycle involves the stages such as egg, larvae, pupae and adult.

Egg: The female flies lay eggs within the fruit.

Larvae: They are plant feeders. Sometimes they behave as saprophages invading decayed plant material. They also infest on fruits. They form cavities within the fruit which grow and coalesce and are called “spot with galleries”. All further development of the larvae takes place within the fruit. This further causes fermentation of the fruit (Bello, *et al.*, 1997).

Pupae: Larvae continued to inhabit in fruits until the pupa state. Pupa stage lasts 15 to 20 days under laboratory conditions.

Adult: They have conspicuously pictured wings with metallic blue or greenish colour on the body and legs. Also they are ovipositors and lay eggs in fruits.

Nature of Damage

Figure 18. Pineapple Fruit Fly Infesting the Fruit
Source: www.flickr.com, retrieved on 14 Sep 2013

Pineapple fruit fly as the name defines it mainly infests fruits. The fruit damage starts when the female fruit fly punctures the fruit with its long and sharp ovipositor. The fruit skin is breached, and bacteria enter and the fruit starts to decay. The larvae that hatch from the eggs feed on the decaying fruit tissue, and on the yeasts and bacteria that multiply in it (ipm.ait.asia). Also the larvae groove into the pineapple fruit creating burrows. This causes discoloration, uneven ripening, early maturation and fermentation of fruit and further decay (Martínez *et al*., 2000).

Management

Prevention: Plucking off infested fruits is an important control of fruit flies. Fermented fruits must be cleared up. Or it can be exposed to sun for death of larvae and decomposition of fruit. Also the fruit stalls leftover fruits form the breeding places for these flies.

***Natural Methods*:** Traps containing fermented fruit covered with an inverted funnel can be placed near its breeding sites. Also bagging and netting of fruits are advisable.

Adults require protein for their reproduction hence the beer wastes impregnated with insecticides can kill the flies. Also harvesting of fruits without much ripening can restrict its attack (ipm.ait.asia).

White Grubs

Figure 19. Left: Masked chafer, Right: May - June beetle

Description and Identification

The white grubs (larval stage) of several beetle species in the family Scarabaeidae of Order : Coleoptera, commonly infest the roots of pineapple plants. Scarab species reported feeding on pineapple roots include, in Australia: the southern one-year canegrub, *Antitrogus mussoni* (Blackburn), Christmas beetle, *Anoplognathus porosus* (Dalman), rhopaea canegrub, *Rhopaea magnicornis* Blackburn, squamulata canegrub, *Lepidiota squamulata* Waterhouse (= *Lepidiota darwini* Blackburn, *Lepidiota leai* Blackburn, *Lepidiota rugosipennis* Lea), noxia canegrub, *Lepidiota noxia* Britton, and *Lepidiota gibbifrons* Britton (Waite, 1993); in South Africa: *Adoretus ictericus* Burmeister, *Adoretus tessulatus* Burmeister, *Trochalus politus* Moser and *Macrophylla ciliata* Herbst; and in Hawaii. Chinese rose beetle, *Adoretus sinicus* Burmeister, and *Anomala* beetle, *Anomala orientalis* Waterhouse (Carter, 1967). White grubs are responsible for a large part of the damage to the roots of pineapple plants, and infestations of 20 grubs per plant are sufficient to reduce the root system, leading to stunting, wilting and yellowing of the plant (Petty 1976, 1977, 1978; Le Roux, 1992).

The adults are fairly heavy-bodied insects; most of them with long, spindly legs. They range in colour from light, reddish-brown to shiny black and in size from 12-25 mm in length. The grubs are white with a brown head and legs and with a darker area at the tip of the abdomen. They curl up in a C-shape when disturbed. Fully grown grubs of larger species are 2.5 cm or more in length.

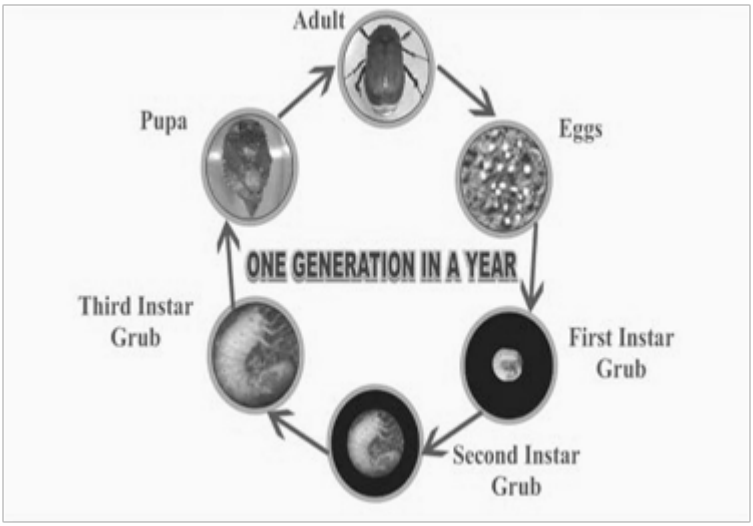

Figure 20. Life cycle of White Grubs
Source www.entnemdept.ufl.edu, Retrieved on 23 Oct 2013

Biology

The usual duration of one complete generation (adult to adult) is 2 to 4 years depending upon latitude. Generations, however, are staggered so that grubs and beetles are present every year. Grubs are usually most numerous and damaging the second season following a large beetle flight. With the exception of the common May or June beetle, which has a three-year life cycle, the life history of the beetles mentioned above is completed in 12 months.

Eggs: Eggs are usually 1.5 to 3 mm in diameter, oval in shape (Waite, 1993) and found encased in soil aggregates. The egg is dull, small, spherical, pearly white that darkens just before hatching. The 20-24 mm long pupae may be creamy white, pale yellow or dark brown.

Larvae: Older scarab larvae develop within the soil among the roots of their host plants (e.g. pineapple). They feed upon organic matter within the soil as well. Although white grubs are not

immobile, they do not disperse far from where the eggs were laid. White grubs are easily identified by their white or ivory-coloured, 'C'-shaped bodies, which are soft and plump. The posterior quarter to third of the larval abdomen is commonly a dark blue-grey colour, due to the contents of the digestive system. Grubs have three pairs of legs near their anterior end and a tan to dark brown head capsule (Waite, 1993).

Adults: Adult beetles differ considerably in colour markings, shape, and size. They are robust, oblong, and hard-shelled. May beetles are about 12 to 25 mm long. The adults often are yellow to dark reddish-brown to black, robust, oblong, shining beetles. The June beetle is dull velvety green on top, brownish yellow on the sides, and shiny green and orange yellow underneath. Japanese beetle adults are brilliant metallic green, 12-25 mm long, bearing coppery brown wing covers, with five lateral spots with white hairs on each side of the abdomen, and short grey hairs covering the underside of the insect.

Nature of Damage: White grub infestations can destroy roots, causing the affected area to become spongy, which allows the sod to be rolled back like a piece of carpet. Evidence of grub damage, including patches of dead or dying turf, are visible during spring (April and May) and late summer and fall (September and October).

Management

Prevention : Adult northern masked chafers can be monitored by using a black light trap, while Japanese beetle adult flight activity can be observed by using a sex pheromone floral lure trap.

***Biological Control*:** Natural enemies of these pests do exist (insect predators, parasitoids and pathogens, as well as birds, toads, wild pigs and rodents), but the levels of control are not typically adequate (Carter, 1967; Petty, 1976b).

Cultural Control: The cultural practices of late-spring and early-fall ploughing or disking provide control. Crop rotation, however, is the most effective cultural control method. Watering in the areas previously sampled is advantageous to prevent the area from drying out and dying.

C*hemical Control*: Preventive control requires the use of long residual insecticides, such as imidacloprid, thiamethoxam, halofenozide, clothianidin or chlorantraniliprole. These products give good control of newly hatched grubs. The best application period is during the month or so before egg hatch until the time when very young grubs are present. Preventive control requires the use of long residual insecticides. Professional combination products have a pyrethroid and a neonicotinoid insecticide premixed together, which could be used to try to reduce both adult and larval populations.

Fig beetle

Figure 21. Fig Beetle
Source: www.mylespaul.com, retrieved on 14 Sep 2013

Description and Identification

Fig beetle, (Order: Coleoptera, Family: Scarabaeidae, Genus: *Cotinis,* Species: *mutabilis)* green fig beetle, peach beetles are all members of the scarab beetle family. They are mostly found in South Western United States and Mexico. They host on variety of plant species like pineapple (Camino-Lavín *et al*., 1996), peech, grapes etc. They mainly feed on fruit and the larvae damage roots (Camino-Lavín *et al*., 1996; Moron and Deloya, 1991). This beetle is very variable in colour. They lay their eggs in soil. They are white coloured and large sized approximately 12-50 mm in size (Stone, 1982). They feed on organic matter in soil surfaces (Coviello and Bentley, 2000). When the larvae get matured they become 2 inches long and become cream coloured. The body of larvae are stiff with brown hairs at the back of the thorax. These hairs are used for locomotion. They form hollow cells in the soil and pupate there (Coviello and Bentley, 2000). The pupae are of size 15 X 25 mm. They are whitish at initial stages and further change to cream coloured as that of larvae stage. At the maturing stages they slightly shift the colour to green. Adults are velvet green in colour. They occupy brownish bands around the edge of the wings and a bright metallic green at the ventral side. Adult females are 17 X 25 mm and adult males are 13 X 22mm size. At the head portion they are equipped with horn like projections for penetrating into the fruit skin (Stone, 1982). Adults are tremendous fliers (Chappell, 1984).

Biology

Eggs: Females lay eggs (app. 60) in August and the eggs develop into larvae after 12 days and are especially attracted to compost and manure piles. Their eggs are whitish in appearance and be easily found over the soil (Stone, 1982).

Larvae: They have head and legs. They live on soil surface and have a length of 2 inches. Their life includes three instars of which first and second get completed by autumn and the final in the spring season of second year. At rest they curl into C shape.

Pupae: After a few days it reaches a size of 12-50 mm. They develop by June- July. Its duration extends from 25-27 days.

Figure 22. Life Stages of Fig Beetle
Source: en.wikipedia.org/wiki/Figeater_beetle, retrieved on 14 Sep 2013

Adult: They develop by June- November (Stone, 1982).

Nature of Damage

The plant part affected mainly includes flower parts like pollen, nectar and petals, fruit and larvae damage roots.

Pineapple weevil

Figure 23. Pineapple Weevil
Source: www.forestryimages.org, retrieved on 14 Sep 2013

Figure 24. Ventral View of Pineapple

Description and Identification

Weevils, Order: Coleoptera, Family: Curculionidae, are one of the most common insects attacking bromeliad family. They include species like *Cholus spinipes, Cholus vaurieae, Diastethus bromeliarum Champion, Cactophagus lojanus, Cactophagus miniatopunctatus, Metamasius dimidiatipennis* (www.bromeliads.info/archieves/bromeliad-eating-weevils). The pineapple weevils are distributed in Northern Venezuela (O'Brien, 1994; Salas and O'Brien, 1997). It affects the parts of the plant like crown, flower stalk, fruit, leaf (O'Brien, 1994). The family has the characteristic, head prolonged forward as a rostrum (beak). It has the life history involving egg, larvae, pupae and adult stages. The female weevils lay eggs inside a hole within the plant part like base of the crown or base of the shoots. The eggs are oval, dull, white and semi transparent. The larvae are white except its head which is brown coloured. It grows to a size of 2.5 cm. The larvae of the pest are infective. It is motile and move up and down destructing the inner tissue of the flower stalk (O'Brien, 1994). This affects the normal growth of the fruit causing lack of crown. Adults appear 10.6 – 18.2 mm long. They are black or brown coloured with no scales over the body. They feed on leaves causing necrotic edges. Sometimes the fruits they attack rot (O'Brien, 1994; Salas and O'Brien, 1997)

Biology

The life cycle completed within 3 – 4 months (Gowdey, 1922).

***Egg**:* The eggs are oviposited singly in shallow excavations made usually in the fruit stalk at the junction of the stalk and fruit of the pineapple. More rarely, females lay eggs at the base of the crown and in the basal shoots (O'Brien, 1994).

Larva: The larvae hatch in eight to ten days and tunnel upward in the rootstock or fruit stalk or in the fruit itself. The larval stage lasts for eight to ten weeks.

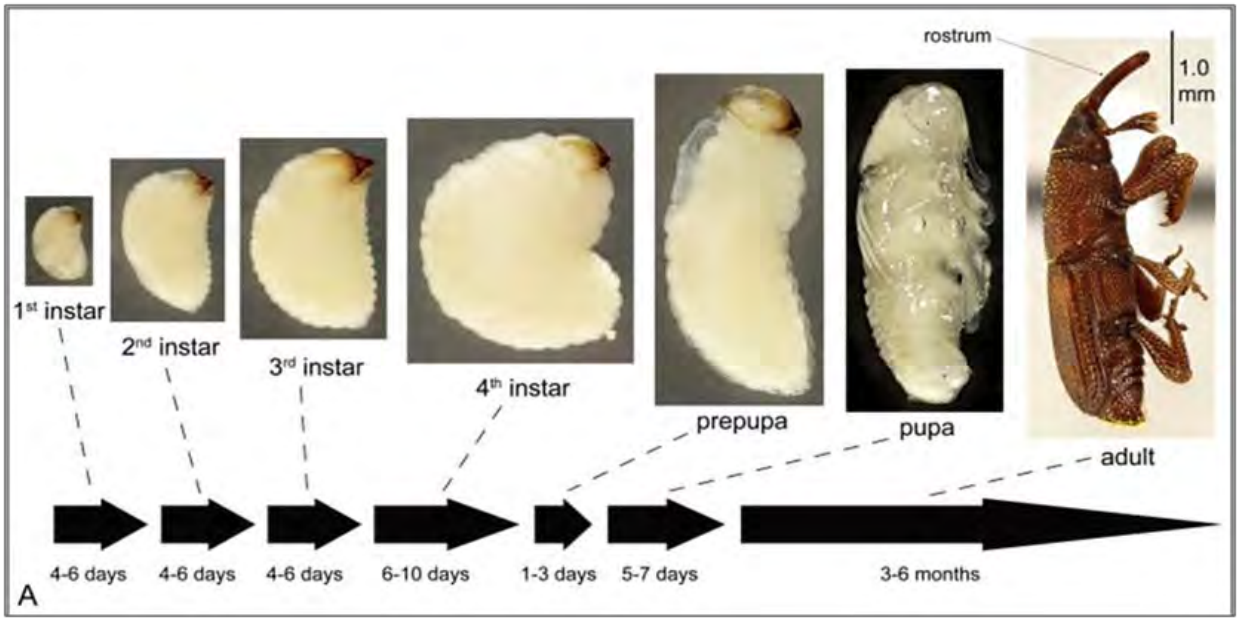

Figure 25. Life Stages of Pineapple Weevil
Source: www.sciencedirect.com, retrieved on 14/09/2013

Pupa: The pupa is formed at the extremity of the tunnel lasting 18 – 24 days.

Adult: The adults are poor fliers and require a great deal of protection from the direct rays of the sun. It prefers a very humid environment as it shows a preference for the recesses of dense vegetation. They are approximately 16.5mm – 22mm long.

Nature of Damage

The whole life span of the weevil occurs in the same plant. The female lays single egg in the slit created by them in the plant leaves. The larvae move to the stem causing tunnels in the plant. The larvae pupate in the central stem. There they make cocoon around the body for its growth. If the plant tissue remains enough the adult develops on the same host plant. The infestation causes the exudation of a gelatinous material which is protective for the weevil slits. The damage to the host plant includes adult feeding marks on the leaves, leaves browning, decomposition of base of central leaves (Barbra and Howard, 2010).

Figure 26. Pineapple weevil larva feeds on pineapple plant
Source: edis.ifas.ufl.edu, retrieved on 16 Oct 2013

Management

***Natural Control**:*

1. Pineapple fields must be cleared of weeds.
2. The planting should be done in shade free areas.
3. After two crop cycles replant the suckers
4. Use fresh disease free samples for planting
5. Incinerate the bio-wastes in and around the field.
6. Dip the fresh plants in Malathion or Diazinon
7. Apply crop rotation with non host plants
8. Restrict the movement of infected samples to other areas (Sherwood, 2010)

Biological control: Biological control agents like *Lixadmontia franki* and *Bacillus thuringiensis* offer the most likely success in management of the weevils.

Lixadmontia franki

A potential parasitoid was discovered in Honduras as the control for bromeliad eating weevil (Cave, 1997; Wood and Cave, 2006) called *Lixadmontia franki.* The female fly lay eggs at the same place were the weevils' oviposits. The larvae of the fly feed on the pests' larvae and thus they won't reach the pupae stage (Frank and Cave, 2005). The effect of the predator is not proved yet in comparison with the weevils' population.

Bacillus thuringiensis

Bacteria also has been used as a biological control against the weevils. The effect of the bacteria *Bacillus thuringiensis* Berliner (Bt) has been studied as pest control (Lacey et al., 2001). The main target pests are of Lepidoptera, Coleoptera, and Diptera species. The pesticidal effect of the bacteria and its ecofriendly nature are well studied (Lacey and Siegel, 2000). The mechanism of action includes insecticidal activity of the delta-endotoxins located in parasporal inclusion bodies (or parasporal crystals). These inclusion bodies are produced at sporulation stage and get activated only when ingested by the pests.

Termites

Figure 27. *Mastotermes darwiniensis*
Source: www.en.wikipedia.org, retrieved on 23 Oct 2013

Description and Identification

It belongs to Order: Blattaria, Family: Mastotemitidae, a very peculiar insect, the most primitive, it shows uncanny similarities to certain cockroaches. These similarities include the anal lobe of the wing and the laying of eggs in bunches, rather than singly. It is the only living member of its genus *Mastotermes* and its family Mastotemitidae. *Mastotermes darwiniensis* is usually not very numerous, nor are the colonies large when left to natural conditions.

However, when given abundant water (such as regular irrigation) and favourable food and soil conditions, populations can be enormous, numbering in the millions, quickly destroying their host. *Mastotermes darwiniensis* is the only known host of the symbiotic protozoan *Mixotricha paradoxa*, remarkable for its multiple bacterial symbionts.

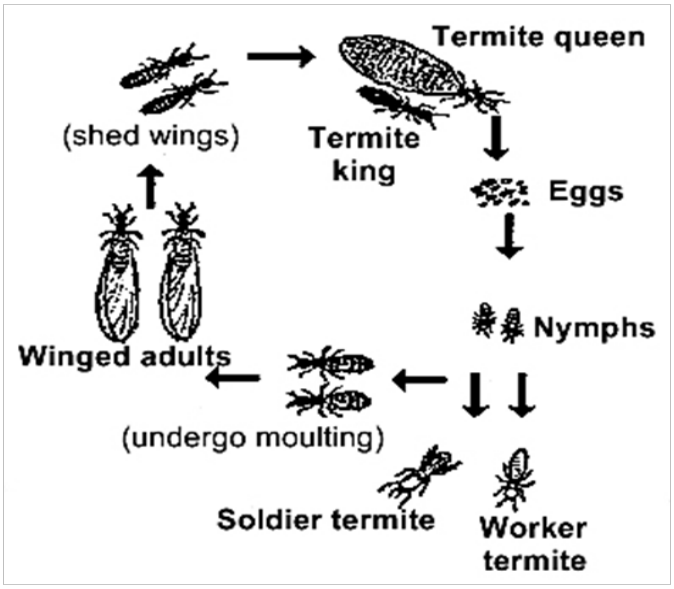

Figure 28. Life cycle of Termite
Source: fzi.uni-freiburg.de, retrieved on 23 Oct, 2013

Pest Biology

The life cycle of termites is described as "incomplete metamorphosis" with egg, nymph and adult stages. In the nymph stage termites grow through a series of moults. The life cycle of true ants is known as "complete metamorphosis"; with egg, larvae, pupa and adult stages.

Eggs: Queen lays eggs in batches of approximately 20 joined together to form one mass. A nymph after hatching passes through 4-7 moults before becoming a mature worker, soldier or winged reproductive. Nymphs resemble the adults or mature castes. Nymphal stage lasts approx 2-3 months, depending on food and climatic conditions. No pupal stage exists. Soldiers and nymphs live 1-2 years. Kings and Queens live longer (often over 20 years. There are some records of original queen living for 50 years).

Larvae: Larvae are short-haired, but the first eight nymphal stages bear dense, long hair. The nymphal integument becomes pale brown by the sixth stage; wing buds are evident in the fourth nymphal stage. Eye pigment first appears in sixth-stage nymphs. The ninth and later stages have whitish integument and short hair.

Adults: There are four different castes of adults

Queen and King**:** The queen and king are the original winged reproductives (alates). When a new colony is formed the pair must feed and care for the young until there are sufficient soldiers and workers to take over the duties of the colony.

Nymph (Pseudergate): This caste is ‘worker like’ the most abundant caste in the colony, performing all the tasks in the colony except defense and reproduction. It is this caste that does the damage to crops.

Soldier: Most distinctive caste and the easiest caste from which to identify a species. The role of this caste is to defend the colony. Males and females whose sexual organs and characteristics have not developed, like workers, are susceptible to desiccation and seldom leave the colony or shelter tubes. The fontanelle is used to discharge a secretion associated with defence, since it is a repellent to ants and other enemies of termites.

Reproductive: The future kings and queens having compound eyes are darker in colour and have a denser cuticle than workers and soldiers. They are often larger. Fully winged (alates) ones will have colonising flight when humidity and temperature conditions outside approximate the conditions inside the colony, normally in summer months.

Nature of Damage: The most destructive species within its range of occurrence. It also ringbarks and kills living trees and damages crops such as sugarcane, pineapple, etc. The nymphs are the caste that causes the damage.

Management

Prevention : Selecting low-risk sites, use of species suitable for a region or resistant species, reduction of mechanical damage, maintenance of plant vigour, removal of nests, increasing biodiversity, inter-planting can be done as preventive measures.

***Biological Control*:** Biological control of termites has largely focussed on the use of fungi (e.g. Metarhizium) and nematodes. It is not easily achieved in the field because of the tendency of termite colonies to cut off and avoid infected areas as soon as disease sets in.

Cultural Control: Clear the area of material that could attract termites before planting trees. Burn or completely remove tree stumps. In areas of high termite activity, the hole and soil may need treatment with bifenthrin or chlorpyrifos during planting.

***Chemical Control*:** If termite activity or damage is located in the premises, repellent termiticides (e.g. Bifenthrin) will NOT be made available as an option. This is to avoid the situation where termites can be 'locked in' rather than use their natural habits and biology against them (which is the benefit of non-repellent termiticides). Drenching of Chlorpyriphos (Hilban 20EC, 2.5 ml/l) is suggested in serious cases.

Pineapple Mites

Figure 29. ***Dolichotetranychus floridanus***
Source: www.kau.edu retrieved on 23, Oct, 2013

Description and Identification

The pineapple red mite, *Dolichotetranychus floridanus*, Order: Acarina, Family: Tenuipalpidae, is the largest mite found on pineapple and bright orange to red colour. It is only found in Florida, Cuba, Puerto Rico, Panama, Honduras, Mexico, Central America, Hawaii, the Philippine Islands, Japan, Okinawa and Java (Jeppson *et al.*, 1975). The adult mite is approximately 0.3–0.4 mm long and 0.1 mm wide. When present on the plant, the mite is always found on the white basal portion of the leaves, where it feeds, particularly on the crown. (Petty, 1975, 1978c). The blister mite, pineapple fruit mite, *Phyllocoptruta sakimurae*, Family: Eriophyidae, is the smallest mite (0.1 mm long and 0.033 mm wide) found on pineapple in Hawaii (Carter, 1967). Individuals are chalky in colour and only have two pairs of legs located near the head. They may be found on detached crowns that are stored for planting. They

originate from prior infestations on the ripe fruit from which the crowns were derived. They normally disappear after the crowns are planted, but may be found later on fruit after the flat-eye stage of fruit development (Carter, 1967). The pineapple tarsonemid mite (also known as pineapple mite, pineapple fruit mite, pineapple false spider mite), *Steneotarsonemus ananas,* Family: Tarsonemidae, may be found infesting pineapple later in the plant's phonological cycle.

Biology

Adults, nymhs and eggs of this species are bright orange in colour when alive. The tiny eupathidium on the palp tarsus has been recorded which is very difficult to see.

Eggs: Orange in colour

Larvae: The larvae are pale and almost translucent. They often have three pairs of legs in the larval stage and four pairs of legs in the nymph and adult stages.

Adults: Adults, nymph and eggs of this species are bright orange in colour when alive.

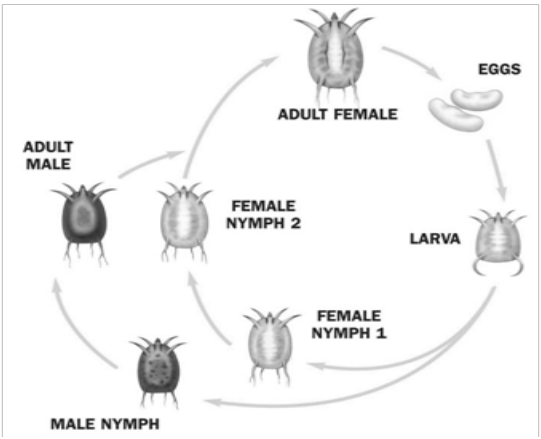

Figure 30. Life cycle of mites
Source:www.farmanimalhealth.co.uk, retrieved on 23 October, 2013

Nature of Damage:

These cause damage to leaves and fruits. Severe infestations produce large, dark brown lesions that almost cover the basal white tissue which can lead to necrosis and death of the leaves. In pineapple-production areas, it may frequently cause severe damage to recently established plants in the field. Plants that are infested in the early stages remain small and fruit production is either curtailed or non-existent. Heavily infested plants may die before producing fruit (Jeppson *et al.*, 1975). It feeds the epidermal tissue to dry and crack which allows fungus and bacteria to enter the plants and cause the tissue rot and scarring and tissue malformation.

Management

Prevention: Control programs are based on crop monitoring – looking for colonies on the basal white tissue of leaves and/or the leaf indentations and "rusty" feeding sites. Three stages in the crop cycle should be monitored – planting, flower initiation and near fruit harvest. Timing of treatments is critical for successful control.

***Biological Control*:** The fungus *Hirustella thompsoni* has been successfully used to control this mite.

Cultural Control: The best management action is to plant only mite-free seed-plant material (Jeppson *et al.*, 1975). Population densities of *D. floridanus* were reduced by routine pesticides and lower or minimal fertilizer treatments.

***Chemical Control*:** Need based repeated spray application of Dicofol 4 ml/l at 500 l/ha is recommended. At flower induction, four sprays may be applied at fortnightly intervals.

Some Organic Practices that can be Adapted for Pest Management

- Cow Urine: Dilute one litre of cow urine in ten litres of water and wet the whole plant at the rate of 200–300 l/ha at regular intervals.
- Cow Dung: 12.5 kg of fresh cow dung and 12.5 litres of cow urine are collected in an earthen pot and mixed thoroughly with 12.5 litres of water. The pot is covered and the mixture is allowed to ferment for a week. Occasionally it is stirred with a stick. After a week of fermentation, the mixture is filtered and 100 g of lime is added. The concentration is diluted with water in a 1: 10 ratio and sprayed on the crop at 200–250 l/ha.
- Neem Oil Spray: Neem oil spray: 2% neem oil is mixed with any detergent powder at 40–50 g/ 100 l and used as a spray solution.
- Neem Seed Kernel Extract (NSKE): It can be used as a prophylactic before the onset of pests.
- Chili Garlic Spray: Chili garlic spray is an effective insect repellent.
- Herbal Mixture Spray: About 500 g of tobacco leaves, 1 kg of neem kernel, 500 g lime powder, 500 g *Datura* leaves and 500 g pods and seeds of oleander (*Nerium oleander)* are powdered and mixed together, then soaked in 15 litres of water for 15 days. On alternate days, the mixture needs to be stirred with a stick. After 15 days, one litre of filtrate is mixed in 15 litres of water and sprayed on the crop. It is enough for 2.5 ha and is a multi-pest repellent.
- Tobacco tea - Tobacco tea is effective against most pests.

(Package of Organic Practices from Assam, Manipur, Meghalaya and Nagaland for Pineapple, *Prepared by North Eastern Region Community Resource Management Project (NERCORMP) for Upland Areas (IFAD & GOI/DoNER/NEC), Shillong)*

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